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# Erosion and Sediment Management Report

Replacement of the Kings Highway bridge  
over the Clyde River at Nelligen

Prepared by:

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26 July 2016



# SEEC

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*Any recommendations contained in this report are based on an honest appraisal of the opportunities and constraints that existed at the site at the time of investigation, subject to the limited scope and resources available. Within the confines of the above statements and to the best of my knowledge, this report does not contain any incomplete or misleading information.*

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26 July 2016



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*Version Register*

Version	Date	Author	Reviewer	Notes	Other
Draft A	03/06/2016	AM	MP	Draft issue for consultation.	Section 6 incomplete.
Draft B	06/06/2016	AM	MP	Final draft issued for consultation	All sections complete. Minor changes made from initial draft.
Draft C	29/06/2016	AM	RMS	Revisions following RMS comments.	
Rev00	11/07/2016	AM	RMS	Final issue	Updated footprint in Figs 1 and 5
Rev01	26/07/2016	AM	RMS	Rev 01	Minor updates to answer comments

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# 1 INTRODUCTION

## 1.1 Background

NSW Roads and Maritime Services (Roads and Maritime) proposes to construct a new bridge over the Clyde River at Nelligen. The proposal involves:

- construction of a new bridge over the Clyde River on a different alignment to the north of the existing bridge, with two traffic lanes (one eastbound, one westbound) plus pedestrian path;
- realignment of the existing highway to direct traffic onto the new bridge, including substantial fill batters;
- reconfiguration of road geometry including changes to large cut batters;
- provision of intersections to provide local road access;
- modifications to existing pavements and drainage; and
- demolition and removal of the existing bridge.

Substantial earthworks would be required to establish fill embankments on the approaches to the new bridge and to modify the existing cut batters located on the eastern approach.

A Preliminary Erosion and Sedimentation Assessment for the proposal identified that it is inherently high risk due to:

- potential complexity;
- steep slopes;
- working in a marine environment;
- the need for extensive cut and fill;
- the presence of sensitive coastal wetlands classified under State Environmental Planning Policy No.14 - Coastal Wetlands (SEPP 14);
- the Clyde River at the proposal is located within the Batemans Marine Park;
- site constraints that limit the amount of available land during construction; and
- construction on low-lying or tidal lands with an inherent risk of acid sulfate soils.

SEEC were engaged by GHD on behalf of Roads and Maritime to prepare this Erosion and Sedimentation Management Report (ESMR) in accordance with Roads and Maritime Procedure PN 143P.

## 1.2 Purpose of This Report

The purpose of this report is to:

- Develop a concept for major erosion and sediment control measures such as up-gradient stormwater diversions, cross-drainage and sediment basins.

- Assess constraints to the installation and operation of major erosion and sediment controls during construction in accordance with Volumes 1 and 2D of the NSW Blue Book (Landcom, 2004 and DECC, 2008).
- Identify methods to eliminate, substitute or manage potential erosion and sediment control hazards during construction.

**1.3 Scope of This Report**

Figure 1 shows the approximate extent of the proposed works. In preparing this ESMR, SEEC have investigated the extent of those works, plus the anticipated additional area that might be expected to be disturbed during construction. SEEC also investigated the prevailing drainage (both overland and piped) that might impact on the construction area.

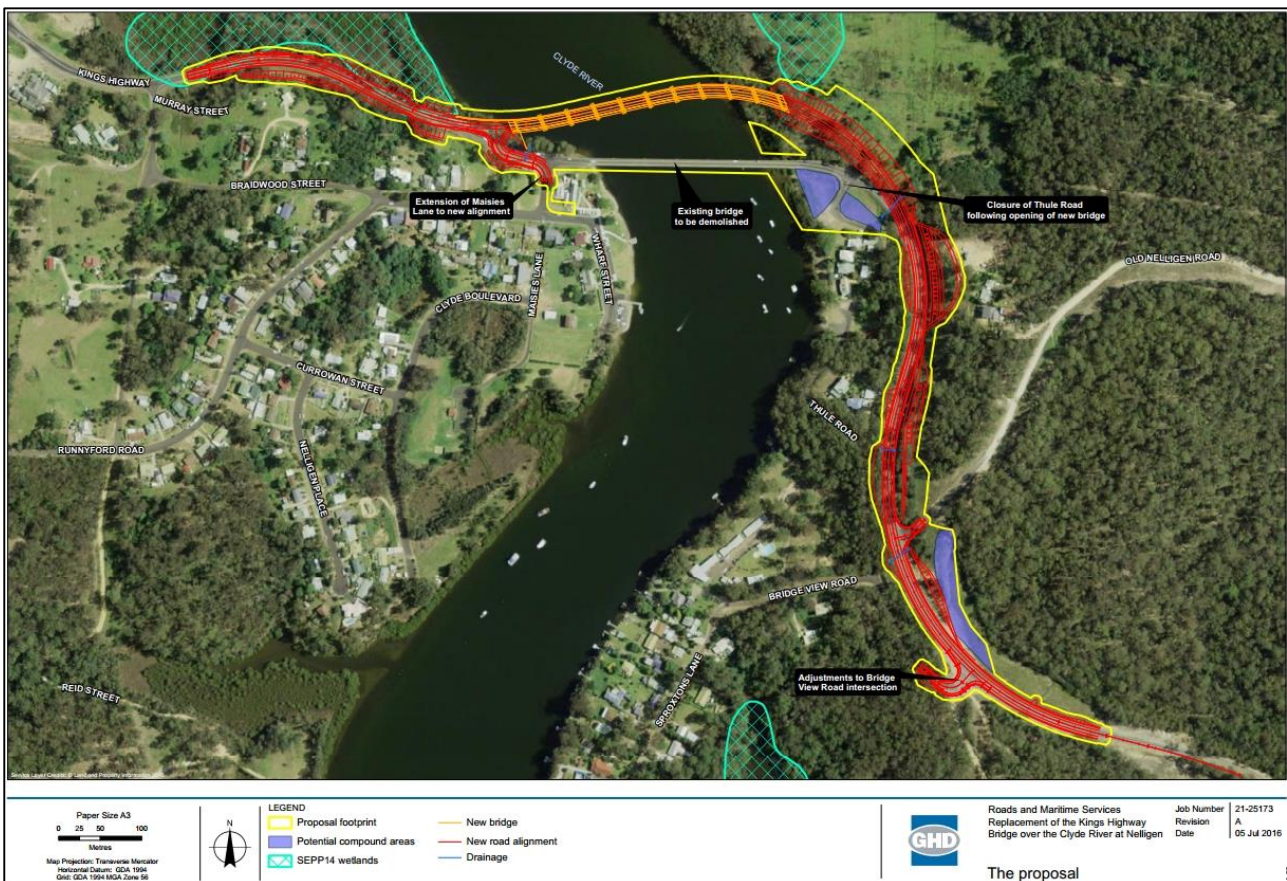


Figure 1 Approximate extent of study area (provided by GHD)

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## 2 DOCUMENTATION AND LIAISON

### 2.1 Design Documentation

In preparing this ESMR a number of draft designs and reports were referred to. These included:

- *Nelligen Bridge: Preliminary Environmental Investigation*. September 2014 (URS, 2014)
- *Nelligen Bridge Replacement: Preliminary Flora and Fauna Assessment*. January 2014 (Biosis, 2014).
- Concept Designs for Nelligen Bridge Replacement (Roads and Maritime, various dates).
- *Nelligen Bridge: Review of Environmental Factors* (GHD, 2016) including the following Appendices:
  - Appendix B – Biodiversity assessment (GHD)
  - Appendix C – Aboriginal Cultural Heritage Assessment Report (Umwelt)
  - Appendix D – Non-Aboriginal heritage assessment (Umwelt)
  - Appendix E – Urban Design Report and Landscape Character and Visual Impact Assessment (Spackman Mossup and Michaels)
  - Appendix F – Noise and vibration assessment (GHD)
  - Appendix G – Flooding and Operational Water Quality Specialist Study (GHD).

### 2.2 Site Inspection, Liaison and Risk Management

A site inspection was conducted by Andrew Macleod from SEEC on 16 May 2016 to observe soil and topographical conditions and identify options for erosion and sediment control during construction.

In preparing this ESMR, SEEC staff liaised with GHD as the coordinating consultant. Draft copies of this report and its accompanying drawings were provided for review by GHD and Roads and Maritime.

During the preparation of this ESMR, a number of iterations were developed to position and size the major erosion and sediment control measures. The recommendations identified in Section 6 of this report reflect the results of that discussion and design process.

### 3 SITE CONDITIONS

#### 3.1 Climate

Bureau of Meteorology climatic statistics for Batemans Bay (about 10 kilometres from Nelligen) are contained in Table 1. Monthly average rainfall statistics are also shown in Figure 2. Table 1 and Figure 2 show that rainfall is fairly consistent throughout the year with no distinct wet or dry season. Temperatures are relatively mild.

Table 1 Monthly climate averages for Batemans Bay (BoM station 69134) as at June 2016.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	91.0	98.6	73.3	68.4	58.9	73.2	43.0	72.5	59.8	93.4	96.1	73.7	923
Mean no of days with rain >1mm	9.0	9.0	7.6	6.8	5.3	6.0	4.9	5.0	7.0	8.2	9.5	8.9	87.2
Mean min temp (°C)	15.6	15.9	14.0	10.6	7.1	5.1	3.7	4.6	7.4	9.7	12.3	14.1	10.0
Mean max temp (°C)	25.8	25.5	24.4	22.3	19.7	17.4	17.0	18.3	20.4	22.1	23.0	24.5	21.7
Mean 3pm wind speed (kmh)	13.1	11.7	10.0	9.2	6.9	7.2	8.4	12.5	13.9	14.1	13.6	12.5	11.1

Rehabilitation would need to be sympathetic to the natural seasonal variations in climate, with species selection, watering and ground preparation all influenced by the time of year.

As a coastal area, winds can be strong at any time of year. Prevailing summer winds are from the north-east, and from the south-west in winter.

The RUSLE R-Factor for this site is 3830, based on the 2-year, 6-hour storm event of 13.3mm/hr for Nelligen (Bureau of Meteorology, 2016).

Refer to Section 5 for a summary of climate-related constraints plus management and mitigation options.



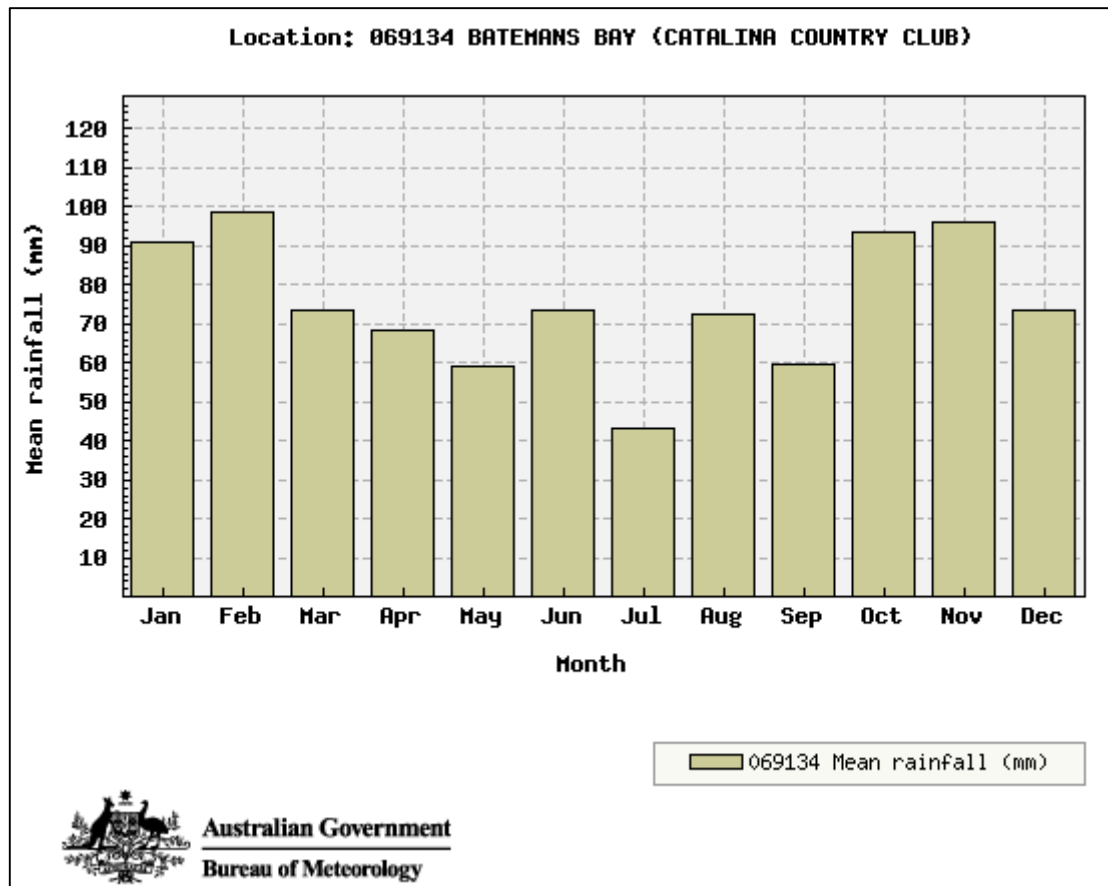


Figure 2 Monthly average rainfall at nearby Batemans Bay (station 69134).  
From Bureau of Meteorology, accessed June 2016.

