



Port Botany Expansion Penrhyn Estuary Habitat Enhancement Plan

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1 Introduction

Penrhyn Estuary was created as a result of the reclamation works associated with construction of the current Port Botany and Foreshore Road in the 1970s. The Estuary has formed in the protected area between the port to the south and Foreshore Beach to the north.

An estuarine ecosystem has developed in Penrhyn Estuary which includes an endangered saltmarsh community, mangroves and intertidal flats. The area has become locally important for shorebirds, as developments on the northern side of Botany Bay have made other habitats unsuitable.

Stormwater from upstream urban and industrial areas and groundwater from the Botany Aquifer enters the Estuary, primarily via Springvale and Floodvale Drains. The Estuary has been closed to fishing and shellfish collection since November 2004 for a period of five years, as a precautionary measure.

Seagrass meadows are present primarily outside the Estuary in the shallow waters off Foreshore Beach.

The Port Botany expansion will partially enclose Penrhyn Estuary (Figure 1). Habitat enhancement works will be undertaken within the Estuary to retain and enhance key ecological habitats.

This Plan, the Penrhyn Estuary Habitat Enhancement Plan (PEHEP), documents the habitat enhancement works to be undertaken within Penrhyn Estuary and the Penrhyn Estuary flushing channel. It has been prepared to satisfy:

- Conditions B2.31 and B2.30 of the 2005 NSW Department of Planning project approval (13/10/05);
- Condition A1.5 of the 2006 NSW Department of Planning project approval (22/8/06); and
- Condition 3 of the Commonwealth Department of Environment and Heritage project approval (as amended 08/12/06).

The information contained within this Plan prevails in the event of any inconsistency between this document and other planning documents prepared prior to this Plan, including the Port Botany Expansion EIS and Commission of Inquiry submissions.

Sydney Ports Corporation (Sydney Ports) is responsible for all aspects of the Penrhyn Estuary habitat enhancement works including construction, monitoring, reporting, long term management and maintenance and implementation of remedial and contingency measures.

1.1 Objectives

The key objectives of the Penrhyn Estuary habitat enhancement are to:

- expand the existing shorebird habitat, to continue to attract migratory shorebirds and potentially attract more shorebirds;
- create seagrass habitat;
- expand the area of saltmarsh habitat; and
- provide controlled public access and minimise disturbances within the Estuary.



 New Terminal Area

PORT BOTANY EXPANSION PROJECT
PENRHYN ESTUARY HABITAT ENHANCEMENT PLAN
FIGURE 1: LOCATION OF
PENRHYN ESTUARY AND
PORT BOTANY EXPANSION

1.2 Consent Conditions

This document is the Habitat Enhancement Plan required under the conditions of approval by the NSW and Commonwealth Governments as set out below.

NSW Department of Planning

Condition B2.31 of the Port Botany Expansion approval (13/10/05) requires that:

“B2.31 Prior to the commencement of enhancement works, the Applicant shall prepare a Penrhyn Estuary Habitat Enhancement Plan in consultation with Botany and Randwick Councils and the Community Consultative Committee, to be agreed between SPC, DEC, DPI (Fisheries), DNR and DOP. The plan is to include:

- *details of the proposed enhancement works, including design, staging and timing for completion of key tasks and timeframe for completion of works.*
- *staging to include definition of completion of Stage 1 for purposes of evaluation of success.*
- *details of success criteria for enhancement works, including measurement of impacts on bird numbers in accordance with a monitoring plan, levels and concentrations of food organisms required for bird, acceptable saltmarsh cover, use of existing environmental status as the benchmark for “no negative impact” together with comparison of relevant reference sites; agreement on time periods for determination of success.*
- *details of contingency plans for specific components for example, erosion of sand/mudflats.*
- *inclusion of Vegetation Management Plan, providing details of method for mangrove removal and control.*
- *inclusion of Marine Mammal Management Plan, prepared in consultation with DEC and DPI (Fisheries).*
- *details of management and monitoring requirements including management and monitoring of surface water quality and groundwater (in liaison with DEC.*
- *details of monitoring of extent, expansion and condition of estuary seagrass, including impact of turbidity, and required management responses.*
- *details of responsibilities for ongoing maintenance of estuary, including maintenance of Stormwater Quality Improvement Devices (SQIDS).*
- *any other requirements identified and agreed on between the Applicant and relevant agencies.*

The plan must be submitted and approved by the Director-General prior to the commencement of construction and all works undertaken to the satisfaction of the Director-General.”

This Plan satisfies condition B2.31.

Condition B2.30 of the Port Botany Expansion approval requires that:

“Prior to the commencement of construction, the Applicant must demonstrate to the satisfaction of the Director-General that the detailed terminal design will achieve predicted water quality outcomes in Penrhyn Estuary. Where appropriate, measures such as culverts, pipes or other water channelling devices shall be incorporated into the design to ensure enhanced flushing and maximum maintenance of water quality in Penrhyn Estuary.”

Condition A1.5 of the Port Expansion approval (22/8/06) requires that:

“Notwithstanding condition B2.30 the development consent granted by the Minister for Planning on 13 October 2005, the Applicant shall, prior to the commencement of construction of Stage 2 of the development, prepare and submit for the approval of the Director-General, a comprehensive Estuary Flushing Protocol to detail how the development has been designed and will be managed to optimise flushing of Penrhyn Estuary and to achieve satisfactory water quality outcomes. The Protocol shall detail specific design measures applied to the development, including measures such as culverts, pipes or other water channelling devices to ensure enhanced flushing. The Protocol shall also include a program to monitor water quality and flushing characteristics of the Estuary both pre- and post-construction, and a framework for the identification and implementation of remedial measures in the event that water quality outcomes are not achieved.”

The Estuary Flushing Protocol is summarised in Section 2.2.6 of this Plan and is provided in Appendix K. This Plan satisfies conditions B2.30 and A1.5.

Commonwealth Department of Environment and Heritage

The Commonwealth Department of Environment and Heritage consent (8/12/06) requires (Condition 3) that:

“The person taking the action must prepare and submit for the Minister’s approval a habitat enhancement plan for Penrhyn Estuary to manage impacts on listed migratory bird species during the construction and operation of the new port facilities at Port Botany. The plan must address the matters listed below and state the environmental objectives, performance criteria, monitoring, reporting, corrective action, responsibility and timing for each of these matters:

- *a detailed description of habitat enhancement works including methodology and staging of works*
- *habitat management and maintenance measures*
- *a habitat monitoring programme*
- *flushing of Penrhyn Estuary*
- *measures to detect and respond to issues identified in the habitat monitoring programme*
- *reporting requirements that include protocols to inform the Minister of relevant issues, milestones, and the results of surveys and studies*

The action must not commence until the plan has been approved. The approved plan must be implemented.”

This Plan satisfies Condition 3.

Response to Consent Requirements

Table 1 identifies where the requirements of the consent conditions are addressed in this Plan.

Table 1: Response to Consent Requirements

DoP (2005) Requirements	Section addressed
Consultation	1.3, Appendix A
Details including design, staging & timing and timeframe for completion	2.0, 4.0
Definition of Stage 1 for evaluation of success	4.0, 6.0
Details of success criteria including: <ul style="list-style-type: none"> - impacts on bird numbers - levels and concentrations of food organisms - acceptable saltmarsh cover - benchmark for “no negative impact” & reference sites - agreement on time periods for success. 	6.0 6.3, Appendix D 6.3.1 6.3.3 6.3, Appendices D - G 6.3
Details of contingency plans for specific components	7.0
Vegetation Management Plan including mangrove removal & control	Appendix B
Marine Mammal Management Plan in consultation with DEC and DPI	Appendix C
Details of management and monitoring requirements including surface and groundwater in liaison with DEC	3.0, 5.0, Appendices B – J
Monitoring of estuary seagrass including impact of turbidity and required management responses	Appendix G, Appendix H
Responsibilities for on-going maintenance of estuary including SQIDS	3.0
Any other requirements identified and agreed on between the Applicant and relevant agencies	Appendix A
Prior to the commencement of construction, the Applicant must demonstrate to the satisfaction of the Director-General that the detailed terminal design will achieve predicted water quality outcomes in Penrhyn Estuary. Where appropriate, measures such as culverts, pipes or other water channelling devices shall be incorporated into the design to ensure enhanced flushing and maximum maintenance of water quality in Penrhyn Estuary.	2.2.6, Appendix K
DoP (2006) Requirements	
Develop a comprehensive flushing protocol with monitoring program and remedial program	2.2.6, Appendix K
DEH Requirements	
Detailed description of habitat enhancement works including methodology and staging	2.0, 4.0
Habitat management and maintenance	3.0, Appendix B
Habitat monitoring program	5.0, Appendices D – J
Flushing of Penrhyn Estuary	2.2.6, Appendix K
Measures to detect & respond to issues identified in the habitat monitoring program.	3.0, Appendices D – J
Reporting requirements to include protocols to inform the Minister or relevant issues, milestones & results	5.2

1.3 Consultation and Approvals

Consultation with government agencies through meetings and circulation of draft documents, has taken place on the:

- concept design for the habitat enhancement;
- monitoring plans for benthic invertebrates, seagrass, saltmarsh, shorebirds, sediment and water quality;
- marine mammal management plan;
- vegetation management plan; and
- draft PEHEP.

The government agencies consulted were:

- Commonwealth Department of Environment and Heritage (DEH) (now Department of Environment and Water Resources);
- NSW Department of Environment and Conservation (DEC);
- NSW Department of Planning (DoP);
- NSW Department of Natural Resources (DNR);
- NSW Department of Primary Industry (Fisheries) (DPI);
- NSW Maritime;
- City of Botany Bay; and
- Randwick Council.

Meetings to discuss the proposed concept for the habitat enhancement have also been held with the Southern Sydney Regional Organisation of Councils (SSROC), Orica and the Port Botany Expansion Community Consultative Committee (CCC). The draft PEHEP was circulated to the CCC for comment.

The concept design for the habitat enhancement works was displayed at a Community Open Day for the project held on 25 November 2006. Community feedback and comments received have been considered within this Plan.

Written feedback was sought from government agencies and the CCC during the consultation process. Appendix A summarises feedback received.

1.4 Plan Structure

The PEHEP has been developed to present:

- a description of the habitat enhancement design (section 2);
- habitat management and maintenance (section 3);
- staging and timing of habitat enhancement works (section 4);
- monitoring plans and reporting (section 5);
- success criteria (section 6); and
- contingency plans (section 7).

1.5 Contributors to this Plan

The following specialists have contributed to development of this Plan:

- Phil Straw (Avifauna Research and Services);
- Geoff Sainty (Sainty and Associates);
- Dr Daniel Roberts (BioAnalysis);
- Dr Marcus Lincoln-Smith & Dr Peggy O'Donnell (The Ecology Lab);
- Dr Doug Treloar, Dr Brett Phillips & David Taylor (Cardno Lawson and Treloar);
- Dr Stefica Key (EP Consulting);
- Dr Gillian Eckert, Jane Wilshaw, Bruce Withnall, Donald McLeod (Maunsell);
- Prof Paul Adam, Dr Silke Nebel (School of Biological Sciences, University of NSW); and
- Dr David van Sanden (Manly Hydraulic Laboratory).

2 Habitat Enhancement Design

2.1 Background Information

There have been a number of environmental changes that have occurred at and surrounding Penrhyn Estuary since the original habitat enhancement concept design was developed for the Port Botany Expansion EIS in 2003 (URS, 2003).

These changes have been considered in the further development of the habitat enhancement design and are reflected in this PEHEP. The key changes are summarised below.

2.1.1 Seagrass Distribution and Quality

Seagrasses are marine flowering plants with a significant role as primary producers in estuarine systems as well as providing structural habitat values. Seagrasses usually grow on sandy or muddy substrates anchored by rhizomes or underground stems. Seagrass beds provide an important nursery area for fish and crustaceans by providing shelter and food. Seagrass leaves act as a filter; the strap-like leaves of seagrass plants slow the overlying water thus allowing any sediment that is suspended in the water to settle out into the seagrass bed. The extensive seagrass rhizome system stabilizes the underlying sediment and prevents sediment movement.

Updated seagrass distribution mapping of the seagrass beds in the shallow waters off Foreshore Beach was undertaken in January 2006 (Roberts *et al*, 2006). The mapping identified a 52% reduction in the area of seagrass cover, compared with the mapping undertaken for the Port Botany Expansion EIS in 2001 (TEL, 2003). The present seagrass cover mainly comprises sparse, short-leaved *Zostera capricorni* with sparse to medium cover *Halophila ovalis*. Small patches of *Posidonia australis* were present.

The dense and longer-leaved beds of *Zostera capricorni* that were found to the west of Foreshore Beach in 2001, close to the Mill Stream, have largely disappeared. Smaller patches of these beds still occur in some places but their density, cover and leaf-length have greatly reduced compared to earlier surveys.

Burial by sand from sand transport along Foreshore Beach is thought to be the major factor responsible for the reduction in cover and leaf length in the seagrass beds.

As at January 2006, the area of seagrass cover along Foreshore Beach was about 4.7 hectares, with 0.9 hectares of this area to be directly impacted by the port expansion activities. This compares with 9.7 hectares and 4 hectares respectively from the mapping undertaken in 2001.

