Summary of key outcomes:

The results of the numerical groundwater modelling demonstrate that the proposed reclamation for the new terminal would have no effect on groundwater levels on the landward side of the present shoreline and would have no effect on the volume or flow directions of groundwater. Hence there would be no interference with the natural migration of contaminants already present in the groundwater to the north of the site.

The reclamation for the new boat ramp and the planned enhancement of sections of Foreshore Beach, to address existing beach erosion, would result in minor localised increases in groundwater levels in the following areas:

- 0.01 to 0.04 m in residential areas to the north of the enhanced beach and new boat ramp;
- up to 0.06 m in the ponds at Sir Joseph Banks Park; and
- up to 0.10 m at the western end of Foreshore Beach.

The habitat enhancement works within Penrhyn Estuary would result in minor localised decreases in groundwater levels in the following areas:

- 0.01 to 0.03 m beneath Botany Golf Course; and
- 0.04 to 0.06 m south of Foreshore Road adjacent to Penrhyn Estuary.

The small anticipated changes in groundwater levels are insignificant when compared with the natural variations in groundwater levels of between 1 m and 5 m due to rainfall variability, tidal influence and variations in groundwater abstraction (i.e. pumping out of groundwater) in the Botany area. These estimated changes are also at the limit of the capability of the model to predict change.

The results also demonstrate that the reclamation for the new boat ramp, the planned enhancement of sections of Foreshore Beach and the habitat enhancement works in Penrhyn Estuary would have minimal effect on the direction of flow or the natural migration of contaminants already present in the groundwater to the north of the site.

17.1 Introduction

The proposed Port Botany Expansion would incorporate:

- reclamation to create the new terminal within Botany Bay;
- reclamation for the new boat ramp;
- beach enhancement along Foreshore Beach to address existing erosion; and
- enhancement of Penrhyn Estuary as an ecological habitat.

When land adjoining a foreshore is reclaimed, there is potential for a rise in groundwater levels on the landward side of the foreshore. The reason for this is that the groundwater has to follow a longer flow path with a reduced hydraulic gradient.

To assess the potential impacts of the expansion on groundwater levels, flow volume and direction, a numerical model of the study area was developed by accessUTS. The modelling is discussed in a report titled *Groundwater Assessment for the Proposed Port Botany Expansion* 2003. The report is provided in **Appendix L**.

The existing groundwater environment and the assessment of impacts of the proposed Port Botany Expansion are discussed below.

17.2 Existing Environment

17.2.1 Hydrogeology

Port Botany is located on the southern edge of the northern zone of the Botany Basin (Groundwater Management Area 018). Groundwater in this zone occurs in Quaternary age unconsolidated sediments which overlie Hawkesbury Sandstone. These sediments comprise the Botany Sands Aquifer and are made up of river, beach and dune sands interbedded with clay and peat lenses.

17.2.2 Groundwater Levels

Groundwater levels in the Botany Sands Aquifer are mainly influenced by rainfall and groundwater abstraction. The main recharge area is in Centennial Park at the northern end of the catchment with substantial recharge also occurring in green space areas (parks, racecourse and golf courses).

There is a strong correlation between rainfall and groundwater fluctuations in the Botany Sands Aquifer. For example, during the late 1980's substantial rises in groundwater levels were noted in the industrial areas near Botany Bay. While some of the rise was attributed to lower groundwater abstraction, most of the rise was caused by relatively high rainfall during this period.

The current estimate of groundwater abstraction in the Botany Sands Aquifer is 20 ML/day. The level of historical groundwater usage in the area has varied significantly with abstraction rates of up to 55 ML/day occurring during the last 50 years. The majority (60%) of the abstracted groundwater is used for industrial purposes while the remaining groundwater is used to irrigate parks and golf courses.

Although a large number of monitoring bores have been installed in the Botany Sands Aquifer, monitoring of water levels has been sporadic. Water level measurements over the period April 2000 to April 2002 have been combined to develop a composite groundwater level pattern shown in **Figure 17.1**. The general pattern of groundwater flow is southwesterly towards Botany Bay, perpendicular to the contours shown in **Figure 17.1**. The pattern has changed considerably over the last decade, with much higher water levels currently existing west of the Botany Industrial Park. This is believed to be due to a substantial reduction in groundwater abstraction in that area, in association with higher rainfall.

Detailed measurements of groundwater levels and electrical conductivity by Woodward-Clyde (1995) indicate very saline conditions beneath the existing port facility with a zone of diffusion beneath Penrhyn Estuary. These conditions indicate that the salt water interface is located close to the shoreline. Due to density differences between the saltwater and groundwater, the relatively fresh groundwater is driven upward to discharge at the shoreline. As a result, there is little or no groundwater flow at depth beneath the Bay.