### 3.2 Topography

Site topography varies along the alignment of the proposed route (from west to east):

- Western portion of the study area, west of the proposed bridge (abutment A): alignment is mostly cut into the side of a steep hillside. Topography includes:
  - Slopes up to about 50% (1V:2H)<sup>1</sup> on natural hillsides;
  - Slopes up to about 150% (2V:1H) on existing highway cut batters;
  - Slopes up to about 90% (4.5V:5H) on existing highway fill batters;
  - Slopes of 0 to 5% (1V:20H) on river flats at the foot of the steep hillside and existing highway fill batters.
- Eastern portion of the study area, east of the proposed bridge (abutment B): alignment is mostly cut into the side of a very steep hillside. Topography includes:
  - Slopes up to about 50% (1V:2H) on natural hillsides;
  - Slopes up to about 100% (1V:1H) on existing highway cut batters;
  - Slopes up to about 90% (4.5V:5H) on existing highway fill batters;
  - Slopes of 0 to 5% (1V:20H) on river flats at the foot of the steep hillside and existing highway fill batters.

<sup>1</sup> Percentage slope is determined by the change in slope (V = Vertical) over a nominated distance (H = Horizontal). For example, a 50% slope is 1m of rise for every 2m of run, and can also be expressed as a "1 in 2" slope.

The Blue Book (Landcom, 2004) recommends slope lengths on bare ground be no greater than 80m whenever rain is falling or imminent. Slope breaks might need to be included during construction at 80m (maximum) intervals.

The Blue Book also includes design recommendations for batter gradients, benching and slope length. Section 4.2 provides details.

Steep pavement gradients on the existing highway east of the bridge will mean that runoff velocities will be high. This increases the risk of erosion.

Refer to Section 5 for a summary of topography-related constraints plus management and mitigation options.

### **3.3 Soils**

Soil Landscape Mapping is not available for this area. Basic soil investigations were made by SEEC during our site inspection, revealing a combination of estuarine, alluvial, colluvial and erosional soils, depending on landscape position. Soils along much of the proposed alignment have been previously disturbed.

On steep slopes, soils are shallow, stony and have a high proportion of silt and fine sand, being derived from weathering of the underlying meta-sedimentary parent material. These soils have poor structure, low fertility and are highly susceptible to erosion by wind and water. Dispersible clay layers were observed lower in the soil profile (about 0.6m below ground level) in small pockets east of the river.

On river flats soils are either alluvial sands and loams, or estuarine muds made up of waterlogged silt, clay and sand. Acid sulfate soils are known to occur within the footprint of the proposal on parts of the river flats.

Soil erodibility factors (K-factors) for use in the Revised Universal Soil Loss Equation are not available without laboratory testing. Given that soils have been disturbed over much of the alignment, obtaining representative samples is not feasible. Instead, we recommend assuming a soil K-Factor of 0.04 across all areas (based on an average K-factor for silty clay loams in IECA, 2008).

Refer to Section 5 for a summary of soils-related constraints plus management and mitigation options.

### **3.4 Receiving Waters**

All drainage from the proposal site drains into the Clyde River, an open-intermediate tide-dominated valley estuary that flows into the Tasman Sea. At Nelligen, waters are brackish depending on tidal movements and rainfall. Although the Clyde River has been subject to human development along its shores, it is considered to be a sensitive receiving environment and is protected as part of the Batemans Marine Park.

The river is used for recreational activities including fishing, swimming, water skiing and boating. Commercial uses include oyster farms between Batemans Bay and Nelligen, plus tourism operators in and around Batemans Bay.

According to URS (2014), water quality in the Clyde River is generally within the acceptable limits of The Interim Water Quality Objectives for Batemans Bay aside from slightly elevated turbidity values in the lower Clyde River between Nelligen and the Princes Highway Bridge. URS (2014) also noted that the Clyde River at Nelligen is a low-energy system and has a flushing time of 19 to 24 days under purely tidal influence. As such, any sediment pollution from construction activities is likely to persist in the river.

The Blue Book (Landcom, 2004) suggests that water discharged from construction sites should not contain more than 50mg/L of suspended sediment. Although this concentration exceeds the recommended release criteria for stormwater flows into the Clyde River under ANZECC guidelines, a more stringent water quality requirement is not recommended because:

- The construction period is relatively short-term (estimated at 18 months maximum) so long-term impacts are unlikely;
- The use of enhanced erosion controls (refer to Section 3.11) reduces the potential for sediment generation;
- A more stringent water quality requirement would add to the cost of site dewatering, and most likely couldn't be achieved within a reasonable timeframe using safe flocculants.

As such, we recommend that the water quality standard in Table 2 be adopted for any site dewatering.

**Table 2 Recommended water quality standard for site dewatering**

Parameter	Recommended standard during construction
Total suspended solids (TSS)	50mg/L
pH	6.5 to 8.5
Oils and greases	<10mg/L and none visible

Refer to Section 5 for a summary of constraints related to working in and around a sensitive waterway, plus management and mitigation options.

### 3.5 Flooding and Tidal Influence

A flood assessment (GHD, 2016) identified potential inundation up to about 5.48m AHD in a 1% AEP (Average Exceedence Probability) event. As such, all of the low-lying, near-level river flats on both shores are flood-prone.

The Blue Book (Landcom, 2004) suggests that special erosion and sediment control measures should apply to any works below the 2-year average recurrence interval (ARI) flood level. This includes:

- Sediment controls should be placed above the 2-year ARI flood level (e.g. basins, sediment fences etc).
- Requirements to stabilise lands using temporary ground cover whenever rain is falling or imminent.
- Scheduling works for lower-risk times of year, based on historical rainfall figures.

These special requirements are likely to apply to portions of the proposal, particularly on the low-lying areas either side of the new bridge.

Refer to Section 5 for a summary of drainage-related constraints plus management and mitigation options.

### **3.6 Existing Drainage**

During construction, there is a risk of offsite (clean) and onsite (dirty) water mixing at various locations due to the proximity of the existing highway to the proposed works, and the need to maintain live traffic through the work area.

The topography of the site and the traffic loads mean that diverting traffic off the current highway alignment during construction is not practical.

West of the existing bridge there is no formal drainage along the highway, only table drains at the base of cut batters draining to cross-formation pipe culverts at approximate chainages 9480 (flows to north), 9280 (flows to north) and 9080 (flows to north). Refer to Figure 3.

East of the existing bridge there is concrete SO gutter on both sides of the highway from about chainage 8250 to 8560 with cross-formation relief culverts at approximate chainage 8250 (flows to west) and 8560 (flows to west). There is also a cross-formation drainage culvert at approximate chainage 8620 (flows to north-east). This latter culvert takes runoff from the majority of the Thule Rd area underneath the highway. Refer to Figure 3.

For the purposes of this assessment, it is assumed that existing cross-formation drainage will need to be replaced or extended as part of the bridge replacement works. During culvert replacement or extension, flows will need to be maintained in a manner that minimises the risks of upstream flooding (i.e. backing up due to impeded drainage) and minimises the risk of sediment pollution to downstream.

Refer to Section 5 for a summary of drainage-related constraints plus management and mitigation options.

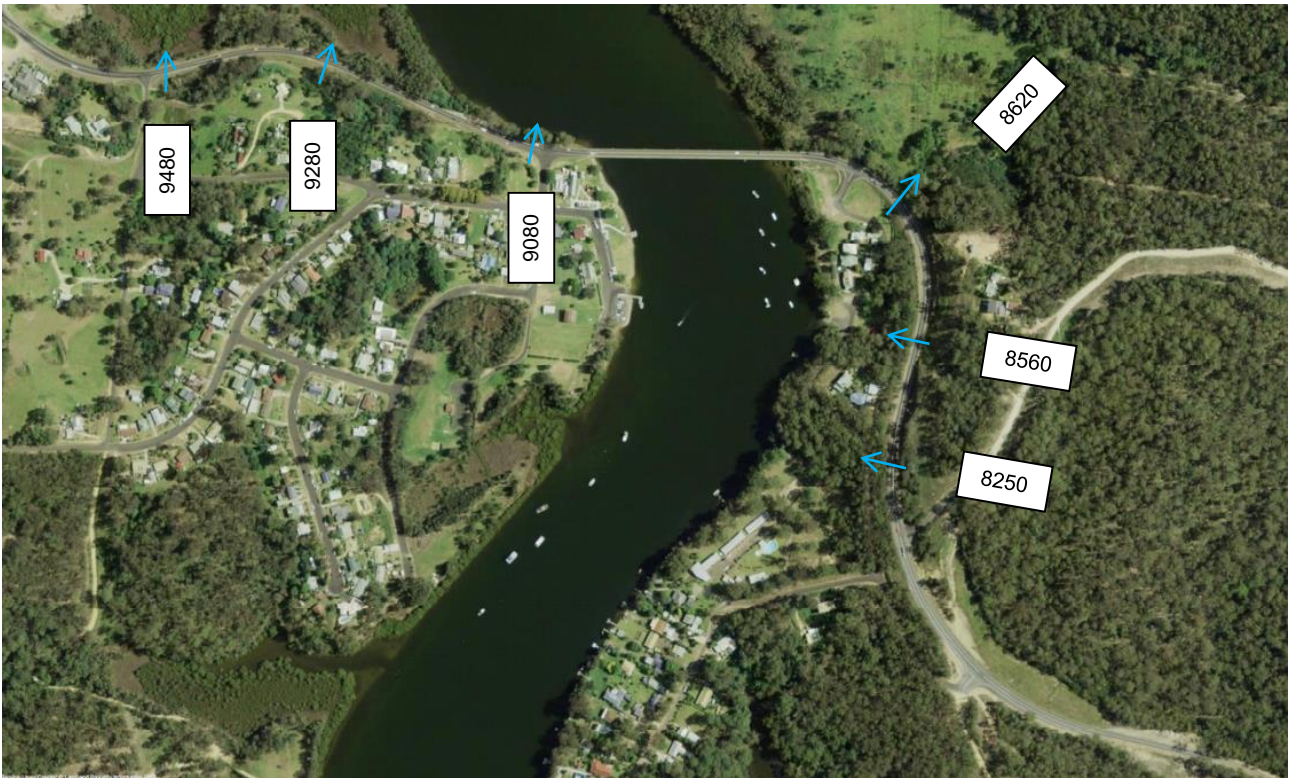


Figure 3 Approximate locations and flow directions of existing drainage culverts along the existing highway alignment. Chainages are approximate only.