The implications to the habitat enhancement design from the reduced area and quality of seagrass are:

- there will be less direct impact on seagrass as a result of the port expansion; and
- there is a significantly reduced chance of successful seagrass transplantation.

These factors have informed the seagrass aspects of the PEHEP.



Plate 1: Typical seagrass condition pre-burial by sand (2004)



Plate 2: Seagrass condition January 2006

2.1.2 Shorebird Abundance

Penrhyn Estuary in its current form provides a significant habitat for migratory shorebirds listed under international treaties or as threatened species under both Commonwealth and NSW legislation. Penrhyn Estuary is the only viable shorebird habitat remaining on the northern side of Botany Bay (URS, 2003).

A wide range of migratory shorebirds visit Penrhyn Estuary from time to time. Some species have used Penrhyn Estuary in the past but are no longer found in the Estuary and in some cases are no longer found in Botany Bay.

Penrhyn Estuary is currently a significant feeding and roosting area in Botany Bay for seven species of migratory shorebirds including the Bar-tailed Godwit, Red-necked Stint, Double-banded Plover, Curlew Sandpiper, Red Knot, Pacific Golden Plover and Sharp –tailed Sandpiper.

Ongoing monitoring of shorebirds in Botany Bay has occurred since preparation of the Port Botany Expansion EIS and more detailed monitoring in Penrhyn Estuary has been undertaken by Orica since September 2005. An assessment of the recent shorebird monitoring results has identified changes to some of the key shorebird species in Penrhyn Estuary.

- Bar-tailed Godwit – over the past five years there appears to have been a gradual decline in this species in Penrhyn Estuary, whilst the Botany Bay population as a whole has remained relatively stable.
- Red-necked Stint – the numbers of these shorebirds in Penrhyn Estuary has continued to decline over the past five years, whilst the numbers at Boat Harbour have remained relatively stable during this time. The decline at Penrhyn Estuary is consistent with the decline of this species in Botany Bay over the past 30 years.
- Curlew Sandpiper – this species has declined more than any other species in Botany Bay, including at Penrhyn Estuary. This decline is also evident throughout south east Australia possibly as a result of broad population level decline.

Localised reasons for the decline in shorebird use of Penrhyn Estuary are considered to include increased disturbance on both sides of the Estuary from people, pets and feral animals and the reduction in suitable habitat due to proliferation of mangroves.

2.1.3 Foreshore Beach Erosion

Erosion of Foreshore Beach has continued and is so severe in some areas that, despite maintenance works undertaken by NSW Maritime, it has undermined vegetation and threatens fuel pipelines located in the easement south of Foreshore Road (refer Plates 3 and 4). Further remedial measures are required to protect infrastructure and are to be implemented by NSW Maritime prior to commencement of construction works.



Plate 3: Existing beach erosion



Plate 4: Undermining of remedial works at Foreshore Beach

2.1.4 Groundwater Extraction

The Botany Groundwater Cleanup Project, being undertaken by Orica, commenced in 2005. This project involves the extraction and treatment of contaminated groundwater from the Botany Aquifer, to prevent its discharge into Botany Bay.

Groundwater extraction wells are operating in the median of Foreshore Road, near Penrhyn Estuary, as well as at other locations further inland. When the Project is operating at full capacity, it is anticipated to reduce dry weather flow from Floodvale and Springvale Drains from 3.1ML/day to 0.5ML/day. In addition, direct groundwater discharge into the Estuary will be stopped by the extraction wells in Foreshore Road. The residual groundwater input will be a result of groundwater recharge between Foreshore Road and Penrhyn Estuary. The clean-up project is expected to continue for approximately 30 years.

Orica have sampled nutrient concentrations in the groundwater (URS, 2004). The concentrations were found to be six to ten times higher than the concentrations entering the Estuary from Springvale and Floodvale Drains.

This additional information has been used in the assessment of future water quality in Penrhyn Estuary, presented in the Estuary Flushing Protocol (Appendix K) and summarised in Section 2.2.6.

In addition, the Cleanup Project will also draw down groundwater levels in the vicinity of the Port Botany expansion

2.1.5 *Caulerpa taxifolia*

Caulerpa taxifolia is an introduced algae that potentially competes with seagrasses and is a problematic species in Botany Bay. *Caulerpa* reproduces asexually through a process of fragmentation, dispersal and eventual anchoring of drifting fragments (Creese et al. 2004).

At the time that the EIS was prepared, the pest species *Caulerpa taxifolia* was an emerging problem in Botany Bay. *Caulerpa* has since spread throughout much of Botany Bay and is present on both the northern and southern sides. Consequently, the risk of spreading this pest species to new locations as part of the construction works is reduced.

2.1.6 Water Quality

Between December 2003 and October 2004, Sydney Ports undertook a water quality monitoring programme, to better characterise wet weather catchment inputs and dry weather receiving water quality.

Automatic samplers were installed in Floodvale and Springvale Drains, upstream of the tidal limit, to collect samples from the Drains during storm events. Samples were taken from the rising limb, peak and falling limb of each event and continuous water level data was recorded. Approximately six to eight wet weather events were sampled in each Drain.

The Total Nitrogen (TN) and Total Phosphorus (TP) wet weather loads for the sampled events were found to be significantly higher than the loads estimated during the EIS investigations. The increase in annual TN and TP loads was calculated to be approximately 65% and 10% respectively.

In addition, monthly dry weather water quality sampling was conducted in Penrhyn Estuary, along Foreshore Beach and in the area between the Parallel Runway and the existing port. Eight sites were sampled at low and high tide.

The collected data identified that:

- In the inner Estuary the median concentrations of TP and TN exceed the ANZECC trigger value for ecological protection. The TP guideline is exceeded for 80% of the samples and TN in over 90% of samples.
- in the outer Estuary, the median TP and TN concentrations meet the ANZECC (2000) trigger values although there are individual sampling times when the guideline is exceeded at these locations.
- the TN concentration, representative of ambient concentrations in Botany Bay, used in the EIS of 0.08mg/l remains appropriate.
- the TP concentration representative of ambient concentrations in Botany Bay, may be higher than that used in the EIS, 0.02mg/l instead of 0.01mg/l.

The results of the water quality monitoring programme have informed the revised Estuary water quality modelling presented in the Estuary Flushing Protocol, Appendix K, and summarised in Section 2.2.6.

2.2 Layout Design

The Penrhyn Estuary layout is presented in Figure 2. The layout design has been developed to provide expanded intertidal flats for shorebird feeding, saltmarsh habitat and seagrass habitat.

The design includes the following habitat areas:

- about 13.8 ha of intertidal flats;
- about 3.4 ha of habitat suitable for saltmarsh; and
- about 6.5 ha of habitat suitable for seagrass.

Table 2 illustrates the design features in terms of area and levels.

Table 2: Design Features

Habitat Type	Design Levels (LAT)	Existing Habitat Area (ha)	Habitat Area Lost (ha)	New Habitat Area (ha)	Total Habitat Area (ha)
Saltmarsh	1.4 to 2.0m	1.4	0.4	2.4	3.4
Seagrass	-1.0 - 2.0m	1.1*	0.9	6.3	6.5
Inter-tidal	0.3 to 1.4m	3.4	1.7 to be reshaped	10.4	13.8
Roosting Islands (3)	2.0m	0	0	0.2	0.2

*There is an additional existing area of 3.6 ha of seagrass outside the Estuary, to the west of the new boat ramp.

The Estuary will be re-shaped to provide appropriate levels for these habitat types (Figures 3, 4a, 4b). Within each habitat type a range of elevations is provided in the design. This ensures that sufficient niche space is included to accommodate changes in environmental conditions should they arise, such as water quality or sea level.

The habitat enhancement works have been designed to minimise disturbance in the upper part of the Estuary as this area provides significant feeding habitat for shorebirds. Shorebirds will be able to continue to feed in this habitat whilst the newly created intertidal flats establish as additional feeding habitat. The upper Estuary also has areas with contaminated sediments, due to historical industrial discharges to the Bay. Minimising disturbance of these contaminated sediments is desirable to reduce the contamination dispersion.

The historic remains of Government Pier will not be disturbed as part of the works.

Noise walls on the terminal will be constructed, prior to operation, to protect the Estuary from operational noise, light and movement.

2.2.1 Intertidal Area

Approximately 3.4 ha of intertidal flats suitable for shorebird feeding habitat is currently available in Penrhyn Estuary. Of this area 1.7 ha in the upper Estuary will be retained and continue to provide feeding habitat for shorebirds both during and following construction (Figure 5).

A total area of about 13.8 ha of intertidal flats will be provided in the enhanced Estuary. The finished level of the new intertidal area will grade from 0.3 m LAT (Lowest Astronomical Tide), near the entrance to the Estuary channel, up to 1.4 m LAT, where it borders the saltmarsh habitat. Three islands, that will be difficult for predators to access, will be created in the intertidal area at a level of +2.0 m LAT to provide high tide roosting sites for shorebirds.

To create the expanded intertidal flat area, the dune to the western side of Floodvale Drain will be largely removed and deeper areas in the outer part of the Estuary will be filled. Sand from the dune and/or clean dredged material will be used to fill the deeper areas of the Estuary.

The surface of the intertidal area will preferably be covered with a minimum of 10 cm of surface material from dredged areas shallower than -6.0 m LAT. This will assist with benthic colonisation of the habitat.

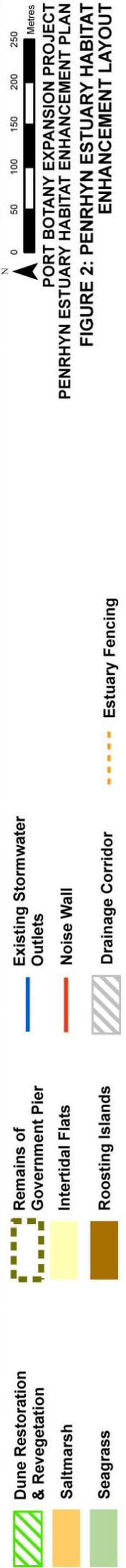
A preferential flow channel will be allowed to form naturally through the new intertidal flat area. This will occur following storm discharges from Springvale and Floodvale Drains.

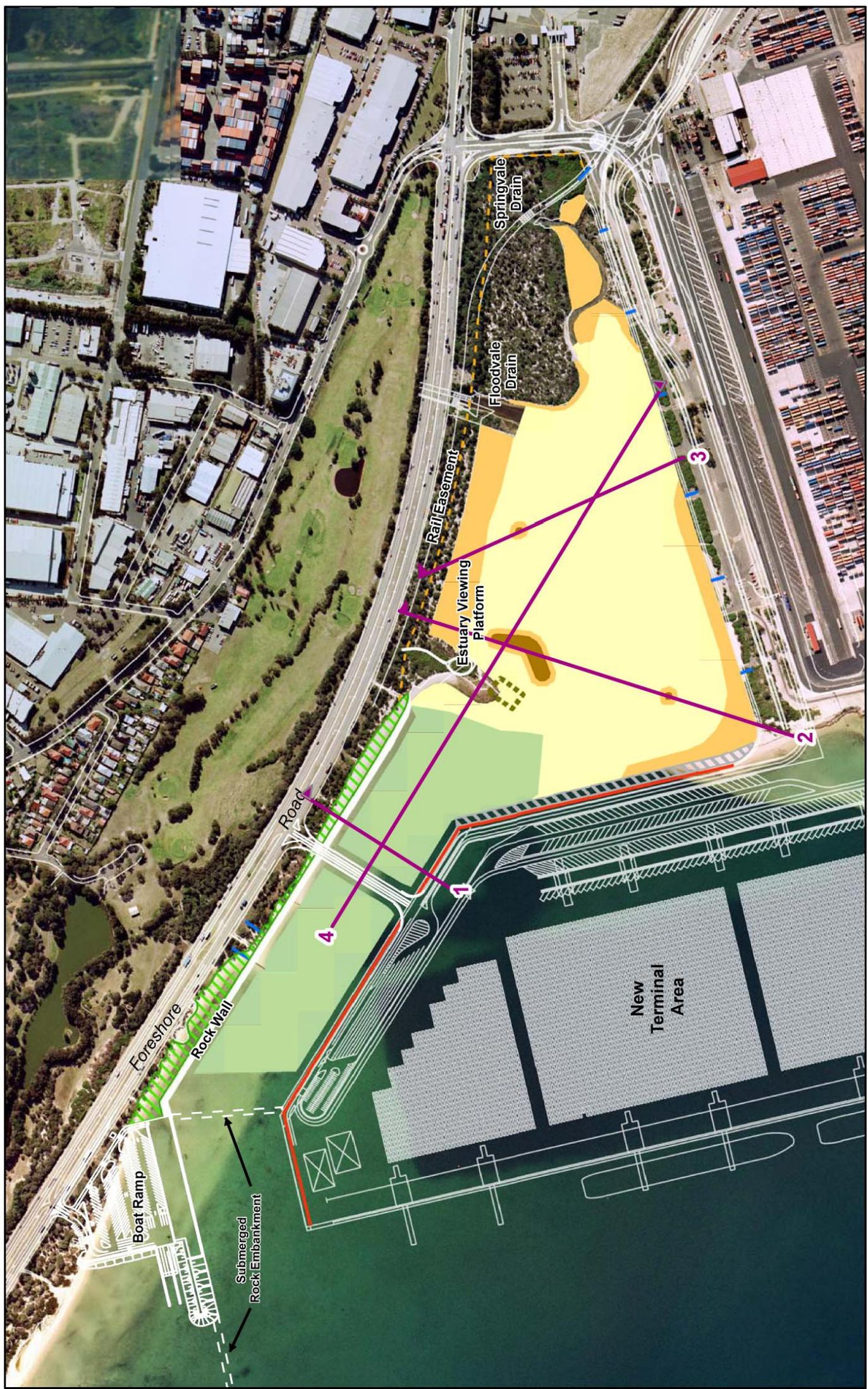
2.2.2 Saltmarsh Habitat

Saltmarsh is an endangered ecological community under the *NSW Threatened Species Conservation Act 1995*. Saltmarsh plays a key role in stabilising the banks of estuaries, filtering surface runoff, reducing nutrients and providing habitat for fauna.