### 3.7 Ecology

The REF (GHD, 2016) plus the Preliminary Environmental Investigation (URS, 2014 and Biosis, 2014) identified several Threatened or Endangered Ecological Communities that occur in and around the footprint of the proposed works and concluded that both direct and indirect impacts were likely.

Under the Roads and Maritime Biodiversity Guidelines (2011), avoiding or minimising impacts is the preferred option.

The presence of Threatened or Endangered Ecological Communities is highly likely to impact on the installation of erosion and sediment control measures, especially those that involve disturbing land outside the footprint of the highway (e.g. sediment basins).

However, installing such devices is very important to help minimise the impact of sediment-laden water generated during construction on Threatened or Endangered Ecological Communities, SEPP14 coastal wetlands and the Clyde River.

Refer to Section 5 for a summary of ecology-related constraints plus management and mitigation options.

### 3.8 Existing Services

Site investigations and utility surveys did not suggest that existing services would significantly constrain the ability to install and operate erosion and sediment control measures such as sediment basins.

### 3.9 Land Availability

Land availability is a common constraint for major road projects during construction, especially for:

- Establishing stockpiles; and
- Constructing sediment basins.

The proposed alignment is relatively narrow, with little space available in many locations for access and/or sediment control during construction. Additional land outside the footprint of the engineered fill is available near the proposed eastern bridge abutment (Abutment B), which could be used for access and/or sediment control. However, this has potential impacts for SEPP14 coastal wetlands and Threatened or Endangered Ecological Communities in that vicinity.

It is generally unacceptable to position temporary construction-phase sediment basins within the footprint of the engineered fill, as they can create geotechnical issues later during fill placement. As such, sediment basins are ideally placed outside the footprint of the engineered fill.

Refer to Section 5 for a summary of space-related constraints plus management and mitigation options.

### 3.10 Design Constraints

Piling will be required for the abutments, pylons and for the proposed retaining wall adjacent to the western abutment (Abutment B). For the purposes of this assessment it is assumed that piling for the abutments, any pylons above the low-water mark and for the retaining wall will be done by a terrestrial-based piling rig. This would necessitate establishing substantial piling platforms for the safe working of the piling rig. These piling platforms would most likely encroach into the river so would risk stirring up aquatic sediments.

Live traffic would need to remain on the existing highway during construction of the new bridge and approaches. There is a risk of sediment tracking onto live roads from construction areas.

Refer to Section 5 for a summary of constraints related to working in and around a sensitive waterway, plus management and mitigation options.

**3.11 Erosion Hazard**

An evaluation of the erosion hazard was made using the approach in Chapter 4 of the Blue Book (Landcom, 2004). This process involves calculating the predicted annual average soil loss using the Revised Universal Soil Loss Equation (RUSLE) as follows:

$$A = R \times K \times LS \times P \times C$$

Table 3 details the above equation and the values used in assessing erosion hazard.

**Table 3 RUSLE definitions and assumptions**

Parameter	Definition	Assumed or adopted value for this site
A	Total calculated soil loss (t/ha/yr)	Varies for each area. See below.
R	Rainfall erosivity factor	3830 for this site.
K	Soil erodibility factor	0.04 assumed for this site.
LS	Slope length and gradient factor	Varies for each area. Both the existing and proposed slope length and gradient were assessed for each section and the maximum adopted.
P	Conservation practice factor	Maximum of 1.3 assumed for this site.
C	Ground cover factor	Maximum of 1.0 assumed for this site.

Table 4 details the results of the Erosion Hazard Assessment for various sections of the proposal, plus the subsequent Soil Loss Classes and implications as detailed in the Blue Book (Landcom, 2004).

Table 4 Erosion hazard calculations and implications for site management

Condition	Assumed conditions	Calculated soil loss (t/ha/yr)	Soil Loss Class	Enhanced requirements as per Blue Book
Cut batters	9m long, 150% gradient to 23m long, 50% gradient LS-factor and assuming benching)	1,315	6 (very high)	<p>Preferably schedule works for the period 1 June to 31 January. If this is not possible, ensure lands are temporarily stabilised with ground cover whenever rain is falling or imminent.</p> <p>The requirement to stabilise lands when rain is imminent should apply at <i>all times</i> if no sediment basin is in place downslope of a high risk cut batter area.</p>
River flat areas	<5% slopes. Flood-prone lands	118	6 (very high) (automatic assumption due to flooding risk)	<p>Preferably schedule works for the period 1 June to 15 November.</p> <p>Ensure lands are temporarily stabilised with ground cover whenever rain is falling or imminent.</p>
Fill batters	16m long, 50% gradient	975	6 (very high)	<p>Preferably schedule works for the period 1 June to 15 November. If this is not possible, ensure lands are temporarily stabilised with ground cover whenever rain is falling or imminent.</p> <p>The requirement to stabilise lands when rain is imminent should apply at <i>all times</i> if no sediment basin is in place downslope of a high risk fill batter area.</p>
Other areas	80m long, 10% average slope	279	3	None – standard erosion and sediment controls apply.



## 4 DESIGN CONSIDERATIONS FOR EROSION AND SEDIMENT CONTROL

### 4.1 Sediment Basins

The Blue Book (Landcom, 2004 and DECC, 2008) notes that a sediment basin should be included where the erosion hazard exceeds 150 m<sup>3</sup>/year of soil loss. It is standard practice that each affected catchment on a road construction project be assessed against this requirement.

Note that Landcom (2004) also notes that sediment basins should not be positioned on lands prone to flooding or lands affected by high ground water tables.

Following on from the erosion hazard assessment in Section 3.11, a sediment basin(s) is required for this proposal. The size of the basin(s) will vary depending on catchment size and conditions.

Note there are several site, soil and drainage constraints to constructing sediment basins, so adequate land should be set aside early to allow for their construction.

Basin design should be based on the following criteria:

- Design rainfall depth: 37.4 mm (5-day, 85<sup>th</sup> percentile for Batemans Bay);
- Basins designed for Type D (dispersible) sediment;
- Volumetric runoff coefficient (Cv): 0.64.

### 4.2 Batters

The Blue Book includes design recommendations for batter gradients, benching and slope length. Table 5 and Figure 4 provide details.

Assuming a K-Factor of 0.04 (refer to Sections 3.3 and 3.11), Landcom (2004) suggests that the considerations detailed in Table 5 should be taken into account for batter design.

Note that these batter recommendations are included in Landcom (2004) primarily to allow for vegetative establishment on batters, not for geotechnical stability. However such recommendations could be considered largely unnecessary for this proposal providing:

- Reliable rehabilitation techniques such as compost blankets were used; and/or
- Irrigation was provided, especially on north or north-west facing batters.

Table 5 Batter gradient and benching recommendations (from Landcom, 2004).

Batter gradient (H:V)	Recommendations for benching
2:1 (50%)	Every 8m
2.5:1 (40%)	Every 10m
3:1 (33%)	Every 12m
4:1 (25%)	Every 17m
5:1 (20%)	Every 22m
6:1 (17%)	Every 30m

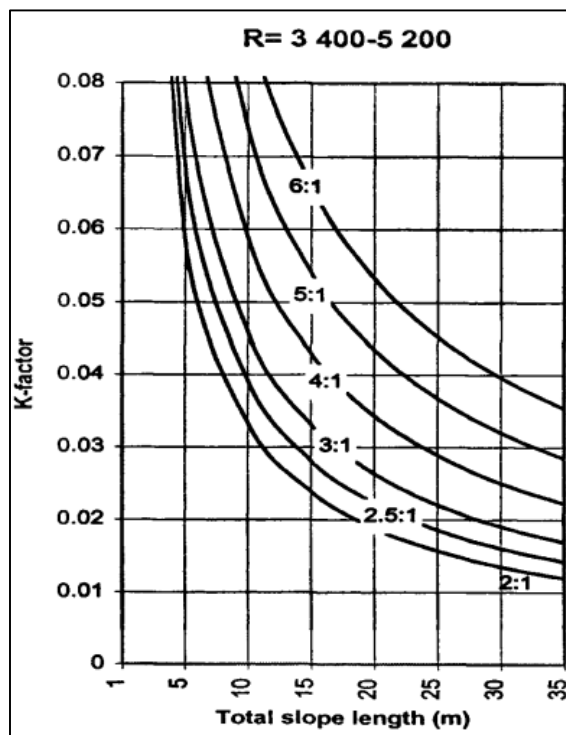


Figure 4 Batter gradient and benching limits as recommended in Landcom (2004).

## 5 MITIGATION AND MANAGEMENT OPTIONS - DISCUSSION

Table 6 details the constraints identified in Section 3, along with potential impacts and potential mitigation or management options.

Table 6 Constraints, impacts and management options.

Constraint	Potential impact for construction-phase erosion and sediment control	Mitigation or management options
<b>Topographical Constraints</b>		
)	Slopes are very steep in places, leading to very high erosion hazard.	<ul style="list-style-type: none"> <li>• Enhanced erosion controls should be employed for steep areas, including:                             <ul style="list-style-type: none"> <li>○ Timing works for the period 1 June to 15 Nov as much as possible;</li> <li>○ Using temporary ground covers such as geofabric or biodegradable polymer sprays to lock-down steep batters when rain is falling or imminent.</li> </ul> </li> <li>• Design of batters could include benches to reduce slope lengths.</li> <li>• Sediment basins should be included downslope of high-risk work areas.</li> <li>• Use efficient and reliable methods for batter stabilisation at the completion of works (e.g. compost blanket).</li> </ul>
Slope gradient (steep slopes)	The Blue Book (Landcom, 2004) recommends slope lengths on bare ground be no greater than 80m whenever rain is falling or imminent.	<ul style="list-style-type: none"> <li>• Slope breaks might need to be included during construction at 80m (maximum) intervals.</li> </ul>
	The Blue Book includes design recommendations for batter gradients, benching and slope length.	<ul style="list-style-type: none"> <li>• Refer to Section 4.2 for recommended design considerations relating to batter gradients and benching.</li> </ul>
	Steep pavement gradients on the existing highway east of the bridge will mean that runoff velocities will be high. This increases the risk of erosion.	<ul style="list-style-type: none"> <li>• Temporary drainage structures on steep slopes should be lined to reduce erosion. Where possible, use 'soft' engineering solutions for lining. However, 'hard' armouring (e.g. concrete) will most likely be required for steep areas.</li> <li>• Check dams should be used to help slow flow velocities in drainage structures on steep slopes.</li> </ul>

Constraint	Potential impact for construction-phase erosion and sediment control	Mitigation or management options
<b>Drainage and Watercourse Constraints</b>		
Works in waterways	Risk of sediment pollution directly in the river from marine works.	<ul style="list-style-type: none"> <li>• Use erosion control on work areas to reduce the amount of sediment mobilized by wind and water.</li> <li>• Use sediment basins and other sediment controls around waterways and drainage pathways to catch eroded sediment.</li> <li>• Use floating silt curtains around marine works which might stir up river sediment or damage the banks.</li> </ul>
	Piling in tidal areas – establishing piling platforms.	<ul style="list-style-type: none"> <li>• Use clean rock over geofabric to create piling platforms, working from the land side towards the river banks.</li> <li>• Use floating silt curtains to contain any sediment plumes stirred up during piling or establishment of piling platforms.</li> </ul>
Drainage	Potential poor drainage and boggy areas in low-lying areas.	<ul style="list-style-type: none"> <li>• Use clean rock over geofabric to create trafficable access.</li> </ul>
	Potential for standing water in low-lying parts of the site after rainfall.	<ul style="list-style-type: none"> <li>• Use clean rock over geofabric to create trafficable access.</li> <li>• Identify locations to pump water to after rainfall to permit access.</li> </ul>
	Earthworks, service installation, piling and foundations might be subject to groundwater ingress.	<ul style="list-style-type: none"> <li>• Pumps will most likely be required for dewatering around piles and abutments.</li> <li>• Trench boxes might be required.</li> <li>• Tidal fluctuation might need to be monitored.</li> <li>• Spear pumps might be required to locally lower water tables.</li> </ul>
	Space is limited for de-watering locations nearby the bridge abutments.	<ul style="list-style-type: none"> <li>• A designated area for pumping or trucking water will be required so that work areas can be effectively dried out.</li> </ul>
	High ground water tables could impact on rehabilitation.	<ul style="list-style-type: none"> <li>• Rehabilitation in areas of high groundwater will need to include plants capable of surviving in such soil conditions.</li> </ul>