There is currently 1.4 ha of saltmarsh habitat in Penrhyn Estuary (Roberts *et al* 2006). Of this, 1 ha will be retained and 0.4 ha will be removed with some of this area being transplanted (Figure 5).

An additional 2.4 ha of saltmarsh habitat is to be created and planted with suitable saltmarsh species. The main saltmarsh species occurring in Penrhyn Estuary are *Suaeda australis*, *Sarcocornia quinqueflora*, *Sporobolus virginicus* and *Juncus kraussi*. The saltmarsh species mix proposed to be planted in the Estuary will increase the diversity of the community by introducing species considered suitable and that currently occur in other saltmarsh sites in Botany Bay.

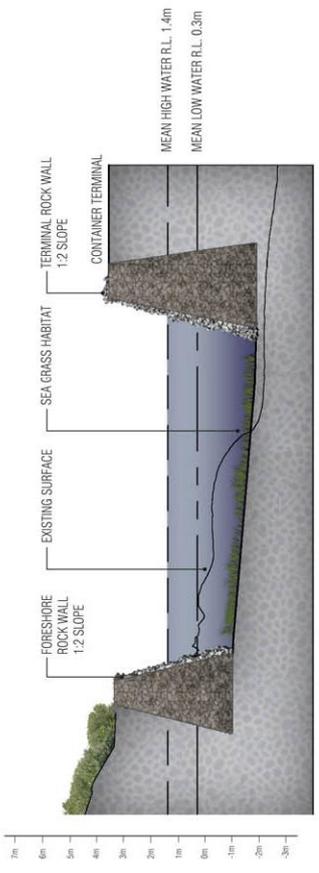




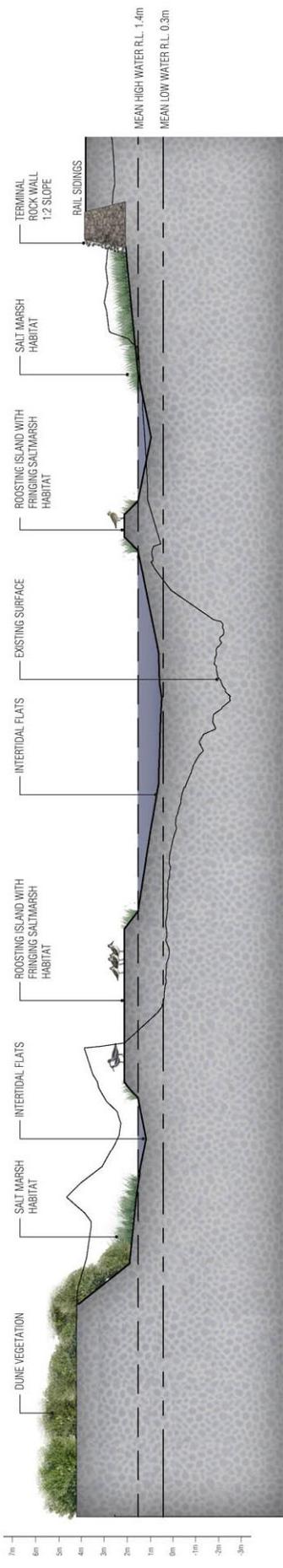
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PORT BOTANY EXPANSION PROJECT
PENRHYN ESTUARY HABITAT ENHANCEMENT PLAN
FIGURE 3: PENRHYN ESTUARY
HABITAT ENHANCEMENT - LOCATIONS
OF CROSS SECTIONS

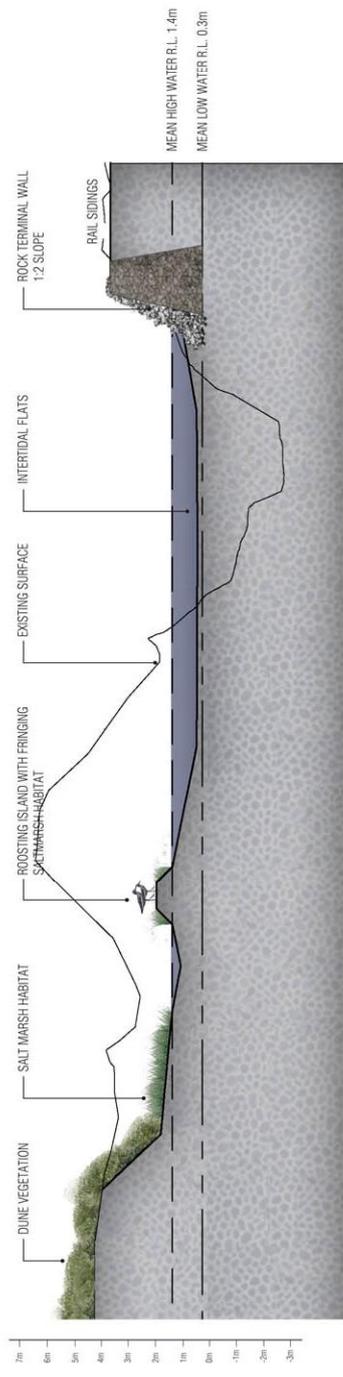
	Dune Restoration & Revegetation		Existing Stormwater Outlets
	Saltmarsh		Noise Wall
	Seagrass		Drainage Corridor
	Remains of Government Pier		Roosting Islands
	Intertidal Flats		
	Estuary Fencing		



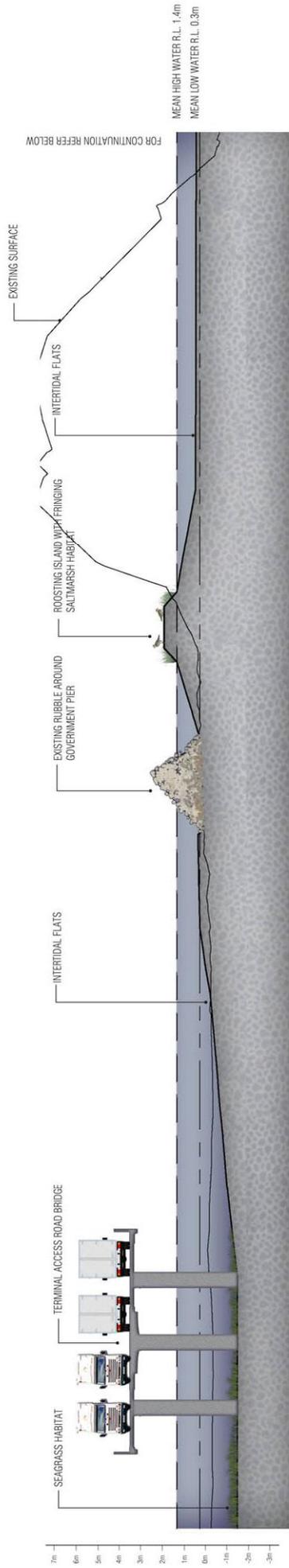
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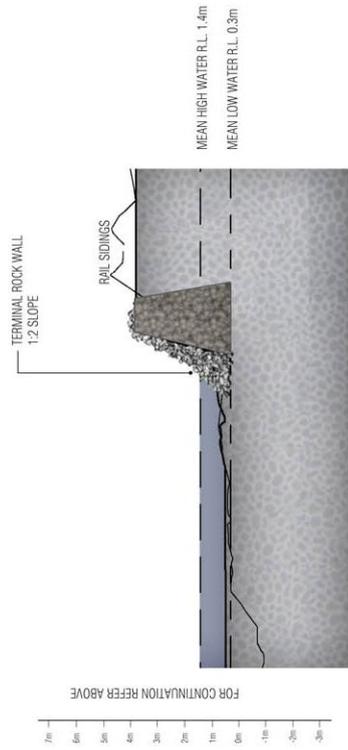
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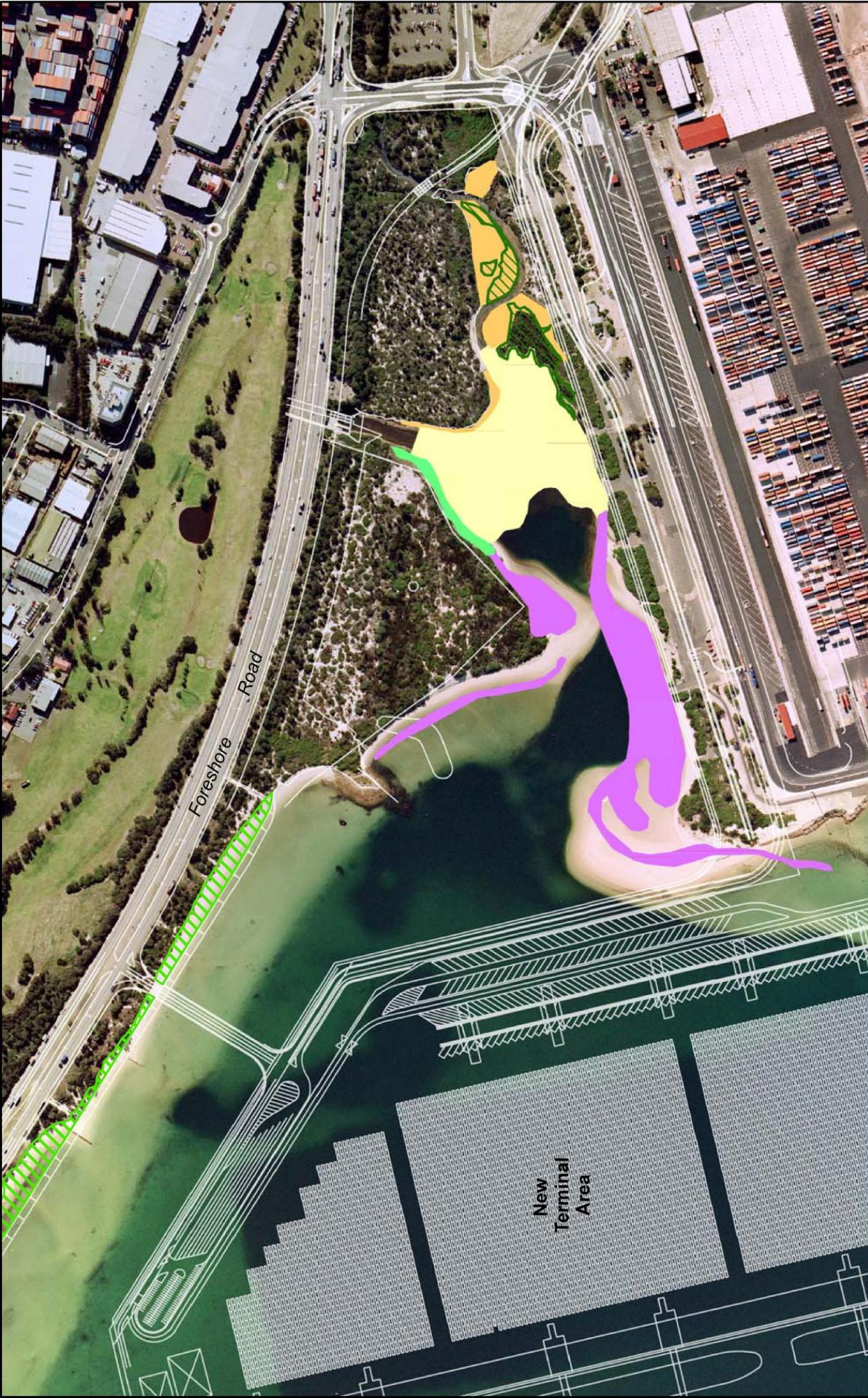
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SECTION 4



PORT BOTANY EXPANSION PROJECT
 PENRHYN ESTUARY HABITAT ENHANCEMENT PLAN
 FIGURE 4B: PENRHYN ESTUARY HABITAT ENHANCEMENT - CROSS SECTIONS



PORT BOTANY EXPANSION PROJECT
 PENRHYN ESTUARY HABITAT ENHANCEMENT PLAN
**FIGURE 5: EXISTING SALTMARSH AND
 INTERTIDAL SHOREBIRD FEEDING
 HABITAT IN PENRHYN ESTUARY**

- | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> Existing Saltmarsh (To Be Retained) Intertidal Shorebird Feeding Habitat Area (To Be Retained) | <ul style="list-style-type: none"> Existing Saltmarsh (To Be Removed) Intertidal Shorebird Feeding Habitat Area (To Be Removed) Existing Mangroves (To Be Removed) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The Vegetation Management Plan (Appendix B) includes the proposed species mix and planting density. Two saltmarsh species, *Sarcocornia quinqueflora* and *Sporobolus virginicus*, will constitute 90% of the new area. The tall saltmarsh species, *Juncus kraussii* and *Suaeda australis*, are not favoured shorebird habitat and will be planted in limited amounts in the new habitat areas.

Saltmarsh will be established in the created saltmarsh habitat by planting seedlings grown from seeds or pieces collected in Penrhyn Estuary and other saltmarsh sites in Botany Bay (subject to being granted relevant permits).

Mangroves and introduced saltmarsh species (eg *Juncus actus*) will be removed from the Estuary as part of the habitat enhancement works. *Sporobolus* and *Sarcocornia* plants will be taken from the 0.4 ha area of saltmarsh to be removed and transplanted directly into the areas from which mangroves and introduced saltmarsh species have been removed (Figure 5).

The new saltmarsh habitat will be created at levels from 1.4 m to 2.0 m LAT. The new habitat adjacent to Foreshore Road will be created by excavating the dune to the western side of Floodvale Drain to create the appropriate levels. The south and south-western saltmarsh habitat will be created by filling deeper areas with sand from the dune and/or clean dredged material as well as re-working existing material to create the appropriate levels. The new habitat will be allowed to stabilise under a series of 1.9 m to 2.0m tides before planting.

2.2.3 Seagrass Habitat

Based on mapping undertaken in January 2006 (Roberts *et al* 2006), 0.9 ha of sparse *Zostera capricornii* and *Halophila ovalis* as well as an isolated 1m² of *Posidonia australis* would be directly impacted as part of the port expansion works (Figure 6).

Posidonia is of the highest conservation value and the 1m² to be directly impacted will be transplanted to Quibray Bay on the southern shore of Botany Bay prior to the commencement of dredging and reclamation. Quibray Bay has been selected as a suitable site because it supports existing, healthy *Posidonia* beds and is in a low energy environment.

The sparse nature of the *Zostera* to be directly impacted provides limited ecological value and would be unlikely to transplant successfully. Any transplanting would need to occur within existing seagrass beds west of the new boat ramp as this location is in close proximity to the donor site, is immediately available, has a similar environment to the donor site and does not involve disturbances to seagrasses elsewhere in Botany Bay unaffected by the construction works. However, disturbance to seagrass beds west of the new boat ramp is not justified given the likely unsuccessful transplanting outcome. It is therefore not proposed to transplant any areas containing *Zostera*. *Zostera* self-colonises readily from seed in Botany Bay and is expected to colonise the new seagrass habitat. A more detailed discussion of options for transplanting *Zostera* is contained in the Vegetation Management Plan (Appendix B).

Halophila is an early coloniser of bare substrata in disturbed areas, as it has done following the loss of *Zostera* since previous mapping in 2001. It is not proposed to transplant *Halophila* as it will readily colonise suitable seagrass habitat.

A total of 6.5 ha of seagrass habitat will be created at a range of depths, for colonisation by *Halophila* and *Zostera*. The channel will be at depths between -2.0 m to -1.0 m LAT and will transition to depths of 0.3 m LAT within the Estuary. This will provide sufficient depth range for seagrass growth, allowing seagrasses to adjust to changing water quality or sea level rise.

There is currently approximately 0.2 ha of *Zostera* within the flushing channel, at a depth of -1.5 m LAT, that would not be directly impacted by the construction works (Figure 6). This will be left in situ and channel works will occur around it. The remainder of the new seagrass habitat will be left to colonise naturally.



- Existing Seagrass
- Zostera capricorni and Halophila ovalis mixed beds
- Seagrass To Be Directly Impacted
- Zostera capricorni and Halophila ovalis

Isolated Patches Of Zostera

N
 0 50 100 150 200 250 Metres
PORT BOTANY EXPANSION
PENRHYN ESTUARY HABITAT ENHANCEMENT PLAN
FIGURE 6: SEAGRASS AREAS
- AS AT JAN 2006

Creation of seagrass habitat within the Estuary channel will be achieved through re-shaping, by removing sand in some areas and filling with sand in other areas. Where seagrass is not currently present, the habitat will be topped with a minimum of 10 cm of sediment with some fines to promote seagrass growth. Surface sediments could be obtained from shallow (less than -6 m LAT) locations to be dredged as part of the works.

Mapping of the seagrass distribution in the Foreshore Beach area is to be repeated prior to the commencement of construction, to confirm the extent of the seagrass areas for transplantation and protection.

Control of the invasive marine algae, *Caulerpa taxifolia* is detailed in the Vegetation Management Plan (Appendix B). The methods proposed are consistent with the *NSW Control Plan for Caulerpa taxifolia* (NSW Fisheries, 2004).

2.2.4 Roosting Islands

Shorebirds feed on intertidal flats at low tide and roost (rest) on higher areas when the tide is high and their feeding areas are covered. In order to provide secure roosting sites for shorebirds, three islands have been included in the Estuary design (Figure 2).

These islands will be composed of sand with a 1:10 slope for stability. The top of the islands will be flat at an elevation of 2.0m LAT so that they are only covered occasionally by king tides.

The sides of the islands will be planted with saltmarsh. The tops of the islands will be bare sand and will provide nesting habitat for the endangered Little Tern.

The total area of the islands is 1650m² with the largest island occupying 1500m². It is recognised that these islands will be reshaped by tidal movement and storms. Small rocks (<15cm diameter) and associated epifauna, which currently provide some feeding habitat for shorebirds on the sand spit to the west of the Patricks terminal, will be relocated around the large roosting island in the completed intertidal flat. In addition to providing variety in feeding habitat, these rocks will provide scour protection for the island.

2.2.5 Estuary Flushing and Nutrient Concentrations

Tidal flushing and nutrient concentrations in Penrhyn Estuary have been investigated for the habitat enhancement design presented in this PEHEP, for average ambient (dry weather) conditions and transient conditions (wet weather defined as a 2 year average recurrence interval storm).

Reduced flushing of the Estuary only becomes a concern when it leads to excessive nutrient retention resulting in eutrophication. ANZECC (2000) defines eutrophication as “enrichment of waters with nutrients, primarily phosphorous and nitrogen, causing abundant aquatic plant growth and often leading to seasonal deficiencies in dissolved oxygen”.

The flushing and water quality investigations utilised the MUSIC model to provide catchment inputs and the DELFT3D model to assess Penrhyn Estuary. Details of the modelling and outcomes are presented in the Estuary Flushing Protocol (Appendix K).

The modelling has taken into account changes to groundwater inputs (volumes and nutrient concentrations) arising from the Orica Botany Groundwater Cleanup Project (discussed in Section 2.1.4) and the more recent catchment and receiving water quality data collected by Sydney Ports between December 2003 and October 2004 (discussed in Section 2.1.6).

Ambient Nutrient Concentrations

The existing Estuary layout and post enhancement Estuary layout were modelled for two scenarios:

- Scenario 1 - no nutrient load reduction from Orica groundwater extraction. This represents the situation modelled in the EIS, prior to the commencement of Orica groundwater extraction. It assumes that there is no groundwater load reduction arising from the reduced groundwater inputs to the Estuary. It represents a worst case scenario.
- Scenario 2 - nutrient load reduction due to Orica groundwater extraction. This represents the more likely situation, whereby groundwater volume reductions to the Estuary also provide a nutrient load reduction (given the high groundwater nutrient concentrations).

The results are summarised in Table 3 and Figure 7 shows the location of the modelled sites.

Table 3: Median Total Nitrogen and Total Phosphorous depth averaged concentrations for ambient conditions for existing layout and post enhancement layout modelled with and without nutrient reduction due to Orica groundwater extraction.

Model Reference	Total Nitrogen (mg/L)			Total Phosphorus (mg/L)		
	Existing (Pre-Orica extraction)	Post Enhancement- no Orica groundwater extraction (Scenario 1)	Post Enhancement- with Orica groundwater extraction (Scenario 2)	Existing (Pre-Orica extraction)	Post Enhancement- no Orica groundwater extraction (Scenario 1)	Post Enhancement- with Orica groundwater extraction (Scenario 2)
H	0.78	0.95	0.19	0.07	0.09	0.02
C	0.29	0.78	0.17	0.03	0.07	0.02
B	0.13	0.64	0.15	0.02	0.06	0.02
D	0.10	0.41	0.13	0.01	0.04	0.02
E	0.10	0.13	0.09	0.01	0.02	0.01

ANZECC (2000) Guideline trigger value: TN =0.3mg/L and TP=0.03mg/L.

The modelling results indicate that:

- Existing conditions - nutrient concentrations in the inner Estuary (Location H) exceed the ANZECC guideline trigger values, at Location C are close to the ANZECC guideline trigger values and at all other locations are below the guidelines. These results are consistent with the surface water quality monitoring data for Penrhyn Estuary.
- Scenario 1 – following habitat enhancement, nutrient concentrations in the outer Estuary (Locations B and C) would be similar to that currently experienced in the inner Estuary, nutrient concentrations in the Estuary channel (Locations D and E) would be similar to that currently experienced in the outer Estuary and nutrient concentrations in the inner Estuary would increase but would be within the range of values recorded at that location ANZECC guideline trigger values would be exceeded in a greater area of the Estuary than at present.
- Scenario 2 – nutrient concentrations within the Estuary are significantly influenced by groundwater contributions. Nutrient concentrations at most locations, particularly in the inner Estuary, would generally be reduced compared with concentrations currently experienced and would meet ANZECC guideline trigger values.

Whilst it is most likely that Scenario 2 will eventuate, assuming the worst case scenario (Scenario 1) the increase in nutrient concentrations following habitat enhancement would be unlikely to result in eutrophication of the Estuary as the higher concentrations are currently experienced in the inner Estuary without any evident issues.

Transient Nutrient Concentrations

During wet weather events, nutrient concentrations at Locations E, H and Springvale and Floodvale Drain outlets will remain relatively unchanged from the existing conditions. However, mid-estuary (Locations B, C and D) peak concentrations of TP and TN increase significantly following habitat enhancement works as these locations will be further away from the open waters of the Bay for tidal exchange. This has the temporary effect of increasing nutrient concentrations at these locations. The effect of this short term increase in nutrient concentrations is not significant as Estuary flushing modelling for transient conditions (Table 4) indicates that this condition is not likely to persist for longer than one day following a storm event, which would be unlikely to lead to eutrophic conditions.

Estuary Flushing

Tidal flushing of Penrhyn Estuary would be expected to be reduced following the construction of the port, as tidal flows would be limited to a 130m wide channel instead of being open to the Bay as currently occurs.

The existing and post-enhancement flushing times (measured as e-folding times – the time taken for concentration to reach 1/e or 37% of the initial concentration) are shown in Table 4.

Table 4: Ambient and transient e-folding time in days.

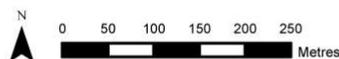
Model Reference	Ambient e-folding time (Days)		Transient e-folding time (Days)	
	Existing	Post-Enhancement	Existing	Post-Enhancement
H	2.0	3.5	0.6	1.0
C	0.7	3.0	0.6	1.0
B	0.6	2.5	0.4	0.9
D	0.3	1.6	0.3	0.7
E	0.2	0.6	0.2	0.7

Ambient e-folding times upstream of the Estuary channel have increased and are in the order of 1.5 to 3 days, compared to less than one day under existing conditions. Flushing behaviour in this area would be similar to that which currently occurs in the Inner Estuary (at Location H).

For transient conditions, post-enhancement flushing has been reduced however peak nutrient concentrations would be significantly reduced in less than one day following a major storm event (2-year ARI).

The change in flushing times under ambient conditions is not considered likely to alter the trophic status of the Estuary, regardless of whether Orica's groundwater extraction program results in the predicted nutrient load reduction. With reductions in groundwater volume discharged to the Estuary, the potential for algal bloom or eutrophication to occur is reduced.

The majority of algal blooms occurring in NSW estuarine waters are harmless and blooms in and around Botany Bay are rare (Adjani *et al.*, 2001 in Lawson and Treloar 2004). The occurrence of macroalgae in intertidal flats is commonly observed in NSW estuaries and would be expected to occur naturally in Penrhyn Estuary (Lincoln Smith M. 2004, in Lawson and Treloar 2004).



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 PENRHYN ESTUARY HABITAT ENHANCEMENT PLAN
 FIGURE 7: WATER QUALITY
 MODELLING OUTPUT LOCATIONS



PORT BOTANY EXPANSION PROJECT
PENRHYN ESTUARY HABITAT ENHANCEMENT PLAN
FIGURE 8: PENRHYN ESTUARY
EXCLUSION ZONES

-  Temporary Barrier
-  Temporary Roosting Area
-  Exclusion Zone Boundary
-  Seasonal Exclusion Zone Boundary



2.2.6 Edge Treatments

Where Penrhyn Estuary interfaces with the port terminal and the northern side of the Estuary channel it will be bounded by rock walls with maximum 1:2 slope. Elsewhere, the Estuary will be bounded by restored and enhanced native dunal vegetation which is described in a Visual Amenity Management Plan.

Design development concluded that a beach along the northern side of the Estuary channel was not viable as the slope required to create a stable beach (gradient 1:20+) would require more land than is available between the channel and Foreshore Road. This rock wall to be constructed in this location will discourage swimming in the Estuary channel which has the benefit of providing: additional protection for seagrass habitat from disturbance; added terminal security; and further discouragement from entering Penrhyn Estuary other than along the designated access path.