Constraint	Potential impact for construction-phase erosion and sediment control	Mitigation or management options
	Potential for saline or brackish groundwater.	<ul style="list-style-type: none"> <li>• Rehabilitation in areas of saline groundwater will need to include plants capable of surviving in such soil conditions.</li> <li>• Engineered structures (e.g. concrete) should be capable of withstanding aggressive soil or groundwater conditions.</li> </ul>
Positioning of sediment basins	Waterlogging, flooding and tidal influence on the river flats limits the locations available for sediment basin construction.	<ul style="list-style-type: none"> <li>• Identify suitable locations for basins outside of such zones.</li> <li>• Identify appropriate alternatives for sediment control in areas where basins cannot be constructed.</li> </ul>
Flooding and tidal inundation	Low-lying areas along the river would be subject to regular inundation from tides or from flooding	<ul style="list-style-type: none"> <li>• Position sediment controls above the 2-year flood level (e.g. basins).</li> <li>• Stabilise lands using temporary ground cover whenever rain is falling or imminent.</li> <li>• Where possible, schedule works for lower-risk times of year, based on historical rainfall figures (i.e. 1 June to 15 Nov).</li> </ul>
Existing culverts and road drainage	Cross-formation drainage will need to be maintained during construction.	<ul style="list-style-type: none"> <li>• Use existing or temporary culverts to allow cross-formation drainage.</li> <li>• Align any new or replacement culverts to allow for drainage during construction without the need for extensive temporary drainage.</li> <li>• Create temporary drainage diversions during culvert construction.</li> <li>• Position new culverts offline from natural drainage lines so they can be constructed with minimal disturbance of the drainage line.</li> </ul>
	Need to maintain existing road drainage, especially through the cuts east of the river. Likely that clean offsite runoff will mix with dirty onsite water in this section.	<ul style="list-style-type: none"> <li>• Design sediment controls to cater for the entire catchment draining to them.</li> <li>• Use temporary drainage along road verges to keep clean and dirty water separate.</li> </ul>

Constraint	Potential impact for construction-phase erosion and sediment control	Mitigation or management options
Sensitive receiving environment	Risk of pollution in a high value, sensitive waterway.	<ul style="list-style-type: none"> <li>• Develop an erosion and sediment control plan (ESCP) for the works.</li> <li>• Employ the services of a qualified soil conservationist during construction to assist with the design and implementation of erosion and sediment control measures.</li> <li>• Adopt a focus on minimising erosion from steep slopes by using temporary ground covers whenever rain is falling or imminent.</li> <li>• Adopt a practical but appropriate water quality standard for releases from sediment basins.</li> <li>• Use a combination of erosion controls and sediment controls to minimise the risk of pollution during construction.</li> <li>• Wherever possible, use sediment basins at the downstream end of construction catchments as the “goalkeepers” to catch any eroded sediment.</li> </ul>
<b>Land Availability and Ecological Constraints</b>		
Space	Limited space for construction of sediment basins.	<ul style="list-style-type: none"> <li>• West of the bridge, there is no room for basins inside the footprint of the study area without encroaching on flood-prone, intertidal or threatened/endangered ecological communities. Smaller, more space-efficient controls should be employed (e.g. modular sediment traps) along with extensive use of temporary ground covers whenever rain is falling or imminent.</li> <li>• East of the bridge, sediment basins are generally feasible and are shown on the concept plans in this report.</li> <li>• Space for basins is limited in the large cuts east of the river. Smaller, more space-efficient controls should be employed (e.g. modular sediment traps) along with extensive use of temporary ground covers whenever rain is falling or imminent.</li> </ul>

Constraint	Potential impact for construction-phase erosion and sediment control	Mitigation or management options
	Limited space for establishing stockpiles.	<ul style="list-style-type: none"> <li>• Identify potential stockpile locations prior to contract award. Options include (but are not limited to):                             <ul style="list-style-type: none"> <li>○ The reserve east of the highway near chainage 8040 (i.e. near the eastern end of the study area).</li> <li>○ The flat area north of the new fill near chainage 8660 (although flood risk should be considered at this location).</li> <li>○ Adjacent to Thule Rd, south of the existing highway near chainage 8680 (although flood risk should be considered at this location).</li> </ul> </li> </ul>
Live traffic	Risk of sediment tracking onto live traffic roads.	<ul style="list-style-type: none"> <li>• Use shakers, rumble grids, washdowns or similar.</li> <li>• Minimise traffic movements on and off public roads.</li> <li>• Minimise traffic movements on and off site during rainfall.</li> </ul>
Ecology	The presence of Threatened Ecological Communities limits the locations and space available for installation of erosion and sediment control measures, especially sediment basins and stockpiles.	<ul style="list-style-type: none"> <li>• Design review of proposed sediment basin locations (as noted in this report) vs ecological constraints.</li> </ul>
<b>Soil Constraints</b>		
Presence of potential acid sulfate soils (PASS) in some areas	Development of actual acid sulfate soils if PASS is exposed to air either by excavation or lowering of the water table.	<ul style="list-style-type: none"> <li>• Avoid the use of spear pumps or other measures which might locally lower water tables.</li> <li>• Develop a management plan for the treatment of acid sulfate soils.</li> <li>• Potentially might require an acid sulfate soil treatment area.</li> </ul>

Constraint	Potential impact for construction-phase erosion and sediment control	Mitigation or management options
Sandy, acidic topsoils with low water-holding capacity.	Rehabilitation is likely to be difficult in such soils, with a high risk of revegetation failure without adequate amelioration.	<ul style="list-style-type: none"> <li>• Rehabilitation will need to include plants capable of thriving in such soil conditions.</li> <li>• Ameliorate soils prior to rehabilitation.</li> <li>• Rehabilitation areas on sandy soils will most likely require frequent watering and an addition of organic matter (compost) to improve soil structure and waterholding capacity.</li> <li>• Acidic soils would benefit from the addition of lime to aid growing conditions for grasses, unless well-adapted species were selected.</li> <li>• Use ameliorants or soil conditioners to help retain moisture in soils.</li> <li>• Select vegetation species that are adapted to variable rainfall conditions.</li> </ul>
Highly erodible soils	Risk of erosion from rainfall and from runoff, especially on steep slopes.	<ul style="list-style-type: none"> <li>• Develop an erosion and sediment control plan (ESCP) for the works.</li> <li>• Employ the services of a qualified soil conservationist during construction to assist with the design and implementation of erosion and sediment control measures.</li> <li>• Adopt a focus on minimising erosion from steep slopes by using temporary ground covers whenever rain is falling or imminent.</li> </ul>
	Risk of sediment pollution in local waterways.	<ul style="list-style-type: none"> <li>• Employ sediment controls such as basins as backup controls for any sediment-laden runoff from construction areas.</li> </ul>
Weak soil structure, with potential for dust generation.	Topsoils are likely to become hard-set and poorly structured as a result of stripping and stockpiling activities. This could impact on successful rehabilitation.	<ul style="list-style-type: none"> <li>• Ameliorate soils prior to stripping to improve structure.</li> <li>• Employ construction practices that minimise damage to topsoils (e.g. avoid excessive compaction, avoid working soils when too wet or too dry).</li> </ul>
	Dust could be generated during earthworks.	<ul style="list-style-type: none"> <li>• Use water application to reduce dust.</li> <li>• Use temporary ground covers on stockpiles and unsealed access roads.</li> <li>• Monitor dust generation.</li> <li>• Monitor weather forecasts for high winds.</li> </ul>



Constraint	Potential impact for construction-phase erosion and sediment control	Mitigation or management options
Dispersible soils	Risk of soils mobilizing when wet, creating highly turbid runoff.	<ul style="list-style-type: none"> <li>• Water treatment (coagulation or flocculation) might be necessary to achieve the required water quality prior to dewatering of sediment basins, traps, excavations or trenches.</li> <li>• Use permanent and temporary erosion control (i.e. ground cover) to limit exposure of dispersible soils during rainfall.</li> </ul>
	Risk of tunneling around built structures or under drains due to dispersible soils.	<ul style="list-style-type: none"> <li>• Ensure that final landform has at least 300mm of non-dispersible soil cover over any dispersible layers.</li> <li>• Ameliorate soils with gypsum to address dispersion around culverts, headwalls, pipes, drains, gutters etc.</li> </ul>
Low fertility soils	Impacts on revegetation success.	<ul style="list-style-type: none"> <li>• Use fertilizers to add organic matter (compost) and improve soil nutrients.</li> <li>• Use a compost blanket for rehabilitation of batters.</li> </ul>
<b>Climatic Constraints</b>		
High winds	As a coastal area, it is prone to high winds at any time of year. This can lead to dust rise from exposed construction areas.	<ul style="list-style-type: none"> <li>• Use water application to reduce dust.</li> <li>• Use temporary ground covers on stockpiles and unsealed access roads.</li> <li>• Monitor dust generation.</li> <li>• Monitor weather forecasts for high winds.</li> </ul>
Variable rainfall	Risk of dry spells which could cause revegetation failures.	<ul style="list-style-type: none"> <li>• Use water carts or irrigation to promote growth of new revegetation.</li> <li>• Use ameliorants or soil conditioners to help retain moisture in soils.</li> <li>• Select vegetation species that are adapted to variable rainfall conditions.</li> </ul>
Variable temperatures	Summer vs winter temperatures could influence revegetation success or failure.	<ul style="list-style-type: none"> <li>• Select vegetation species that are appropriate to the time of year that sowing/planting will occur.</li> <li>• Select vegetation species that are adapted to the local climate.</li> <li>• Preferably plant from tubestock rather than seed.</li> </ul>

## 6 RECOMMENDATIONS

Recommendations for management of the constraints identified in Section 3 are detailed in Table 7. Note that the recommendations in Table 7 are not in priority order.

Table 7 Recommendations for Erosion and Sediment Control

Item No.	Recommendation	Reasoning
<b>General</b>		
1	An erosion and sediment control plan (ESCP) should be prepared prior to commencing construction, in accordance with the NSW Blue Book. Figure 5 provides a concept ESCP and should be used as the basis for the construction-stage ESCP.	<p>To meet Blue Book (Landcom, 2004 and DECC, 2008) requirements for planning of erosion and sediment controls.</p> <p>To ensure sufficient resources and space are allocated to erosion and sediment controls.</p> <p>To ensure that erosion and sediment controls are adequately considered as part of construction planning.</p>
2	A soil conservationist should be engaged by the contractor for the duration of construction. The soil conservationist should provide input into the ESCP and conduct regular site inspections during construction to assess compliance and provide advice on best practice.	<p>To meet Roads and Maritime environmental requirements for high risk projects.</p> <p>To ensure adequate input from a specialist in erosion and sediment control.</p>
3	Erosion and sediment control training should be provided for construction personnel.	To ensure all construction personnel are aware of their environmental obligations and how to correctly install and maintain erosion and sediment controls.
4	<p>Adopt appropriate limits for water quality for discharge waters from sediment basins. Blue Book (Landcom, 2004) recommends:</p> <ul style="list-style-type: none"> <li>• no more than 50mg/L suspended sediment;</li> <li>• pH 6.5 to 8.5; and</li> <li>• &lt;10mg/L and none visible for oils or greases</li> <li>• no visible wastes.</li> </ul>	To protect sensitive receiving environments such as SEPP14 coastal wetlands.
<b>Design Considerations</b>		
5	<p>Wherever possible, batter gradients and benches should be designed to take into account Blue Book recommendations – refer to Section 4.2 in this report for details. However, these are not necessary if:</p> <ul style="list-style-type: none"> <li>• Reliable rehabilitation techniques such as compost blankets were used; and/or</li> <li>• Irrigation was provided, especially on north or north-west facing batters.</li> </ul>	To aid with slope stability and rehabilitation of batters.