A subtidal rock wall with an average height of 5.5m will be constructed between the tug berth area and the downstream end of the Estuary channel. Another 4.5m subtidal rock wall will be constructed as an extension of the boat ramp rock revetment (refer Figure 2). The purpose of these rock walls is to dissipate energy arising from tug vessel operations, which will reduce potential for scour of the Estuary channel and protect recreational boat users from tug vessel wash.

2.2.7 Stormwater Drainage

Stormwater currently enters Penrhyn Estuary from the areas immediately surrounding the Estuary as well as the Springvale and Floodvale Drain catchments (Figure 2).

The most significant stormwater impact is from Springvale and Floodvale Drains as they input stormwater from large catchments, 241 ha and 118 ha respectively.

Table 5 summarises the existing stormwater inputs and changes to these inputs following the port expansion works.

Table 5: Stormwater sources and treatment

Stormwater Source/ Entry Point	Status	Stormwater Treatment	
		Current	Post Development
Springvale Drain	Existing	No treatment	No change
Floodvale Drain	Existing	Trash Rack, McPherson St.	No change*
New operational land along southern edge of Estuary	Existing land for boat ramp access and parking	None. Overland flow into Estuary	Stormwater will be collected and treated prior to discharge into Estuary.
Foreshore Road	Existing	Infiltration, with overland flow into Estuary	No change
Patrick's Terminal	Existing. Seven pipes enter southern side of Estuary	Stormtec system	No change to level of stormwater treatment.
New Terminal	New	N/A	First flush collected and treated. Overflows, beyond the first flush, will discharge to Estuary.
Foreshore Beach catchment discharging via pipe into Estuary channel	Existing. Two discharge points enter the northern side of channel	None	No change

* Contingency installation of stormwater quality improvement device if shown to be required by water quality monitoring

Where stormwater pipes discharge into the Estuary, rocks will be used (eg. reno mattresses) to dissipate flow energy and minimise scouring of adjacent habitats.

2.2.8 Access and Disturbance

Minimising disturbances to shorebirds using Penrhyn Estuary is a key objective of the PEHEP (Section 1.1). Public access to the Estuary will be controlled by restricting access to a boardwalk and public lookout, accessible only from the foreshore pedestrian pathway. The entry will be via a self-closing gate which will be locked at night. Domestic animals will not be permitted past the gate and into the Estuary. Access from the foreshore and Foreshore Road will be prevented by security fencing. This fencing will also assist in restricting feral animal access. A floating boom across the Estuary channel will prevent access by boats.

3 Habitat Management and Maintenance

This section covers management of existing estuarine habitats, management during habitat construction and establishment, and maintenance post habitat establishment. Further detail is provided in the Vegetation Management Plan provided in Appendix B.

Sydney Ports is committed to managing and maintaining Penrhyn Estuary under a long term arrangement with NSW Maritime.

3.1 Existing Habitats

3.1.1 Seagrass

The existing seagrass habitat in the project area, as mapped in January 2006, consists of (refer Figure 6):

- 14m² of *Posidonia australis*
- 4.7 hectares of mixed beds of *Zostera capricornii* and *Halophila ovalis*

Of this seagrass:

- 1m² of *Posidonia* will be directly impacted as a result of the port construction and will be transplanted to Quibray Bay.
- 0.9 hectares of sparse mixed *Zostera* and *Halophila* beds, as well as *Halophila* and isolated patches of *Zostera* within the Estuary channel, will be lost as a result of the port construction.
- 0.2 hectares of mixed *Zostera* and *Halophila* will be retained within the new Estuary channel.
- the remaining 13m² of *Posidonia* and 3.6 hectares of mixed *Zostera* and *Halophila* will be retained to the west of the new boat ramp.

Mapping of seagrass distribution will be repeated prior to the commencement of construction, to confirm the extent of the seagrass area affected by the project and the *Posidonia* area for transplantation.

Posidonia

Posidonia will be transplanted with its rhizomes and shoots attached within another *Posidonia* bed. The shoots will be trimmed prior to transplantation to reduce the buoyancy of the plant and the rhizomes of each plant will be buried into the sediment. Once *Posidonia* is removed from the substrate it becomes buoyant therefore the ability to successfully anchor the seagrass is a significant factor in successful transplantation. A sheltered location assists with successful anchoring.

A number of possible recipient sites were identified, as discussed in Appendix B, and Quibray Bay was selected because it supports existing, healthy *Posidonia* beds and is in a low energy environment where there is relatively little disturbance associated with waves or storms. Quibray Bay is more sheltered than Foreshore Beach, which will increase the potential for successful transplanting.

If *Caulerpa taxifolia* is present within the *Posidonia* to be transplanted it will be removed by hand and disposed of at an appropriate land-based site.

Posidonia removal and transplantation will be supervised by an appropriately qualified ecologist.

Seagrass to be lost

The *Zostera* and *Halophila* to be directly impacted by the construction works will not be transplanted. Options for transplanting these seagrasses were considered but not adopted for the following reasons:

- the condition or “health” of the seagrass to be transplanted is very poor;
- seagrasses in poor condition are less likely to survive the stress associated with transplantation;
- the seagrass to be directly impacted offers limited ecological value due to burial by sand;
- transplanting of the seagrass into recipient areas nearby would create disturbance to the existing seagrass habitat which may be recovering from effects of previous burial by sand; and
- the seagrass habitat to be created within Penrhyn Estuary and the Estuary channel would provide new habitat for natural colonisation of about seven times the area of seagrass to be lost as part of the port expansion.

Even if improvements to the condition of seagrass were to occur prior to construction, there is still considered to be limited ecological benefit from transplanting this seagrass. *Zostera* grows readily from rhizomes and self-colonises regularly from seed in Botany Bay if the conditions are suitable at a location. *Halophila* is an early coloniser of bare substrata in disturbed areas and will readily colonise new suitable habitat.

There is significant seagrass habitat being created as part of the habitat enhancement works to offset the project related loss of seagrass.

Retained seagrass

Seagrass that will not be directly impacted upon will at times be in close proximity to dredging and channel forming works associated with port construction. The retained areas of seagrass will be protected during construction using a high quality silt curtain and will be monitored during the construction period. Monitoring of potential construction impacts on seagrass is outlined in the Seagrass Monitoring Plan (Appendix G).

3.1.2 Saltmarsh

Three species of saltmarsh (*Suaeda australis*, *Sarcocornia quinqueflora* and *Sporobolus virginicus*) currently cover approximately 50% of the 1.4 hectare area of saltmarsh in the Estuary, in varying densities across the site (Roberts *et al* 2006).

The existing saltmarsh habitat in Penrhyn Estuary will be affected by the proposed habitat enhancement in two ways:

- 0.4 hectares of saltmarsh, along the dune edge to the west of Floodvale Drain, will be affected by landform changes and will be removed. *Sarcocornia quinqueflora* and *Sporobolus virginicus* species from this area will be transplanted into existing saltmarsh habitat within the Estuary.
- 1.0 hectares of saltmarsh is to be retained, with introduced saltmarsh species eg. *Juncus acutus* and mangroves, to be removed from this area.

Saltmarsh to be transplanted

Sarcocornia and *Sporobolus* will be transplanted into areas within and adjacent to existing saltmarsh habitat in the upper Estuary, following removal of mangroves and introduced saltmarsh species from these areas (Figure 5). *Sarcocornia* and *Sporobolus* will be harvested in clumps and planted within 24 hours of having been harvested, if possible. If it is not possible, then the plants will be kept damp and covered to prevent desiccation.

Saltmarsh harvesting and transplanting will be supervised by an experienced saltmarsh specialist.

Saltmarsh to be removed

It is not proposed to transplant *Suaeda* as it is not preferred roosting habitat for shorebirds and the recipient site for the transplanted saltmarsh will be required to provide shorebird roosting area during construction.

Top soil from the saltmarsh area will be retained and used as cover in sections of newly created saltmarsh habitat areas to provide a potential seedbank.

Retained saltmarsh

The retained areas of saltmarsh will be protected by the exclusion zones established for the construction phase, discussed in Section 3.1.4.

3.1.3 Mangroves

Mangroves are to be removed from the Estuary, as they colonise shorebird feeding habitat and compete with saltmarsh for habitat. Mangrove seedlings and plants less than 1 metre in height will be removed manually as these plants can be relatively easily pulled out by hand. Plants that cannot easily be removed manually will have their stems cut as close to the ground as possible to reduce the chance of the plants resprouting via epicormic buds.

The removal of mangroves will be undertaken in a manner that minimises disturbance of potentially contaminated sediment.

3.1.4 Shorebird Habitat

The intertidal flats in the upper reaches of the Estuary (inner Estuary) are to be retained to provide shorebird feeding habitat during and immediately after habitat enhancement.

Two exclusion zones will be implemented to isolate this area from construction activity, to ensure minimal disturbance to shorebird feeding and roosting and to minimise disturbance of contaminated sediments (Figure 8).

Exclusion Zone

The only activities permitted in the Exclusion Zone are:

- removal by hand of mangroves and introduced saltmarsh species;
- transplanting of saltmarsh;
- landscaping associated with the dune vegetation, rehabilitation and enhancement (not permitted during the exclusion season (see below));
- maintenance activities;
- environmental protection works;

- edge treatment of the terminal (not permitted during the exclusion season (see below))
- stormwater management and infrastructure works (not permitted during the exclusion season (see below); and
- environmental monitoring and sampling.

With the exception of the dune landscaping, edge treatment and stormwater infrastructure works, the above activities can occur in the Exclusion Zone at any time.

Seasonal Exclusion Zone

The Seasonal Exclusion Zone limits the majority of works within the Zone to the period between 31 March and 1 August, when most migratory shorebirds are on migration or at their northern hemisphere breeding grounds.

Habitat enhancement and terminal construction works will be permitted in the outer part of the Estuary (outside the Seasonal Exclusion Zone) during the exclusion season (1 August to 31 March – the period when shorebird use of the Estuary is greatest), subject to the construction of a temporary barrier to a height of 3 m LAT in the location shown on Figure 8. This could be achieved by retaining the eastern face of the existing sand dune or by providing an alternate barrier in this location. This barrier is to be retained as long as work is being undertaken during the exclusion period.

The only activities permitted to occur within the Seasonal Exclusion Zone during the exclusion season are:

- saltmarsh removal;
- construction of the temporary roosting island;
- removal by hand of mangroves;
- creation of the temporary barrier. Note that removal of the barrier must occur outside the exclusion season;
- maintenance activities;
- environmental protection works; and
- environmental monitoring and sampling.

Temporary Roosting Island

A temporary roosting island at +2.0m LAT will be constructed from clean sand at the western end of the existing intertidal area (Figure 8). The temporary roosting island will be constructed prior to removal of roosting areas in the outer Estuary. It is preferable for the temporary roosting island to be created outside the exclusion season. However if this is not possible then the island can be created during the exclusion season following removal of mangroves and introduced saltmarsh species and the construction of the temporary barrier along the northern edge of the Seasonal Exclusion Zone.

3.2 Habitat Construction and Establishment

3.2.1 Seagrass habitat

Creation of seagrass habitat within the Estuary channel will be achieved through re-shaping, by removing sand in some areas and filling with sand in other areas. Where seagrass is not currently present, the habitat will be topped with a minimum of 10cm of surface sediments with some fines to promote seagrass growth. Surface sediments could be obtained from a shallow (less than -6m LAT) location to be dredged as part of the works.

To avoid compaction of the top layers of sediment, which would affect growth of seagrasses, material for the surface layer of the seagrass habitat will be graded using equipment such as swamp dozers or dozer/loaders with marsh tracks.

3.2.2 Saltmarsh Habitat

The new northern saltmarsh habitat area, adjacent to Foreshore Road, will be created by excavation of the existing dune to the west of Floodvale Drain. The south and south-western saltmarsh habitat will be created through filling of deeper areas, using either sand from the excavated dune and/or clean dredged material, or reworking existing material to create the appropriate levels.

The particle size for the material to be used in the saltmarsh creation will be selected to match the substrate on which saltmarsh currently grows in the Estuary. A slow-release fertiliser may be applied around the roots of the stock at the time of planting.

To avoid compaction of the top layers of sediment, which would affect growth of saltmarsh, material for the surface layer of the saltmarsh habitat will be graded using equipment such as swamp dozers or dozer/loaders with marsh tracks.

The newly created saltmarsh habitat will be inundated by a series of 1.9 to 2.0m tides prior to planting of seedlings to aid consolidation and to confirm the landward extent of tidal penetration which will guide seedling planting.

Saltmarsh will be established in the newly created habitat areas by planting seedlings. Seedlings will be grown from seeds or pieces collected in Penrhyn Estuary and other locations in Botany Bay (subject to being granted relevant permits). A more diverse mix of species than currently occur in Penrhyn Estuary would ideally be created within the Estuary.

Open weave hessian would be used, if required, to provide protection of habitat from erosion, by pinning the hessian to the substrate.

Following planting, planted and transplanted saltmarsh will require frequent irrigation with freshwater. Regular inspection of the planted area will occur during plant establishment and is outlined in the Saltmarsh Monitoring Plan in Appendix F.

3.2.3 Intertidal Flats

To create the expanded intertidal flat area, the constructed dune to the western side of Floodvale Drain will be largely removed and deeper areas in the outer part of the Estuary will be filled. Sand from the dune and/or clean dredged material will be used to fill the deeper areas of the Estuary.