Item No.	Recommendation	Reasoning
6	Sufficient space should be provided off-alignment for constructing sediment basins. Refer to Figure 5 for a concept ESCP showing likely locations for sediment basins.	To catch sediment from earthworks and protect sensitive receiving environments such as SEPP14 coastal wetlands. Additionally, providing space for basins off-alignment means they can be used effectively during fill placement and don't impede efficient construction.  To ensure that ecological impacts of constructing basins are addressed during the planning phase of the proposal.
7	Identify suitable locations for stockpiling outside of river flat and flood-prone lands. Some suggestions include (but are not limited to): <ul style="list-style-type: none"> <li>• The reserve east of the highway near chainage 8040 (i.e. near the eastern end of the study area).</li> <li>• The flat area north of the new fill near chainage 8660 (although flood risk should be considered at this location).</li> <li>• Adjacent to Thule Rd, south of the existing highway near chainage 8680 (although flood risk should be considered at this location).</li> </ul>	To ensure suitable land is available for temporary stockpiling of materials away from high risk areas.
<b>Staging and Scheduling of Works</b>		
8	Works in the flood zone should ideally occur during the period 1 June to 15 November (as much as possible).	To meet the Blue Book (Landcom, 2004) requirement for High Erosion Hazard lands in a flood zone.
9	Culvert extensions or replacements should occur early, preferably prior to bulk earthworks. Refer also to the section on Drainage Management in this table.	To allow for the passage of clean offsite water from upslope under the road alignment during earthworks.
10	Works on the large cut batters on the eastern approach should ideally occur during the period 1 April to 31 January (as much as possible). If this is not possible, refer to Item 12 for alternatives.	To meet the Blue Book (Landcom, 2004) requirement for High Erosion Hazard lands.
<b>Erosion Controls</b>		
11	Stage the earthworks on steep batters. Refer to Figure 6 for conceptual details.	To minimise the risk of erosion, reduce sediment loads in runoff, and ensure adequate clean and dirty water separation
12	Temporary ground cover such as geofabric, biodegradable polymer or similar should be used on cut and fill batters in any catchment not protected by a sediment basin whenever rain is imminent.	To minimise the generation of sediment from earthworks and protect sensitive receiving environments such as SEPP14 coastal wetlands.
13	Use water carts and/or biodegradable dust control agents on exposed surfaces during hot, windy weather.	To minimise fugitive dust during construction.

Item No.	Recommendation	Reasoning
14	Cover stockpiles within 10 days of formation.	To minimise the generation of sediment from stockpiles and protect sensitive receiving environments such as SEPP14 coastal wetlands.
<b>Drainage Management</b>		
15	The existing culvert near chainage 8620 will need to be extended to the north-east early in the construction program.	To allow for the passage of clean offsite water under the new alignment during fill placement.
16	If they are not replaced, existing culverts at chainages 8250, 8560, 9280 and 9480 might need to be extended to allow for the wider road footprint. Extension of these culverts should occur early in the construction program.	To allow for the passage of clean offsite water from upslope under the road alignment during fill placement.
17	Existing SO gutters through the cut batters on the eastern approach will need to be maintained during construction, or alternative lined drainage provided. These drains will carry road runoff and also dirty onsite water from the works on the cut batters. They will discharge either into the sediment sumps at chainage 8550 (see Item 22 below) or into the sediment basins (see Item 21 below).	To ensure drainage of dirty onsite water to sediment controls during construction.
18	The existing culvert near chainage 9080 will need to be diverted or realigned. This should occur early in the construction program.	To allow for construction of the retaining wall near Abutment A and for filling works in that area.
19	During fill placement east of the river, temporary drainage will be required in the form of earth windrows and batters chutes. Refer to Figure 7 for conceptual details.	To allow for drainage off fills into sediment basins, minimise erosion and minimise the risk of fills scouring.
<b>Sediment Controls</b>		
20	A floating silt curtain will be required during piling and earth works in the inter-tidal zone or in shallow waters near the river banks. Refer to Appendix 1 for guidance on curtain types, installation and maintenance.	To contain potential sediment plumes.
21	Sediment basins will be required. Figure 5 shows potential locations, although not all of these might be necessary, depending on construction staging and methodology.	To catch sediment from earthworks and protect sensitive receiving environments such as SEPP14 coastal wetlands.
22	Sediment sumps will be required around chainage 8550 on both sides of the alignment. These will discharge into an existing culvert at chainage 8560.	To catch sediment from cut batter works between chainage 8250 and 8550.
23	Sediment basins and sumps should be designed to manage dispersible soils, and include a regime for flocculation of sediment prior to discharge.	To address the potential for dispersible soils to produce highly turbid runoff into sensitive receiving environments including SEPP14 coastal wetlands.
24	Sediment basins should be designed for the 5-day, 85 <sup>th</sup> percentile rainfall event (37.4mm for nearby Batemans Bay).	To address the potential for dispersible soils to produce highly turbid runoff into sensitive receiving environments.

Item No.	Recommendation	Reasoning
25	Use shakers, rumble grids or washdowns where construction traffic exits onto live traffic roads.	To minimise the risk of sediment tracking offsite, help promote safer traffic management (avoids muddy, slippery roads) and help minimise the spread of weeds.
<b>Rehabilitation and Soil Management</b>		
26	<p>For rehabilitation, select vegetation species and seed mixes that are:</p> <ul style="list-style-type: none"> <li>• appropriate to the time of year that sowing/planting will occur; and</li> <li>• adaptable to the local climate.</li> </ul> <p>Preferably plant from tubestock rather than seed.</p>	To reduce the risk of rehabilitation failures due to climatic and soil factors.
27	Use compost blankets for rehabilitation of north and north-west facing batters.	To reduce the risk of rehabilitation failures due to climatic and soil factors, and to reduce the need for benching of batters.
28	Use water carts or fixed irrigation to water newly rehabilitated areas until established. This is particularly required for rehabilitation of north and north-west facing batters.	To reduce the risk of rehabilitation failures due to lack of natural rainfall.
29	Ameliorate and fertilize topsoils prior to stripping (if possible) to address problems of acidity, poor structure and low fertility.	To reduce the risk of rehabilitation failures due to soil-related factors.
30	Develop a plan for the management and treatment of Acid Sulfate Soils.	<p>To reduce the risk of environmental harm from acid leachate or runoff during construction.</p> <p>To reduce the risk of acid-generating material being transported offsite without adequate treatment.</p>
31	Avoid excessive compaction of topsoils and avoid working topsoils when too wet or too dry.	To reduce the risk of damaging topsoil structure and pore voids.
32	Blend gypsum into soils under and around drainage structures, culverts and earth bunds.	To reduce the risk of tunneling failure in dispersible soils.

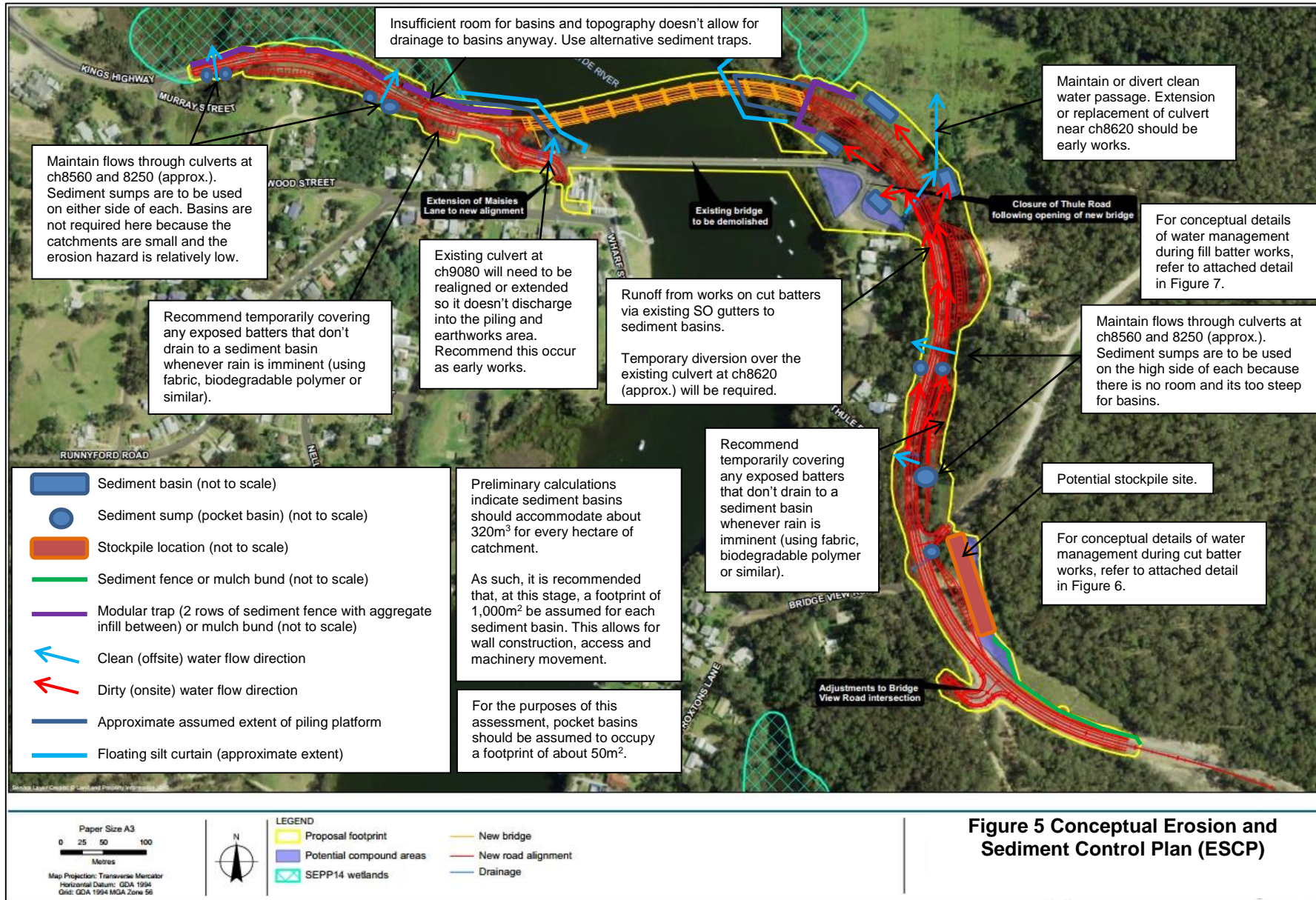


Figure 5 Conceptual Erosion and Sediment Control Plan (ESCP)