To assist with colonisation of the newly created intertidal area, the material for at least the top 10cm of the newly created intertidal flats will preferably be taken from the surface of subtidal dredging areas (at depths shallower than -6m LAT) and placed in its final position within 8 hours of removal. The intent is to provide material containing live animals to assist with benthic colonisation and therefore stockpiling of this material should not occur.

Compacted top layers can greatly affect the development and survival of benthic invertebrates in the intertidal flats. To prevent substrate compaction the surface material for the intertidal flats will be graded using light equipment such as swamp dozers or dozer/loaders with marsh tracks.

3.2.4 Roosting Islands

Three roosting islands are to be created using excavated or dredged sand to achieve the desired elevations. The large roosting island is to be ringed with small rocks (< 15cm diameter) that are currently used as feeding habitat for shorebirds on the sand spit to the west of the Patricks terminal. If the roosting island is not complete when the rocks are required to be moved, the rocks will be temporarily placed in the intertidal area near the temporary roosting island (Figure 8).

3.2.5 *Caulerpa taxifolia*

Any dredged sediments to be used as surface material in Penrhyn Estuary, the Estuary channel or for beach nourishment, will be mapped for *Caulerpa* prior to their use. Any of this material likely to contain *Caulerpa* would be buried within the reclamation footprint.

3.3 Habitat Maintenance

3.3.1 Mangrove Management

Follow up mangrove inspections will be carried out quarterly, with removal as required, for a period of two years to exhaust the soil seed bank for this species. Ongoing inspections beyond this period will occur annually and mangrove removal carried out as necessary. The aim of this maintenance program is to prevent re-colonisation by mangroves.

The floating boom to be installed across the Estuary channel will limit mangrove seeds being washed into the Estuary as the seeds are buoyant and likely to be trapped outside the boom.

3.3.2 Public Access

Public access to Penrhyn Estuary will be limited to a boardwalk and viewing platform, accessible only by a self-closing gate. The gate will be locked between sunset and sunrise. Public access to the Estuary from other parts of the foreshore will be prevented by security fencing. A floating boom across the Estuary channel will prevent boats from entering the Estuary.

Sydney Ports will have an ongoing presence in proximity to the Estuary and will undertake routine surveillance of the area to ensure that the implemented measures are effective. Any breaches of the security fencing will be repaired as soon as practicable.

3.3.3 Feral Animal Management

The presence of feral animals in the Estuary will be monitored as part of the Shorebird Monitoring Plan (Appendix D). Following any predation being reported, the perimeter fence will be inspected for damage or evidence of burrowing. Damaged fencing will be repaired as soon as practicable.

If greater intervention is required, trapping or baiting programs will be implemented following discussion with relevant authorities and a shorebird specialist.

3.3.4 Bird Hazard

Restricting public access to the Estuary will limit the presence of food scraps which may attract bird species that have the potential to be hazardous for operations at Sydney Airport (such as the Silver Gull, Australian Pelican and Australian White Ibis).



Sydney Ports will have an ongoing presence in proximity to the Estuary and will undertake routine surveillance of the area to ensure that there is no build up of hazardous bird species. Additionally, hazardous bird species will be identified as part of the Shorebird Monitoring Plan outlined in Appendix D.

If deterrent measures are to be implemented to address bird hazard species present in the Estuary, this will be undertaken in consultation with a shorebird specialist to minimise disturbance effects on the shorebirds.

Bird hazard management for areas outside the Estuary will be addressed in the design of the foreshore works and boat ramp and managed in accordance with a maintenance plan for these areas

4 Staging and Timing

4.1 Staging

The habitat enhancement works will be completed in one stage rather than the two stages indicated in the Port Botany Expansion EIS. The reasons for this are:

- areas of existing saltmarsh and intertidal shorebird feeding habitat in the upper Estuary will be retained in the final design to provide habitat for shorebirds during and immediately after construction; and
- there are practical difficulties in bringing construction machinery into the area to undertake a second stage of works, potentially disrupting the stabilisation of Stage 1 works.

The probability of success of the habitat enhancement is considered to be significantly improved by undertaking the work in a single stage.

4.2 Timing

The detailed program for construction of the Port Botany expansion and the habitat enhancement works will be developed by the Contractor. The habitat enhancement works will commence as early as possible in the construction schedule. Habitat enhancement works are anticipated to commence in 2008 and be completed by 2010.

This section presents particular timing constraints that need to be incorporated into the scheduling and sequencing of the habitat enhancement works.

Seagrass

- Seagrass distribution in the project area will be remapped prior to construction to confirm the extent of *Posidonia* requiring transplanting and the areas of seagrass requiring protection during construction.
- A permit is required from the DPI (Fisheries) under the NSW *Fisheries Management Act 1994* prior to removal of seagrass.
- Transplantation of *Posidonia* to Quibray Bay will be undertaken prior to commencement of construction.

Saltmarsh

- A Section 91 Licence under the *NSW Threatened Species Conservation Act 1995* will be required from DEC to harvest saltmarsh seeds and remove saltmarsh plants.
- Removal of introduced saltmarsh species from Penrhyn Estuary will be undertaken prior to commencement of construction, to increase the available feeding area for shorebirds.
- Saltmarsh transplanting will be undertaken in winter or early spring, when partly dormant.
- Harvested saltmarsh plants will preferably be transplanted within 24 hours of harvesting.
- Saltmarsh seed and pieces for propagation will be harvested in January to May.
- Saltmarsh seedlings require at least 4-6 months growth prior to planting in the newly created habitats.
- Seedlings will be planted in Spring (preferably) or Autumn.



- The newly created saltmarsh habitat will be inundated by a series of 1.9 to 2.0m tides prior to planting of seedlings to aid consolidation and to confirm the landward extent of tidal penetration which will guide seedling planting.

Mangroves

- A permit is required from the DPI (Fisheries) under Part 7 of the NSW *Fisheries Management Act 1994* prior to removal of mangroves.
- Removal of mangroves will be undertaken prior to commencement of habitat enhancement works and terminal construction, to increase the available feeding area for shorebirds.

Shorebird Habitat

- Construction activities within the Seasonal Exclusion Zone, and in some cases the Exclusion Zone (refer Figure 8), are restricted during the exclusion season from 1 August to 31 March. Permissible activities during this period are described in Section 3.1.4.
- A temporary roosting island is to be created within the Seasonal Exclusion Zone prior to the removal of roosting areas in the outer Estuary.

Subtidal dredge sediments to be used as the surface layer within the intertidal flats are to be placed in their final position within eight hours of being removed to provide material containing live animals to assist with benthic recolonisation.



5 Monitoring Plans

5.1 Summary of Monitoring Plans

Seven monitoring plans have been prepared in consultation with government agencies (section 1.3) to provide an assessment of the ecological health of Penrhyn Estuary. The plans, which are included as Appendices D - J of this report, are summarised in Table 6.

Table 6: Monitoring Plan Summary

Monitoring Plan	Objectives/Aims	Indicators Measured	Sampling Program Summary	Estimated Duration
Shorebirds	<ul style="list-style-type: none"> To monitor the numbers and species composition of shorebirds found in Penrhyn Estuary prior to, during and following the habitat enhancement works and assess changes. To assess the feeding behaviour of shorebirds in Penrhyn Estuary prior to and following habitat enhancement to determine habitat usage patterns. To monitor the existing and future effects of disturbance in Penrhyn Estuary on the behaviour of shorebirds. To monitor disturbance and predation in the Estuary and assess the effectiveness of security access restriction measures. 	<ul style="list-style-type: none"> Species and abundance Health of key species Disturbance Feeding and roosting behaviour Predation 	<p>Locations: Penrhyn Estuary and reference locations</p> <p>Frequency: Same for Before, During and After</p> <ul style="list-style-type: none"> – Weekly during peak – bird usage (Aug – Mar) – Fortnightly at other times 	5 years post commencement of terminal operations.



Port Botany Expansion

Monitoring Plan	Objectives/Aims	Indicators Measured	Sampling Program Summary	Estimated Duration
Benthos	<ul style="list-style-type: none"> To monitor changes in benthic invertebrate communities in existing and new intertidal/shallow subtidal habitats in terms of their impacts on food items for shorebirds. To assess changes in benthic communities in different feeding sub-habitats used by shorebirds. To assess the sustainability of created habitats with respect to their provision of food items for shorebirds. 	<ul style="list-style-type: none"> No of taxa No of individuals Total biomass Sediment characteristics 	Locations: Penrhyn Estuary and reference locations Frequency: Before – Minimum of 3 times During – None After – 6 monthly	2 to 5 years post completion of intertidal flat creation.
Saltmarsh	<ul style="list-style-type: none"> To monitor changes in existing saltmarsh habitats that will be retained in terms of the impacts of port construction and operation. To assess the success of created saltmarsh habitat, including its ecological function. 	<ul style="list-style-type: none"> Area of saltmarsh % cover of saltmarsh No of species No of Individuals/abundance Condition of plants Height of plants Abundance of epifaunal invertebrates No. mangroves 	Locations: Penrhyn Estuary and reference locations Frequency: Before – Minimum of 2 times During/After – Varies for different treatments. Typically 3, 6 and 9 months, 1, 2, 3 and 5 years.	5 years post habitat enhancement.
Seagrass	<ul style="list-style-type: none"> To monitor changes in distribution, density, morphology and ecological function of seagrass habitat in the project area before, during and after the works. To assess the survival of Posidonia seagrass transplanted to Quibray Bay. 	<ul style="list-style-type: none"> Distribution of seagrass Distribution of <i>Caulerpa</i> Density of seagrass % cover of seagrass Morphology of seagrass Epiphytic load 	Locations: Penrhyn Estuary, Foreshore Beach and reference locations Frequency: Before – Minimum of 2 times During – Monthly surveillance After – Varies for different treatments. Typically 3 months, 1, 2, 3, and 5 years.	5 years post completion of habitat enhancement, beach nourishment and dredging and reclamation works.


Port Botany Expansion

Monitoring Plan	Objectives/Aims	Indicators Measured	Sampling Program Summary	Estimated Duration
Water Quality	<ul style="list-style-type: none"> To monitor the flushing of Penrhyn Estuary using physico-chemical water quality parameters, to assess the potential for eutrophic conditions to form. 	<ul style="list-style-type: none"> Conductivity (salinity) pH Total suspended solids Dissolved oxygen Biological oxygen demand (ultimate) Temperature Photosynthetic Active Radiation Total Nitrogen Total Phosphorus Chlorophyll –a Visible Signs of eutrophication 	Locations: Penrhyn Estuary, Floodvale & Springvale Drains Frequency: Before – 2003/2004 SPC data (collected) During – Part of Construction Environmental Management Plan After – Dry weather monthly – Wet weather event based (minimum 3 events)	3 years post habitat enhancement, foreshore works and dredging and reclamation.
Sediment	<ul style="list-style-type: none"> To establish baseline surface topography (landform) for future relative comparison. To measure any change in surface topography (landform) due to the movement or displacement of sediments through hydrodynamic processes and/or scour and erosion. To determine the need to remove/ relocate any excess build up of sediments. To determine the need for maintenance replenishment/nourishment due to a loss or displacement of sediments. To identify potential risks to the sustainability of seagrass and/or saltmarsh areas. To identify the need for alternative remediation actions/works due to unexpected or unwanted changes to the area. 	<ul style="list-style-type: none"> Surface levels Surface slopes Beach width Volume of sand accumulation at Mill Stream groyne 	Locations: Penrhyn Estuary, Foreshore Beach Frequency: Before – None During – None After – Annual with inspections 6 monthly and/or after major events.	3 years post habitat enhancement.
Groundwater	<ul style="list-style-type: none"> To measure any change in groundwater levels as a result of the Port Botany Expansion project. 	<ul style="list-style-type: none"> Levels 	Locations: Foreshore Beach and up gradient of Foreshore Road Frequency: Before, During and After Continuous at 1 hour intervals.	1 year following beach nourishment, boat ramp reclamation and terminal reclamation.

5.2 Reporting and Management Action

Data reports will be produced after each monitoring event and interpretative reports will be produced annually or at key project stages eg completion of baseline surveys and habitat enhancement/construction completion. Interpretive reports will be made available to the public via Sydney Ports' website and will be provided to DoP and DEH. Interpretive reports will include: analysis of monitoring results to identify trends in variables monitored in previous years; recommendations for further monitoring (including changes in monitoring protocol and reasons); and recommendations for management measures, remedial actions or contingency plan implementation.

The results of each year's surveys would inform the monitoring for the subsequent year and identify the need for any remedial action or the need to implement contingency plans (refer Section 7).

5.3 Monitoring Duration

Nominal monitoring durations have been set, as identified in Table 5, based on reasonable time periods within which success of the habitat enhancement works would be expected to be achieved.

These durations may need to be revisited and extended in the event that contingency measures are required to be implemented.

Should the nominated monitoring period arrive without success having been achieved (as defined in Section 6) but with trends suggesting success was likely, monitoring would continue until the relevant success criterion was achieved or the applicable offset package triggered.

5.4 Marine Mammal Management

The key cetacean mammal species that are known to visit Botany Bay and surrounding waters are the Southern Right Whale (*Eubalaena australis*) and the Humpback Whale (*Megaptera novaeangliae*).

Humpback Whales regularly visit Botany Bay, however do not usually penetrate very far into the Bay (usually no further than Bare Island). The furthest recorded penetration into the Bay of a Humpback whale was the revetment wall near Molineaux Point (Geoff Ross pers comm. 2006).

Southern Right Whales venture deeper into the Bay (two whales were recently recorded up the Georges River) and visitations are usually between the Cooks River, Sydney Airport Parallel Runway, Port Botany and Molineaux Point (Geoff Ross pers comm. 2006). These species have been noted more regularly in deeper parts of the Bay. Southern Right Whales present a higher risk to port construction and operations as they often 'Bay Hop' especially on their southern migration, and once within Botany Bay may stay for a period of days to weeks (the longest recorded stay was a single whale in 2003 for 10-12 days) (Geoff Ross pers comm. 2006). In addition, Southern Right Whales are difficult to spot (Plate 5), especially in poor weather conditions.

Occasional visitors to Port Botany may include the Bottlenose Dolphin (*Tursiops truncatus*), Common Dolphin (*Delphinus delphis*), Pygmy Sperm Whale (*Kogia breviceps*), Australian Fur Seal (*Arctocephalus pusillus doriferus*) and Leopard Seal (*Hydrurga leptonyx*). These species are at lower risk of harm/injury due to their higher mobility.



Plate 5. Southern Right Whale in Botany Bay 22/7/06 (provided by DEC)



Plate 6. Australian Fur Seal, off Molineaux Point, Botany Bay 22/7/06 (provided by DEC)

A Marine Mammal Management Plan has been prepared (Appendix C) and will be implemented during the construction phase of the project. Management measures have been developed for potential:

- disorientation during dredging and other construction activities;
- entanglement in the silt curtain; and
- emission of high energy, low frequency noise (eg. piling and dredging).

Three areas have been established, based on the risk of harm or injury to a whale, as whales are the most sensitive of the marine mammals. Area 1 presents a low risk and Area 3 presents a high risk to whales. Other marine mammals are unlikely to be impacted by the lower frequency noise sources and are able to avoid the slower moving commercial shipping vessels.

The presence and location of marine mammals in Botany Bay will be monitored through:

- Contact with the DEC Cape Solander Whale Migration Study Team. This Team is a research team organised by DEC to monitor the presence of whales from a lookout at Cape Solander during the Whale Migration Season;
- monitoring of Marine Channel VHF-17 an alternative channel, VHF-15, may be allocated by Harbour Control. Which permits interagency communication between the DEC, NSW Maritime, Water Police and commercial vessels This Channel is continuously monitored by Sydney Ports Harbour Control (Harbour Control);
- Marine Channel VHF-13 which is a dedicated working marine channel for communications between Harbour Control and commercial vessels transiting with the port areas. Harbour Control provides hourly broadcasts to all vessels on this channel; and
- Sydney Ports' constant operational presence in Botany Bay with tug boats, pilot boats, emergency response vessels and security surveillance.

A sample of management actions in response to the presence of marine mammals are presented in Table 7. Further detail is in Appendix C.

Table 7: Sample of Marine Mammal Management Actions

Trigger	Action
Start of whale season	Contact to be made with Cape Solander Whale Migration Study Team. Sydney Ports and Contractor to provide contact details so that Cape Solander Team can advise both parties of any whale sightings and their location.
Whale in area 2 (approx. from Botany Bay Heads to western side of Bay)	Contractor to be on standby to stop water based construction works.
Whale in area 3 (within the area to the north of the line between the Parallel Runway and Molineux Point)	Contractor to immediately stop water based construction works. Works are not to commence until 30 minutes after whale(s) has left Area 3. DEC to be notified.
Marine Mammal in Botany Bay (all Areas)	Commercial vessels to be made aware of the presence of a whale(s). Vessel movement approvals by Sydney Ports, into/out of Port Botany, to be managed to avoid conflict with any whale(s). If this is not possible DEC will be contacted for assistance with moving the whale on.
Marine mammal in distress or experiencing disorientation.	Contractor to stop water based construction works immediately if mammal in Area 3. Works are not to commence until 30 minutes after mammal has left Area 3. DEC to be contacted. Vessel movement approvals into/out of Port Botany to be managed to avoid distressed mammal(s). If this is not possible, DEC will be contracted to assist with moving the mammal on.
Vessel collision with a marine mammal	Sydney Ports to manage vessel movement approvals into/out of Port Botany to avoid impacted mammal. DEC to be contacted.

5.5 Benthic Recolonisation

Benthic invertebrates in the Estuary will be monitored as described in the Benthos Monitoring Plan (Appendix E). However monitoring of recolonisation of the dredged berth and adjacent shallow habitats, as nominated in the EIS, was not addressed by the Monitoring Plan as it was considered that such monitoring would have limited value from the perspective of both gaining scientific knowledge and using monitoring results to trigger the implementation of management measures.

Ecological reasons for not monitoring the dredged shipping berth and adjacent shallow habitats include (see Appendix L):

- The colonisation of deep, dredged areas was investigated by The Australian Museum following the dredging for the Parallel Runway. Monitoring of the deep dredged hole, which is located immediately adjacent to the future dredged shipping berth, found that the deep hole recolonised although it took longer due to its isolation from other parts of the Bay. The shipping berth for the Port Botany Expansion is expected to be well-connected to the Bay via the navigation channel and will experience tidal flushing. It is therefore expected to become colonised.
- As The Australian Museum has already studied a deep dredged area in the same location as the future dredged shipping berth, there is little to be gained by repeating the exercise.
- The resources that would be used for monitoring recolonisation of the dredged shipping berth and adjacent shallow habitats have been put into a comprehensive monitoring programme for Penrhyn Estuary, including compilation of baseline information and monitoring of reference locations. The information obtained from this monitoring will be more important for understanding the effectiveness of the works and informing other habitat enhancement projects.

In addition to the reasons set out above, there are also a number of practical reasons why monitoring of the dredged shipping berth and adjacent shallow areas is not considered appropriate:

- The future shipping berth is not unique to the locality. There is an existing dredged shipping berth in Brotherson Dock that would experience similar operational conditions to the new shipping berth.
- Due to the depth and extent of diving and the need to manage diving around vessel visits and protect divers from recreational boating craft, the monitoring would present occupational, health and safety challenges as well as additional cost.
- Once the dredging has been completed there are no management measures that would be able to be implemented to address any outcomes from the monitoring. Therefore the monitoring would be for research value only and such research has already been conducted by The Australian Museum.

For these reasons Sydney Ports will not be monitoring benthos recolonisation of the dredged shipping channel and adjacent shallow habitats.

6 Success Criteria

6.1 Background

Success of the Penrhyn Estuary habitat enhancement works will be determined by:

- shorebird use of Penrhyn Estuary;
- area and quality of seagrass in the project area; and
- area and condition of saltmarsh in Penrhyn Estuary.

These three elements of the habitat enhancement works have been chosen as the indicators for success as they are the focus for the works and their successful achievement would indicate attainment of the main objectives of the habitat enhancement.

Each of the above components of the habitat enhancement works will be reported against the following potential outcomes:

- **Positive impact** – increase in shorebird usage of the Estuary, or increase in seagrass cover along Foreshore Beach and the Estuary channel, or increase in saltmarsh habitat in the Estuary.
- **No impact** – no change in shorebird usage of the Estuary, or no net loss of seagrass cover/quality along Foreshore Beach and the Estuary channel, or no net loss of saltmarsh area/quality in the Estuary.
- **Negative Impact** – reduction in shorebird usage of the Estuary, or reduction in area of seagrass cover along Foreshore Beach and the Estuary channel, or reduction in area of saltmarsh habitat in Penrhyn Estuary.

Whilst the habitat enhancement works have been designed to provide a 'positive impact' outcome, the 'no impact' outcome will be the determinant of success for each of the three elements.

As failure of one of the primary habitat elements would not necessarily be linked to failure of any other habitat element, success for each habitat will be assessed separately. Failure to achieve a 'no impact' or 'positive impact' outcome for that habitat element would result in the implementation of an offset package for that habitat.

Whilst 'no net loss' of any of the key habitat elements is the determinant of success, the success criteria also recognise that another objective of the habitat enhancement works is to enhance habitat values by increasing not only the area of habitat created but also the quality of these habitats. This wider objective is reflected in the structure of the monitoring plans (section 5).

6.2 Compensatory Habitat

The Penrhyn Estuary habitat enhancement works have been designed to provide the following ratios of compensatory habitat, to compensate for impacts associated with the Port Botany expansion:

- shorebird feeding habitat – approximately 4 times the current shorebird feeding habitat.
- seagrass habitat – approximately 7 times the area of seagrass to be lost by the development, which will nearly double the current area of seagrass in the project area.
- saltmarsh habitat – approximately 6 times the area of saltmarsh to be lost by the development, which will more than double the current area of saltmarsh in the Estuary.

This information has been included here to illustrate that the habitat enhancement works have been designed to substantially increase the area of each of the key habitats within Penrhyn Estuary, to provide a positive outcome associated with the project.

Notwithstanding this, it is appropriate for the success criteria to be based on achieving a minimum ‘no impact’ result. This result would indicate that the Port Botany expansion has not adversely affected the key habitat requirements for Penrhyn Estuary.

6.3 Success Criteria

The success criteria and measurement framework, presented in the following sections, have been developed based on the need and ability to objectively measure changes between pre and post enhancement works, using recognised scientific methods.

6.3.1 Success Criterion 1 - Shorebird Usage

A primary objective of the habitat enhancement works is to ensure that the Port Botany Expansion has no negative impacts on migratory shorebirds.

Success will be measured by the numbers of key migratory shorebird species using Penrhyn Estuary following the completion of habitat enhancement works, compared with the baseline data collected before the enhancement works and any large scale changes observed at reference sites.

There are also several related secondary objectives that would need to be achieved in order to achieve the ‘no impact’ outcomes for shorebird use of the Estuary. These are:

- expansion of intertidal feeding area;
- provision of high tide roosting area;
- successful colonisation of the expanded intertidal flats with invertebrate food species; and
- controlled access to the Estuary to reduce disturbance of birds from both humans and potential predators.

Achieving the shorebird usage success criterion will be an indicator that each of the above secondary criteria have been achieved. Achieving the primary objective is therefore an appropriate integrated measure of success.

Baseline

Although a wide range of species of migratory shorebirds visit Penrhyn Estuary from time to time, it provides the most significant feeding and roosting area in Botany Bay for seven species: the Bar-tailed Godwit, Red-necked Stint, Double-banded Plover, Curlew Sandpiper, Red Knot, Pacific Golden Plover, and Sharp-tailed Sandpiper (Appendix D).

Six of these species are considered to be key indicators for measuring the success of the Penrhyn Estuary habitat enhancement works. The Sharp-tailed Sandpiper is not considered a suitable indicator as it does not feed on the open tidal flats which are the focus of the habitat enhancement works (Appendix D).

A wide range of other migratory shorebird species have used northern Botany Bay in the past and some visit Penrhyn Estuary from time to time. As a result of the enhancement works, these birds may visit on a regular basis and return in larger numbers (Straw, 2006).

The baseline for measuring success will be the annual counts of the six key shorebird species, that feed in intertidal habitats, recorded in Penrhyn Estuary from September 2005 up to the commencement of construction (early 2008). September 2005 has been selected as the commencement date for determining the pre-construction baseline as it is proximate to the commencement of construction and is the start of the detailed shorebird surveys in Penrhyn Estuary undertaken by Orica, which has adopted a similar monitoring methodology to the proposed Sydney Ports monitoring for this site (Appendix D).

Measurement of Success

The numbers of the key species using the enhanced Estuary would be monitored as described in the Bird Monitoring Plan (Appendix D). Achievement of no reduction in the key indicators compared with the baseline will be used as the measure of success. This will be informed by monitoring of key species at reference sites. Should populations of key indicators decrease at reference sites (indicative of a bay-wide population decrease) then decreases at Penrhyn Estuary compared to the baseline would need to be considered in determining success. This will also be informed by any changes in the flyway populations measured by the Australasian Wader Studies Group.

Timeframe

Due to the time required for colonisation of benthic invertebrates (food items) in the new habitat, and the variability of the bird counts from year to year, at least five years of monitoring data may be required to report on performance of the works' success.

While colonisation of newly created intertidal area is an important factor to an increase in bird usage of the Estuary, bird usage could also be affected by port operations. Therefore reporting on this objective will be linked to the period following the commencement of Port operations.

Success will be assessed 5 years following commencement of Port operations. Should the assessment be inconclusive or trends indicate that future success is likely but not yet achieved, monitoring would continue beyond this time until success has been achieved or the offset package for shorebirds implemented. Following a decision to implement the offset package, no further shorebird monitoring would be undertaken.

6.3.2 Success Criterion 2 – Seagrass Area

A primary objective of the habitat enhancement works is to compensate for the loss of seagrass due to the port construction, with no net loss within the project area (between the Estuary and the Mill Stream) being the objective. Success will be measured against the criterion of no net loss of *Zostera capricorni* in the project area.

Baseline

The baseline area and quality (as measured by seagrass morphology) of seagrass in the project area will be re-assessed immediately prior to construction. Establishing the baseline immediately before construction is necessary as the most recent mapping in January 2006 identified a significant decline in area (about 52%) and quality of seagrass over a 5 year period. Seagrasses in the project area are therefore changing rapidly.