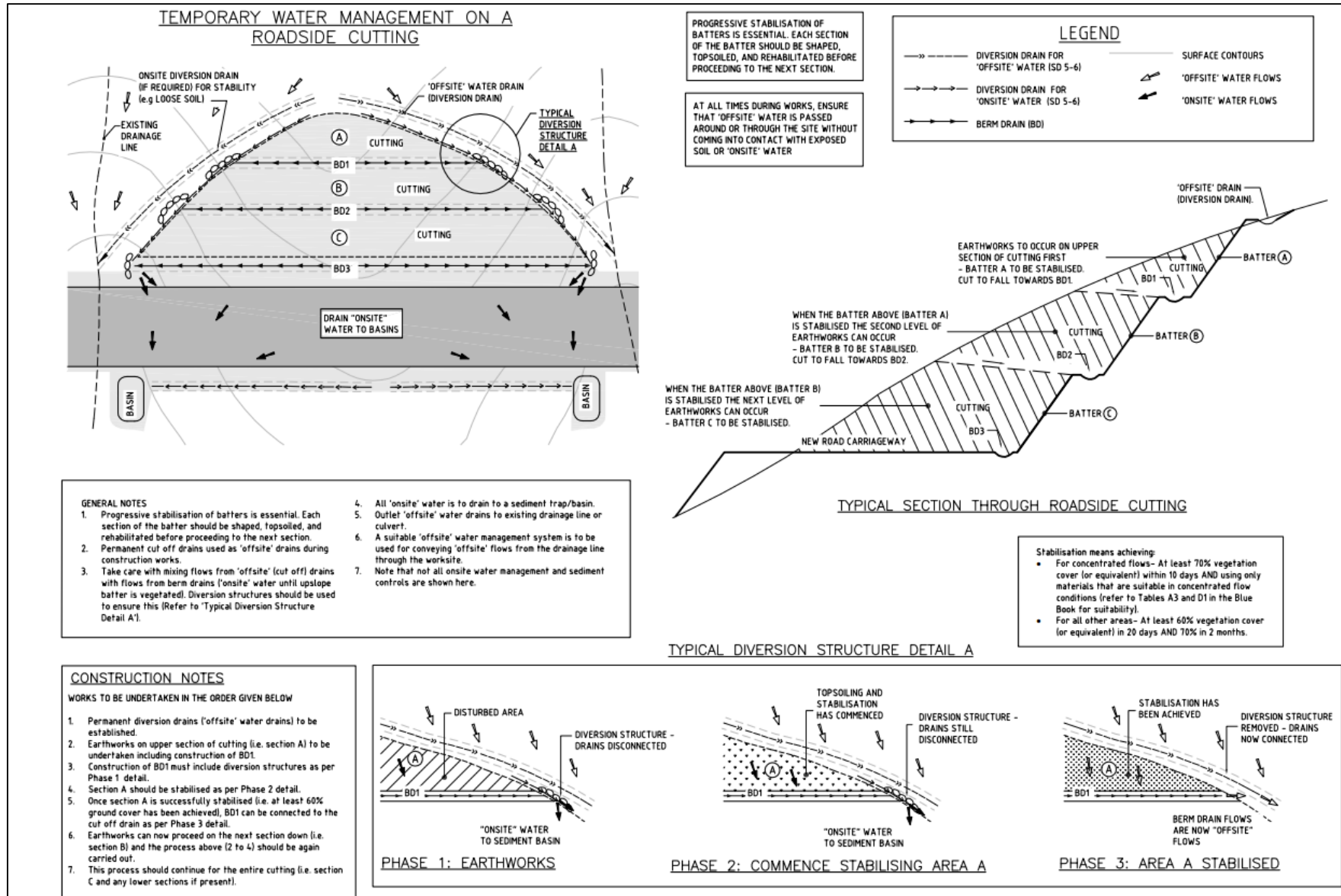


Figure 6 Conceptual details for managing drainage from cut batters, plus progressive rehabilitation as works proceed.

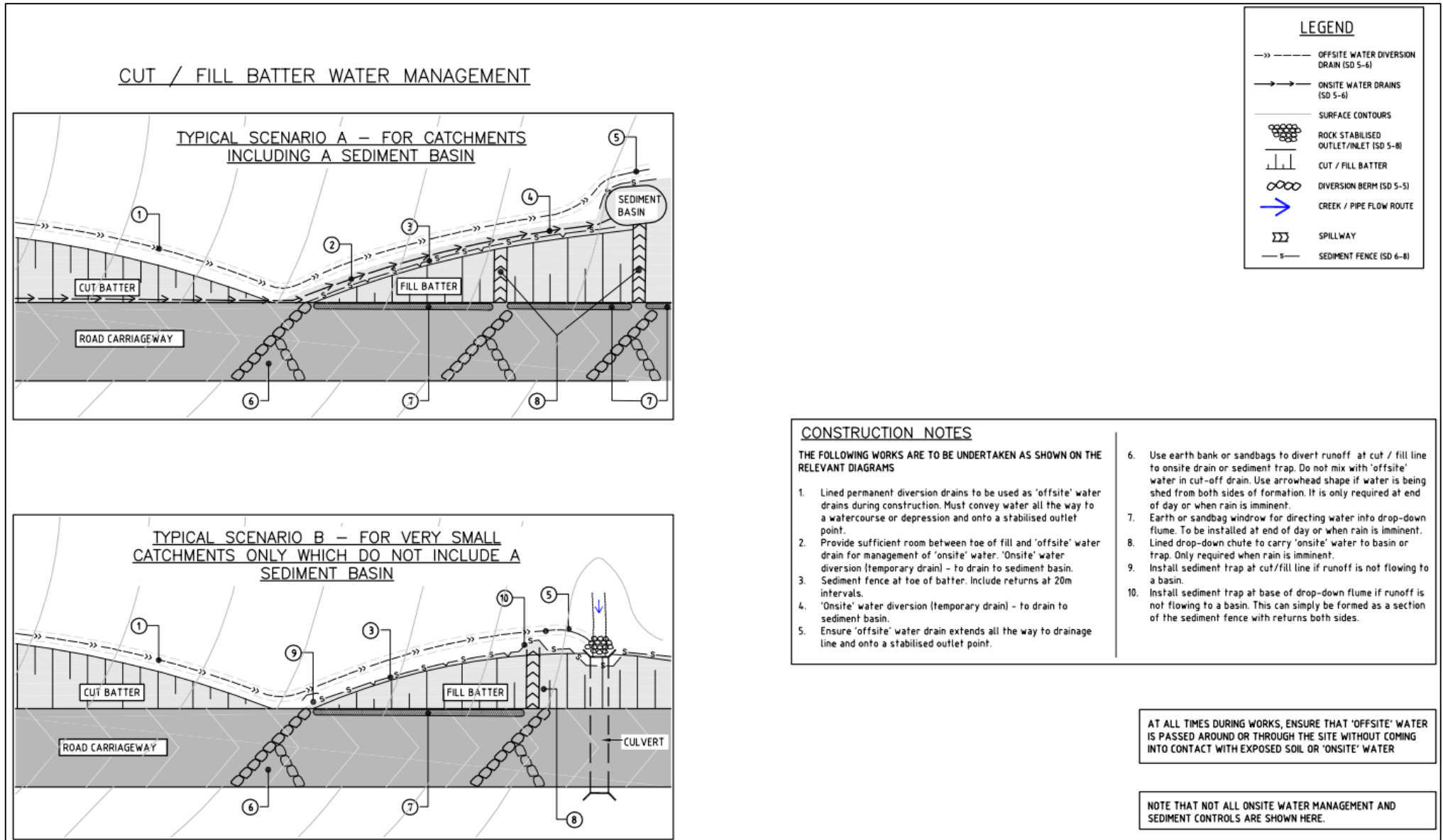


Figure 7 Conceptual details for drainage from fill batters.



## 7 CONCLUSION

NSW Roads and Maritime Services (Roads and Maritime) proposes to construct a new bridge over the Clyde River at Nelligen.

The purpose of this report is to determine management issues for construction-phase erosion and sediment control.

- Section 3 identifies potential constraints to construction-phase erosion and sediment control;
- Section 4 identifies design considerations for erosion and sediment control measures;
- Section 5 summarises options for addressing potential impacts and constraints;
- Section 6 summarises a series of recommendations to manage potential impacts.

Providing the recommendations in Section 6 of this report are adopted in the design and during construction, the risk of pollution from erosion and subsequent sediment runoff can be minimised, in accordance with recognised best-practice in NSW. Section 6 includes a conceptual ESCP showing the setup of key erosion and sediment control measures such as sediment basins (Figure 5).

The recommendations in Section 6 are not considered to be beyond the scope of the expected erosion and sediment control practice for a major road project in a sensitive environment such as this. However, successful environmental management will rely on adequate experience of the contractor and adequate oversight from Roads and Maritime environmental staff. The use of a soil conservationist is recommended during construction due to the inherent risk of erosion, challenging soil conditions and project complexity.

## 8 REFERENCES

DECC (2008). *Managing Urban Stormwater: Soils and Construction. Volume 2D: Main Road Construction*. Department of Environment and Climate Change, Sydney.

GHD (2016). *Nelligen Bridge Flooding and Operational Water Quality Technical Specialist Study*.

IECA (2008). *Best Practice Erosion and Sediment Control*. International Erosion Control Association (Australasia). Picton, NSW.

Landcom (2004). *Managing Urban Stormwater: Soils and Construction. Volume 1*. NSW Government, Sydney.

URS (2014). *Nelligen Bridge: Preliminary Environmental Investigation*. September 2014.

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## 9 APPENDICES

### 9.1 Appendix 1: Silt Curtains

The following Fact Sheet is by Catchments and Creeks Pty Ltd and has been reproduced from IECA (2008).

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# Floating Silt Curtains

## INSTREAM PRACTICES

Flow Control	✓	No Channel Flow	✓	Dry Channels	
Erosion Control		Low Channel Flows	✓	Shallow Water	
Sediment Control		High Channel Flows	✓	Deep Water	✓

Symbol  FSC



**Photo 1 – Silt curtain used as an isolation barrier**



**Photo 2 – Sheet piling used to form a dry work area with a floating silt curtain used as a sediment containment system**

### Key Principles

1. A floating silt curtain is not a filtration system or an instream sediment fence.
2. Instream sediment control is achieved by isolating sediment-laden waters from passing stream flows, thus allowing sedimentation of disturbed waters within the enclosed area.
3. The placement of silt curtains within tidal waters is complex and requires careful planning and design. Inappropriate design can result in unnecessary sediment releases.

### Pre-Design Data Collection

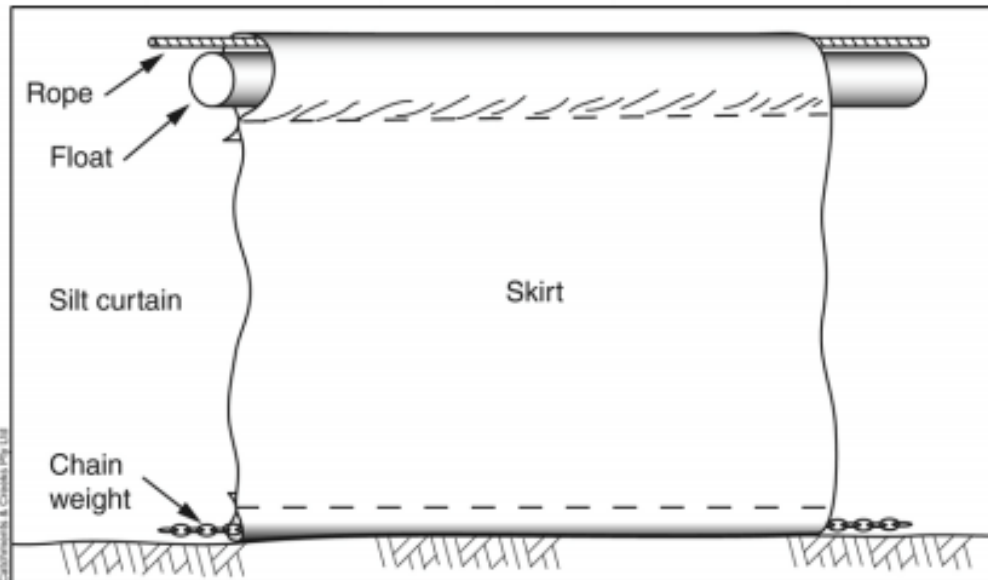
Observations to be made during the initial site inspection include:

- Suitable anchor points for the silt curtain both instream and along the bank.
- Location of launching and retrieving points for the barrier. This may involve the use of a boat, truck, winch, launch ramp, or crane.
- Identification of the overbank catchment area likely to contribute stormwater runoff into the isolation area, and potential options for managing this lateral inflow.
- Location of any stormwater outlets discharging near the work area. It is not recommended for flow diversion barriers to enclose stormwater outlets unless appropriate design measures are taken to account for the inflows generated by the outlets.
- Indication of tidal range (if data is not already available within tide charts).
- Ascertain the channel profile and water depths (if not already available from marine survey).
- Estimate channel discharge and stream velocity. Stream velocity will likely vary across the channel, so as a minimum, estimate the flow velocity at 1/4, 1/2 and 3/4 channel width.
- Ascertain typical wave heights, including waves generated by boat traffic.
- Identify any protected or 'non-disturbance' areas.
- Collect pre-disturbance water quality data.