As at January 2006, there was about 4.55 hectares of *Zostera capricorni* in the project area and their condition was assessed as sparse.

The area and morphology of seagrass would be monitored as described the Seagrass Monitoring Plan (Appendix G).

Measurement of Success

Achievement of no net loss ('no impact') of the area and quality of *Zostera capricorni* in the project area would indicate success. This would be informed by any Bay-wide changes to seagrass, as measured at reference sites (ie. Bay-wide decline in area and quality of *Zostera* would need to be considered in determining seagrass success at Penrhyn Estuary should baseline criteria not be met.) The area and morphology of seagrass would be monitored as described in the Seagrass Monitoring Plan (Appendix G).

The seagrass *Halophila ovalis*, which currently occurs off foreshore beach, is a fast growing early colonising species. Its presence in the newly created seagrass habitat in the Estuary channel would provide an early indicator of the suitability of the habitat for *Zostera* growth. It is a precursor to *Zostera*, which may take longer to colonise. Therefore colonisation by *Halophila* can be considered to indicate that success would be achieved.

Timeframe

An appropriate timeframe for colonisation by *Zostera* is considered to be within five years of completion of dredging, reclamation, foreshore beach and habitat enhancement works. Success will therefore be assessed 5 years following the completion of these works.

Should the assessment be inconclusive or trends indicate that future success is likely (eg. through the colonisation by *Halophila*) but not yet achieved, monitoring would continue beyond this time until success has been achieved or the offset package for seagrass implemented. Following a decision to implement the offset package, no further seagrass monitoring would be undertaken.

6.3.3 Success Criterion 3 – Saltmarsh Area

A primary objective of the habitat enhancement works is to compensate for the loss of saltmarsh due to the reshaping of levels in the Estuary, with no net loss being the objective.

Baseline

The baseline area and condition of saltmarsh in Penrhyn Estuary will be reassessed immediately prior to construction. Establishing the baseline immediately before construction is necessary because of the potential impacts on the saltmarsh arising from the extraction of groundwater by Orica, which will essentially remove groundwater flows into the Estuary as well as baseflows into Springvale and Floodvale Drains (which discharge into the Estuary).

As at January 2006, there was about 1.4 hectares of saltmarsh in the Estuary. The condition of this saltmarsh area will be measured prior to the commencement of construction, as detailed in the Saltmarsh Monitoring Plan (Appendix F).

Measurement of Success

The area and condition of saltmarsh in Penrhyn Estuary would be monitored as described in the Saltmarsh Monitoring Plan (Appendix F). Achievement of no net loss ('no impact') of the area and condition of saltmarsh in Penrhyn Estuary would indicate success. This would be informed by any Bay-wide changes to saltmarsh, as measured at reference sites (ie. Bay-wide decline in area and condition of saltmarsh would need to be considered in determining saltmarsh success in Penrhyn Estuary should baseline criteria not be met.)

Timeframe

An appropriate timeframe for measurement of success is five years following completion of habitat enhancement works. In the event that limited saltmarsh is available for planting and natural colonisation is required to take place, this time period may need to be revised as natural colonisation may take longer to achieve the required coverage of plants.

Should the assessment be inconclusive or trends indicate that future success is likely but not yet achieved (eg. natural colonisation is occurring but has not yet become established), monitoring would continue beyond this time until success has been achieved or the offset package for saltmarsh implemented. Following a decision to implement the offset package, no further saltmarsh monitoring would be undertaken.

6.4 Contingencies

Achievement of success criteria will be measured in accordance with the monitoring plans summarised in Section 5.0 and provided in Appendices D-I. If monitoring identifies unsatisfactory trends, contingency actions may be implemented as detailed in Section 7. Implementation of remedial measures or contingency actions may trigger a change in the estimated timing for achieving success.

6.5 Compensation

If, despite implementation of contingencies and ongoing monitoring, success criteria are not likely to be achieved, Sydney Ports will implement an offset package in accordance with Condition B2.32 of the Department of Planning consent, 13 October 2005.

The offset package is being prepared and will be based on the principles of the Green Offsets paper prepared by DEC (EPA 2002) as compensation for failure to meet the 'no impact' criteria for any one of the key habitat elements discussed above.

Should an offset package be implemented for any of the three habitat elements, ongoing monitoring and assessment associated with this habitat will no longer be undertaken.

7 Contingency Plans

As part of the development of the PEHEP, a risk assessment workshop was held in order to identify potential risks that could be controlled in the design stages of the project. Design elements and management actions to either eliminate the identified risks or reduce them to acceptable levels have been incorporated in the habitat enhancement design, management and maintenance outlined in the preceding sections of this report.

For the residual risks, contingency measures have been developed and are outlined in this section. These contingency measures focus on events that could affect implementation of habitat enhancement works or could result in adverse effects following implementation of the works.

The monitoring plans, described in Section 5, are designed to provide information on the performance of the habitat enhancement works and identify the need for management actions or contingency measures.

7.1 Implementation Phase

The residual risks that could affect implementation of the habitat enhancement works relate to the following events:

- no permit issued, or difficulties in obtaining practical and timely permits, to collect saltmarsh seeds in Botany Bay;
- limit on permit to collect saltmarsh seeds does not result in required seedling establishment to achieve planting cover within the defined planting period;
- natural variability in saltmarsh seed production and seed germination results in reduction in number of seeds collected and seedlings available for the planned planting period; and
- unsuccessful saltmarsh seedling plantings.

The proposed contingency measures for each of these potential risks are described below.

7.1.1 No permit issued to collect saltmarsh seed

Coastal saltmarsh in the NSW North Coast, Sydney Basin and South Eastern Corner bioregions is listed under the *Threatened Species Conservation Act 1995* as an endangered ecological community. Under the Act, a Section 91 licence is required to harm or pick a threatened species, population or ecological community or damage habitat. Due to the endangered status of the saltmarsh community DEC has advised (December 2004) that there may be difficulties in obtaining a permit to collect saltmarsh seed, particularly from Towra Point as the saltmarsh communities largely occur within the Towra Point nature Reserve which is also listed as a Ramsar wetland. Further, the locations from which seed is to be sourced are not owned by Sydney Ports.

Contingency Measure: Should a permit or permission from the landowner(s) for saltmarsh seed collection not be issued, or not be issued to meet the projected timetable, or be issued with impractical conditions, then saltmarsh habitat would be colonised by natural processes from the seed stock in the existing saltmarsh community in the Estuary.

7.1.2 Limit on permit to collect saltmarsh seeds

It is possible that a permit for seed collection or approval from landowner(s) for seed collection would allow only limited seed collection either in volume of seed or area of collection. Two scenarios were considered: where seed collection is permitted only in Penrhyn Estuary; or there is a limit on seed volume that could be collected elsewhere in Botany Bay.

Contingency Measure: In the event that seed collection is restricted to Penrhyn Estuary only, the diversity of the proposed planting mix would be reduced to only the species that currently occur in the Estuary. The seed collection would be undertaken over two consecutive years to reduce the impact on any self seeding that may occur. The overall planting density would likely be reduced. The ability to achieved planned planting densities in the created habitat will depend on the volume of seed able to be collected. The remainder of the habitat would be colonised through natural processes.

Similarly, if seed collection in areas elsewhere in Botany Bay is restricted in volume, diversity may be reduced and seed collection would be required over two seasons. Natural colonisation may still be relied upon to achieve the design planting density in the new saltmarsh habitat.

7.1.3 Natural variability in saltmarsh seed production

Natural variability in saltmarsh seed production and seed germination could result in the reduction in number of seeds collected and the number of seedlings available for the planned planting period.

Contingency Measure: The proposed contingency measure is the same for the scenario described above.

7.1.4 Unsuccessful saltmarsh seedling planting

The possibility that saltmarsh seedlings that are planted could die soon after planting in the new habitat areas was considered. This could be a few individual plants, small patches or larger areas that could be continuous or discontinuous across the newly created saltmarsh habitat areas.

Contingency Measure: In all instances of plants not surviving, the cause will be established through review of planting and maintenance records. In the event that only a few individual plants or small patches of seedling die, natural colonisation would be relied upon to re-establish saltmarsh in these areas.

Where seedlings die in larger areas of saltmarsh habitat, the causal analyses may require further evaluation of physical and chemical properties of the sites. If site conditions were found to meet the planned specifications for saltmarsh areas then any subsequent saltmarsh establishment at these sites would be left to occur through natural colonisation processes. These sites could also be planted if staged planting is to occur as part of any of the contingencies mentioned previously.

If site conditions were found not to meet the planned specifications for saltmarsh areas, and that was determined to be the cause of seedling failure, then rectification would be undertaken. Any subsequent saltmarsh establishment at these sites following rectification would be left to occur through natural colonisation processes or they could be planted if staged planting is to occur as part of any of the above contingencies.

7.2 Post Implementation Phase

The residual risks that could affect the success of habitat enhancement following implementation of habitat enhancement works relate to the following events:

- **Shorebirds** Erosion of shorebird roosting sites and intertidal flats. Port operations deter bird use of Estuary habitat areas.
- **Seagrass** High turbidity levels do not allow sufficient light penetration. Sedimentation in, or erosion of, the Estuary channel results in smothering or erosion of seagrass.
- **Saltmarsh** Erosion of saltmarsh habitat results in loss of planted area.
- **Water Quality** Evidence of eutrophication is recorded.

The proposed contingency measures for each of these potential risks are described below.

7.2.1 Shorebirds

Potential residual risks to shorebirds include erosion of roosting sites and the intertidal feeding areas and the potential for port operations to deter bird use of Estuary habitat areas.

Contingency Measure – Erosion of Roosting Islands: The sides of the roosting islands would be planted with saltmarsh. The largest island would have some rock protection around the base, further reducing the risk of water erosion. It was considered that wind could erode the sand off the tops of the islands as these would not be planted. The proposed contingency measures on the roosting islands include remedial treatments such as placement of coarse materials, for example shell grit or gravel, to reduce or prevent further loss of sand material.

Contingency Measure – Erosion of Intertidal Flats: Erosion of intertidal flats could affect the quality and quantity of shorebird feeding habitat. Contingency measures could include lining the areas prone to erosion (e.g. preferred water flow path or stormwater pipe outlets) with rock to dissipate energy and reduce sediment transport.

Contingency Measure – Port Operations: Should port operations have adverse impacts on the shorebird use of the Estuary, operational changes or further mitigation measures would be implemented to address the causes of the adverse impact e.g. additional shielding of lights, modification of certain activities etc. The precise measures to be implemented would be subject to the cause of the adverse impact and would be identified as part of the Shorebird Monitoring Plan (Appendix D).

7.2.2 Seagrass

Potential residual risks to the seagrass habitat in the Estuary Channel could arise due to high turbidity levels not allowing sufficient light penetration for seagrass growth, excessive sediment deposition smothering seagrass, or scouring of seagrass beds.

Contingency Measure – High turbidity levels: The contingency measure to address high levels of turbidity would depend on the cause of the problem. If it is as a result of high sediment loads from the catchment, a stormwater quality improvement device or sedimentation pond at the outlet of Floodvale or Springvale Drain could be installed to reduce the sediment load entering the Estuary. If the turbidity is a result of high velocities in the Estuary, then erosion protection measures, as outlined for erosion of intertidal flats above could be implemented.

Contingency Measure – Smothering of seagrass habitat: Seagrasses can accommodate gradual deposition of sediments. If significant sediment deposition is occurring within the Estuary channel, then the source of the sediment would need to be investigated and addressed. Contingency measures would be the same as those outlined above for high levels of turbidity.

Contingency Measure – Erosion of seagrass habitat: If erosion processes are preventing the establishment of seagrass in the Estuary channel, then the feasibility of constructing physical measures to dissipate storm event energy would be investigated. Localised erosion from stormwater inputs could be addressed similarly to that proposed for addressing the erosion of intertidal flats, discussed above.

7.2.3 Saltmarsh

The residual risk to the newly established saltmarsh habitat in Penrhyn Estuary could arise from erosion at stormwater entry points into the Estuary, resulting in loss of planted area.

Contingency Measure – Erosion of Saltmarsh Habitat: Erosion could be limited to a small area or occur over a wider area. The cause of erosion needs to be established in the first instance. Localised erosion, e.g. at stormwater pipe outlets can be addressed through lining of the areas with rock to dissipate energy and reduce ongoing erosion. Erosion over larger areas may be a result of the saltmarsh plants not being established or able to provide stabilisation or protection of the surface. These areas would be reinstated and provided with additional erosion protection to provide temporary protection whilst the area becomes established.

7.2.4 Water Quality

The risk that eutrophication of the Estuary occurs has been considered. The framework for monitoring and implementing remedial actions and contingencies are listed in the Estuary Flushing Protocols Report (Appendix k) and are summarised here.

Contingency Measures: The proposed contingency plan for water quality improvements in the Estuary is based on the implementation of a staged response to the result of monitoring programs. If monitoring shows evidence of eutrophication then the contingency actions include the following:

- implementation of time series monitoring to develop a better understanding of nutrient dynamics;
- physical removal of algal growth in the shallows;
- installation of a water quality improvement device at the outlet of Floodvale Drain to reduce the sediment and nutrient load entering the Estuary; or
- installation of forced flushing of the Estuary by using a pump to improve water circulation within the Estuary.



8 References

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