**Design Information**

*The design information provided below is a general guide. Manufacturers and distributors of silt curtains may provide their own design guidelines and specifications.*

Silt curtains are normally manufactured for a specific installation, thus dimensional information (e.g. length and fall height) must be obtained prior to ordering the curtain.



**Figure 1 – Typical features of a floating silt curtain**

The depth of the barrier should be approximately 10% greater than the water depth to ensure it rests on the channel bed. The barrier, however, should not be so deep as to form large pleats along the bottom of the fabric where sediment may collect causing the barrier to be pulled under the water surface.

The length of the barrier should be 10-20% longer than the measured length of the proposed enclosure to reduce the stresses on the barrier and allow for necessary adjustments during its installation.

**Curtain fabric:**

Silt curtains are **not** manufactured from sediment fence fabric. Instead the material consists of a woven geotextile, canvas/tarp material, or a commercially available silt curtain such as nylon reinforced polyvinyl chloride (PVC) or equivalent.

Table 1 provides the suggested material properties for a floating silt curtain.

**Ballast chain:**

Sew or heat-seal a galvanised chain into the base of the curtain. Alternatively, attach weights to the bottom edge of the curtain at a maximum spacing of 1.5m. The individual weights must provide at least the equivalent total weight per unit length as specified for a ballast chain.

Specifications for the ballast chain/weights are provided in Table 1

**Load line (tie rope):**

In still water, no load line other than the fabric itself will be necessary. Place a rope in the sleeve with the flotation units and attach the anchors to it. Do not directly attach an anchor to the fabric.

Specifications for the ballast chain/weights are provided in Table 1

Table 1 – Suggested material property for floating silt curtain

Material property	Test method	Typical value	Units
<b>Skirt fabric:</b>			
Grab tensile strength		900	N
Pore size (EOS) ( $O_{95}$ )	AS 3706.7	0.21	mm
UV resistance	AS 3706.11	Required	
Panel lengths		30m for depths less than 4m	m
		15m for depths greater than 4m	m
<b>Ballast chain:</b>			
Galvanised		Yes	
Typical size	velocity < 0.15m/s	10	mm
	velocity > 0.15m/s	13	mm
Required weight	velocity < 0.15m/s	1.9	kg/m
	velocity > 0.15m/s	3.3	kg/m
<b>Land anchor:</b>			
Timber post (min)	diameter	100	mm
<b>Marine anchors:</b>			
Firm mud bed	Mushroom anchor	34	kg
	Danforth anchor	5	kg
Sandy bed	Danforth anchor	5	kg
Tie rope	velocity < 0.15m/s	10	mm
	velocity > 0.15m/s	13	mm
Connecting chain	length	3	m
	size	8	mm

**Location:**

The most effective placement methods for a floating silt curtain are:

- a semicircle or U-shape configuration around the disturbance (Figure 2);
- a circle or elliptical shape encircling the disturbance (Figure 3).

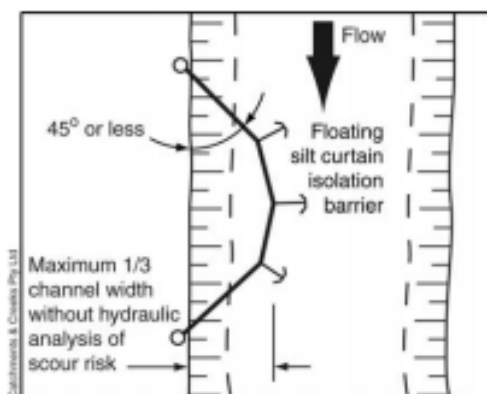


Figure 2 – Installation of a silt curtain around a bank disturbance

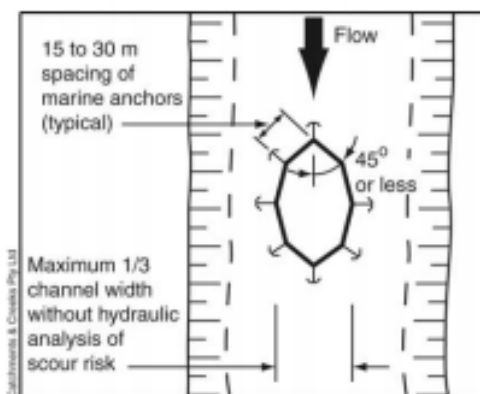


Figure 3 – Installation of a silt curtain around a mid-channel disturbance

Ideally, avoid isolating more than 30% of the effective channel width during periods when stream flows are possible. However, if appropriate hydraulic analysis is performed on the adverse effects of potential stream velocity increases, then it may be possible to isolate a larger proportion of the channel width.

It is generally **not** recommended for a silt curtain to be placed across the full width of a watercourse channel. The full-width installation shown in Photo 2 is only possible because this particular channel reach is located near the upstream limit of the tidal channel, thus only minor channel flows are expected.

The 'effective' stream width does not include backwater areas, i.e. those areas that do not significantly contribute to the conveyance of stream or flood flows.

**Mooring:**

All silt curtains should be adequately anchored to prevent their displacement by stream flow.

The landward anchor may consist of a secure post, buried anchor, large diameter tree, or other immovable object (Figure 4).

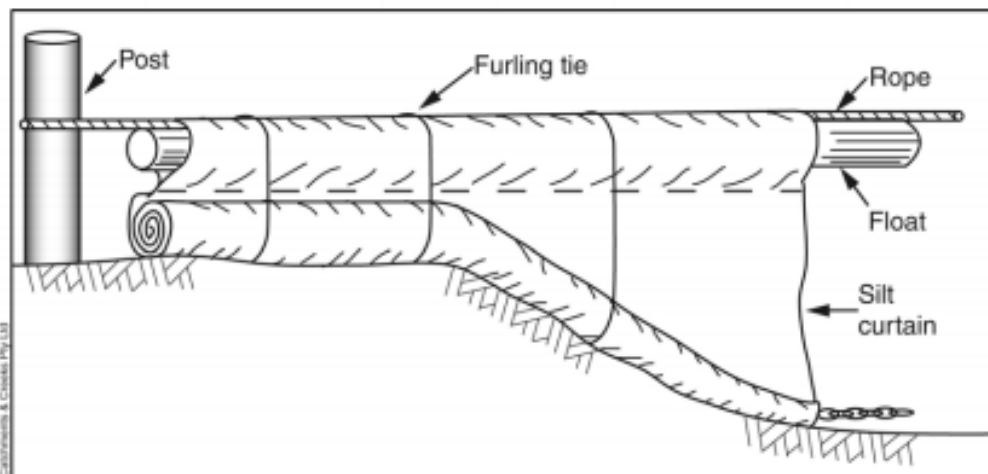


Figure 4 – Mooring of Silt Curtain to anchor post on stream bank

Secure the rest of the silt curtain to marine piles or marine anchors consisting of an anchor, chain, anchor rope, mooring and identification buoy (Figure 5). An alternative to a marine anchor is to drive piles into the channel bed; however, this anchoring method should be considered only as a last resort.

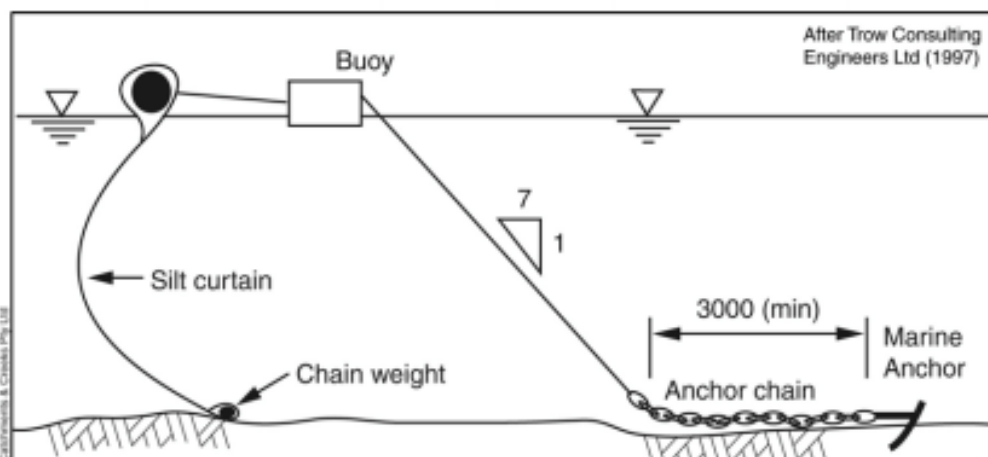


Figure 5 – Typical marine anchorage system

The silt curtain should be anchored at the junction of each panel section, but at least every 30m for depths up to 4m, and every 15m for depths exceeding 4m.

To reduce pressure on the curtain, slant the silt curtain at an angle to the stream flow. If the curtain will be exposed to reversing currents (tidal areas), anchor it on both sides.

The chain attached between the end of the anchor line and the anchor has three purposes:

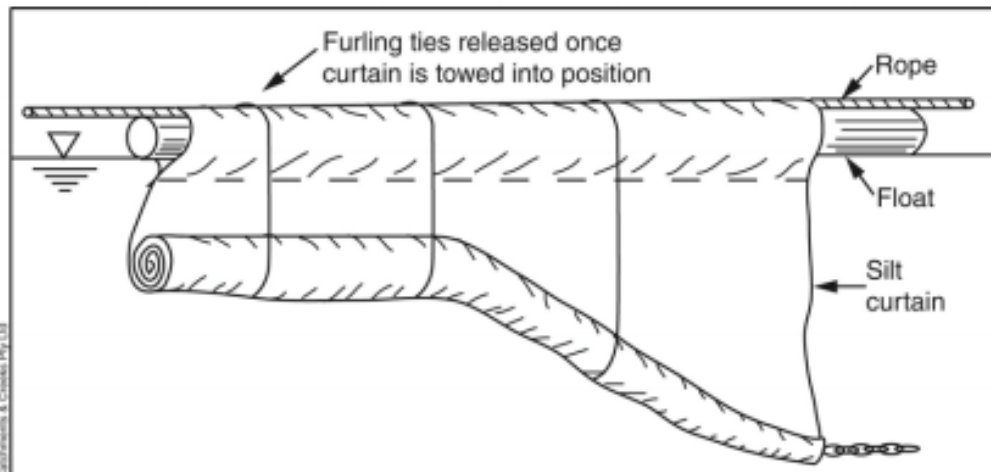
- to prevent fouling (damage) of the anchor line or rope;
- to lower the angle of pull at the anchor;
- to act as a shock absorber.

In trafficable waterways, the anchor should be accompanied with a buoy—generally 300mm diameter—to warn daytime boat traffic. The enclosure should also be marked with warning lights or navigational markers if there is expected to be night time boat traffic.

If piles are used, then do not attach the floating barrier directly to the piles as this may cause chafing of the barrier against the supports.

#### **Deployment of a floating silt curtain:**

Prior to deploying the silt curtain, gather up the fabric and tie it with lightweight straps or rope every 1 to 1.5m (Figure 6). This will enable the curtain to be set in place easily without the weights being dragged along the channel bed.



**Figure 6 – Furling of skirt for deployment and/or recovery of silt curtain**

#### **Installation within tidal waters:**

Critical to the design of silt curtain installations within tidal waters is the determination of the ideal location of the curtain. If located too close to the shoreline, sediment-laden waters will spill out of the enclosure during the falling tide. If located too far from the shoreline, the size and thus cost of the curtain can be excessive.

First priority should be to design of the installation such that the enclosed water volume at high tide is equal to the enclosed volume at low tide. If this can be achieved, then sediment-laden waters can remain trapped inside the enclosure until a suitable water quality is achieved that would allow removal of the curtain.

There are two design options for a 'no release' enclosure. Firstly the silt curtain can be sized such that it is near vertical during the highest expected tide (Figure 7). As per normal design requirements, the specified 'fall' of the skirt should be at least 10% greater than the maximum water depth at the chosen location of the curtain. The key design task is to locate the curtain such that the curtain can contain the same volume of water at low and high tide (Figure 8). This design option should result in the smallest curtain size, and therefore the cheapest curtain; however, in reality this design option is often the most difficult to achieve.



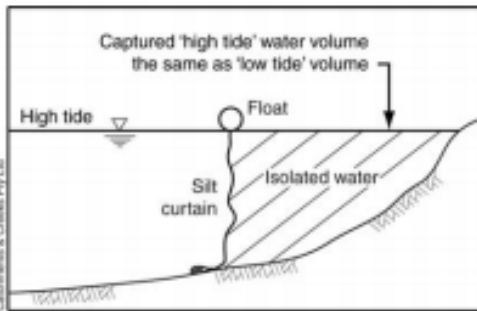


Figure 7 – Near vertical curtain at high tide

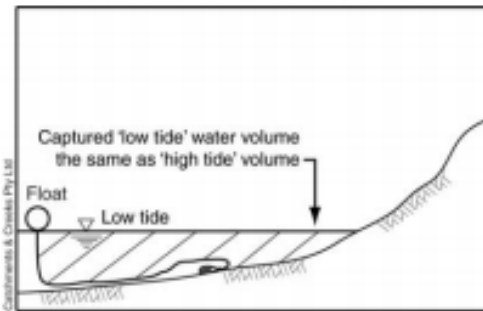


Figure 8 – Same curtain (left) at low tide

The second design option for a 'no release' enclosure is to allow the curtain to pull towards the shoreline at high tide (Figure 9). Again, the specified 'fall' of the skirt should be at least 10% greater than the maximum skirt length (measured in the vertical plane). The curtain must be located such that there will be no movement of the weighted bottom of the skirt throughout the tidal cycle.

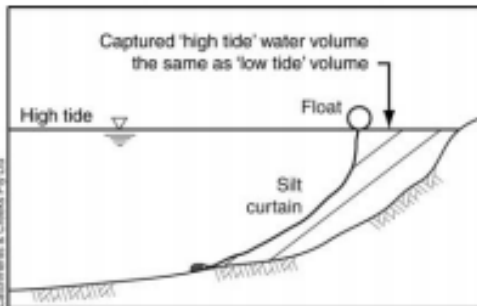


Figure 9 – Second design option at high tide

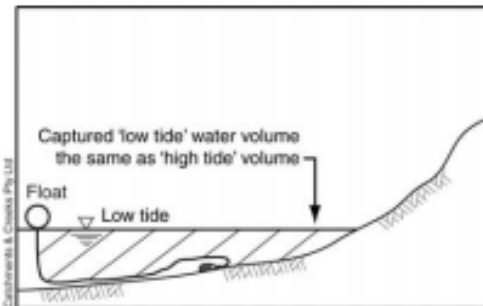


Figure 10 – Same curtain (left) at low tide

If it is not practicable to locate the silt curtain such that there will be no exchange of water during the tidal cycle, then various alternative (less desirable) design options exist. These design options include 'short' silt curtains that are elevated above the riverbed (Figures 11 & 12), and the manufacture of silt curtains with flow exchange windows or flaps. The latter option allows the use of flexible, one-way flow control flaps that encourage inflow into the enclosure towards the top of the curtain (i.e. during the flood tide), and the release of sediment-laden water through separate flaps located closer to the riverbed.

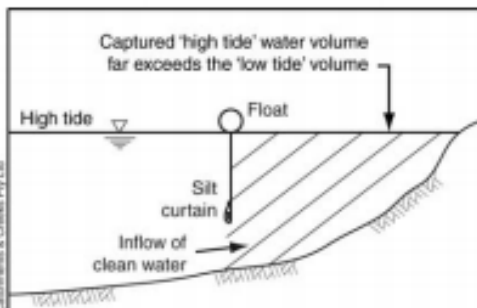


Figure 11 – 'Short' curtain at high tide

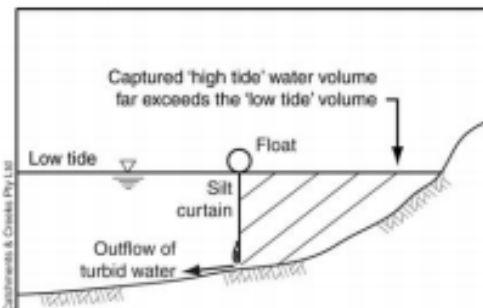


Figure 12 – Same curtain (left) at low tide

The principle reference document for this fact sheet is:  
 Trow Consulting Engineers Ltd, 1997. *Instream sediment control techniques field implementation manual*. Ontario Ministry of Natural Resources, Northeast Sciences & Technology. Nest Field Guide FG-007, Ontario, Canada, ISBN 0-7778-4772-8

### Description

A geotextile fabric of low permeability suspended vertically from the top of the water surface and used to separate areas of contaminated and uncontaminated water.

Floating silt curtains normally consists of the following components:

- geotextile filter fabric
- flotation units secured along the top
- anchor weights secured along the bottom
- load lines secured along the top
- anchor or mooring cables

### Purpose

Used to isolate a section of enclosed 'still' water from passing stream flows, thus allowing sediment-laden water generated from construction activities to be isolated from the main channel.

Usually used in waters at least 0.8m deep such as a stream, river, lake or estuary.

Typical uses include flow isolation during the installation and maintenance of boat ramps and stormwater outlets, and the construction of waterway crossings.

### Limitations

Specialist advice is required if placed in waters with a flow velocity exceeding 0.15m/s.

Water depth at least 0.8m.

Typically limited to a wave height less than 150mm, or greater than 150mm but less than 5% of water depth.

In all but exceptional circumstances, silt curtains should not be placed across the full width of a flowing stream, channel or waterway.

Avoid blocking more than 50% of a channel width at any given point in time.

### Advantages

Can be effective in controlling turbidity in saline waters.

Generally the most effective sediment barrier in deepwater environments.

### Disadvantages

Sediment that has settled on the bed of the isolation area can be resuspended and enter the water column once the silt curtain is removed.

Can be damaged by waves and fast flowing water.

Time consuming to install and remove.

Easily vandalised.

May cause a hazard to watercraft.

### Special Requirements

Wherever practicable, the bottom of the silt curtain must be anchored to the bed of the water body to prevent sediment-laden water passing under the fabric.

Generally anchored in a U-shape around the channel disturbance.

### Location

Generally used as an isolation barrier running mostly parallel to the stream flow.

The curtain should **not** be located across the full width of a flowing stream.

### Site Inspection

Check for turbid plumes outside the silt curtain.

Check for damage to the anchorage system.

### Materials

- Silt curtain fabric: manufactured from a woven geotextile, canvas/tarp material, or a commercially available silt curtain such as nylon reinforced polyvinyl chloride (PVC) or equivalent.
- Ballast chain: 10 to 13mm galvanised chain with minimum 1.9 to 3.3kg/m weight.
- Land anchor: minimum 100mm diameter timber post (or equivalent).
- Marine anchor: minimum 5kg lightweight (Danforth) type anchor with 10 to 13mm nylon tie rope and minimum 3m length of 8mm galvanised connecting chain.

**Installation**

*Installation procedures should be provided by the product manufacturer or distributor. A typical installation procedure is described below, but should be confirmed with the product manufacturer or distributor.*

1. Prior to commencing any works, obtain all necessary approvals and permits required to conduct the necessary works including permits for the disturbance of riparian and aquatic vegetation, and the construction of all permanent or temporary instream barriers and instream sediment control measures.
2. Prior to the installation, check weather reports for a suitable windless, calm day. Do not proceed with the installation unless safe to do so.
3. Refer to approved plans for location and dimensional 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.
4. Clear the immediate launching area of rock and debris. Avoid disturbing groundcover vegetation.
5. Layout a plastic launching pad (spillway) at right angles to the watercourse bank and peg or anchor it down. This is to protect the curtain and reduce friction when launching.
6. Unfold the curtain in an open area prior to its installation. Ensure the barrier is fabricated with sufficient dimensions to be in good contact with the bottom of the channel. The depth of the barrier should be approximately 10% greater than the water depth to ensure it rests on the bed.
7. Ideally, the length of the barrier is 10 to 20% longer than the measured length of the proposed enclosure.
8. Unfold the first curtain panel on the slipway.
9. Insert the floats both ends for ease of installation.
10. Pull through the steel chain in the bottom sleeve using the draw cord.
11. Pull through the rope using the draw cord.
12. Prior to deploying the barrier, gather up the curtain and tie the curtain with lightweight straps or rope every 1 to 1.5m. The aim of this is to enable the curtain to be set in place in the water easily without the curtain being dragged along the channel bed.
13. Set the upstream bank anchor point and tie off one end of the barrier, ensuring no water will be able to flow into the upstream end.
14. Deploy the barrier from the end of a boat. Fasten the free end of the barrier to the downstream anchor point, then anchor the barrier at intermediate points.
15. Taper the ends of the barrier to the shape of the shoreline, otherwise tie the ends of the barrier with furling straps so the depth of the barrier can be adjusted to the shape of the bank.
16. After the barrier has been anchored, check to see that the skirt is not twisted around the flotation units. When the barrier is properly deployed, cut the tie ropes and let the ballast weights sink to the bed.
17. Ensure the skirt (at maximum water level) is free of large pleats that may collect sediment causing the barrier to be pulled under the water surface.

**Alternative land-based installation procedure:**

1. Unfold the first curtain panel on the slipway.
2. Insert the floats both ends for ease of installation.
3. Pull through the steel chain in the bottom sleeve using the draw cord.
4. Pull through the rope using the draw cord.
5. Prior to deploying the barrier, gather up the curtain and tie the curtain with lightweight straps or rope every 1 to 1.5m. The aim of this is to enable the curtain to be set in place in the water easily without the weights being dragged along the bottom.
6. Set the upstream bank anchor point and tie off one end of the barrier, ensuring no water will be able to flow into the upstream end.
7. Install an extra length of rope or cable in the final curtain position in the water.

8. Tie the end of the curtain rope to the extra length already in position and pull the curtain into the water stopping when the end of the first section of curtain is still on the bank.
9. Unfold the second section of curtain on the slipway making sure the curtain is correctly orientated with the first section of curtain
10. Insert the floats, chain and rope as before.
11. Using the draw cord from the first section, tie up the ends using the eyelets already in the curtain.
12. Gather up the curtain and tie together with twine or thin rope.
13. Launch as before.
14. Continue until the entire curtain is installed.
15. Anchor well to shore anchors.
16. Using a suitable boat, move along the curtain and cut the ties holding the chain and curtain and allow the weighted end to sink.
17. Ensure the skirt (at maximum water level) is free of large pleats that may collect sediment causing the barrier to be pulled under the water surface.

#### Maintenance

1. Inspect the silt curtain daily for damage.
2. Ensure the top of the barrier remains above the water surface, and the curtain is free of tears or gaps.
3. Ensure the barrier remains in the specified location.
4. Check for turbidity leaks.
5. Check all anchor points.
6. Repair or replace any torn segments.
7. Check for sediment build-up on the bottom of the skirt that may begin to pull the curtain under the water.
8. Dispose of any excessive sediment or debris deposits in a manner that will not create an erosion or pollution hazard.
9. Repair any places in the isolation barrier that have weakened or that have been subjected to damage from inflows or overtopping water.

#### Removal

1. The silt curtain should be removed as soon as possible after it is no longer needed.
2. If excessive sediment or debris has collected around the barrier, then remove such material before the barrier is removed and dispose of such material properly.
3. Ensure the channel water contained within the enclosure has achieved a suitable water quality before removing the silt curtain.
4. Ensure the release of sediment and the damage to the channel's bed and banks is minimised during removal of the silt curtain.
5. If it is not feasible to wait for adequate settlement of suspended sediments, then where practicable, pump the sediment-laden water to an off-stream de-watering sediment control system for treatment. This treatment area should ideally be located at least 50m from the channel.
6. Remove all construction materials, excessive sediment deposits and debris and dispose of in a suitable manner that will not cause an erosion or pollution hazard.
7. Restore the watercourse channel to its original cross-section, and smooth and appropriately stabilise and/or revegetate all disturbed areas.