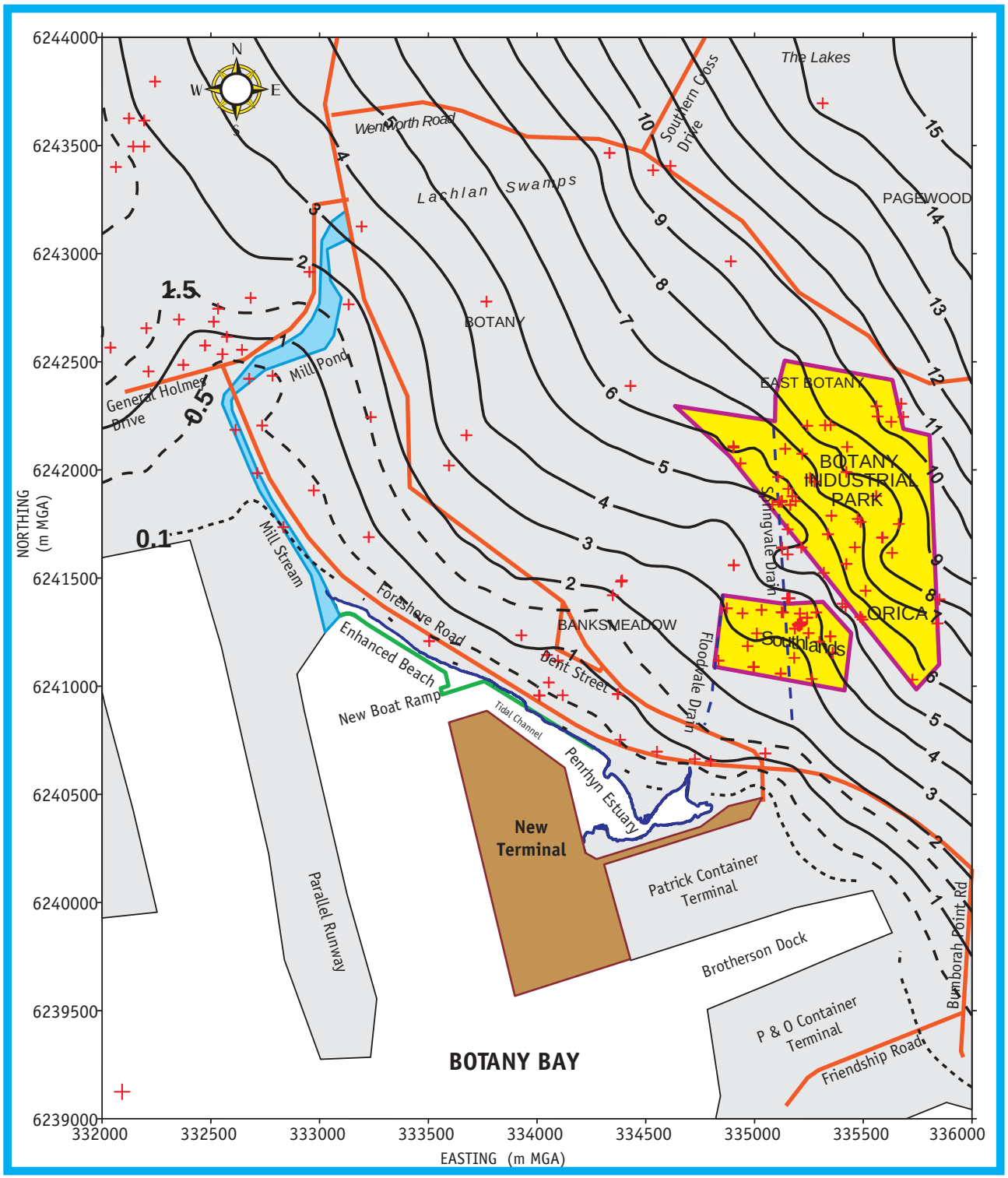
17.2.3 Groundwater Quality

Groundwater quality in the Botany Sands Aquifer has been impacted by industrial development over a period of more than 50 years. The aquifer is now classified as a “high risk resource”, in terms of groundwater quality (Bish et al. 2000), due to contamination of groundwater from industrial sites in the area. Historical contamination in the Botany Sands Aquifer is not attributable to the existing port operations at Port Botany.

In the area to the north of the proposed Port Botany Expansion, several plumes of contaminated groundwater have been identified. The most significant areas of contamination are three chlorinated hydrocarbon plumes which occur in groundwater flowing from the Botany Industrial Park (formerly ICI). These plumes are known as the Southern, Central and Northern Plumes. A groundwater protection zone has been declared along the projected path of some of these contaminant plumes as shown in **Figure 17.2**. The effect of this zone means that no new groundwater abstraction licences will be issued in this area except for activities related to the clean-up or control of the contaminant plumes.

Details of the plumes and implementation of remedial activities are detailed in Orica (2001 and 2002) and Woodward-Clyde (1999) reports. The following points provide a brief summary of the plumes:

- Southern Plume: consists of 1, 2-dichloroethane (ethylene dichloride or EDC) and trichloroethene (TCE) and is currently discharging to Penrhyn Estuary in a zone between Floodvale and Springvale Drains at a concentration of about 10 mg/L;
- Central Plume: consists of EDC with concentrations greater than 5,000 mg/L in the core of the plume. The leading edge (100-1,000 mg/L) of the plume is expected to begin discharging into the western portion of Penrhyn Estuary in 2007, with the core of the plume reaching the estuary in about 2009. The plume is expected to discharge into Penrhyn Estuary over a period of about five years (2007 to 2012); and
- Northern Plume: consists of EDC with concentrations between 100 mg/L and 200 mg/L. Current estimates indicate that the plume would enter Botany Bay at Foreshore Beach northwest of Penrhyn Estuary by 2006.



Source: accessUTS Pty Ltd 2003

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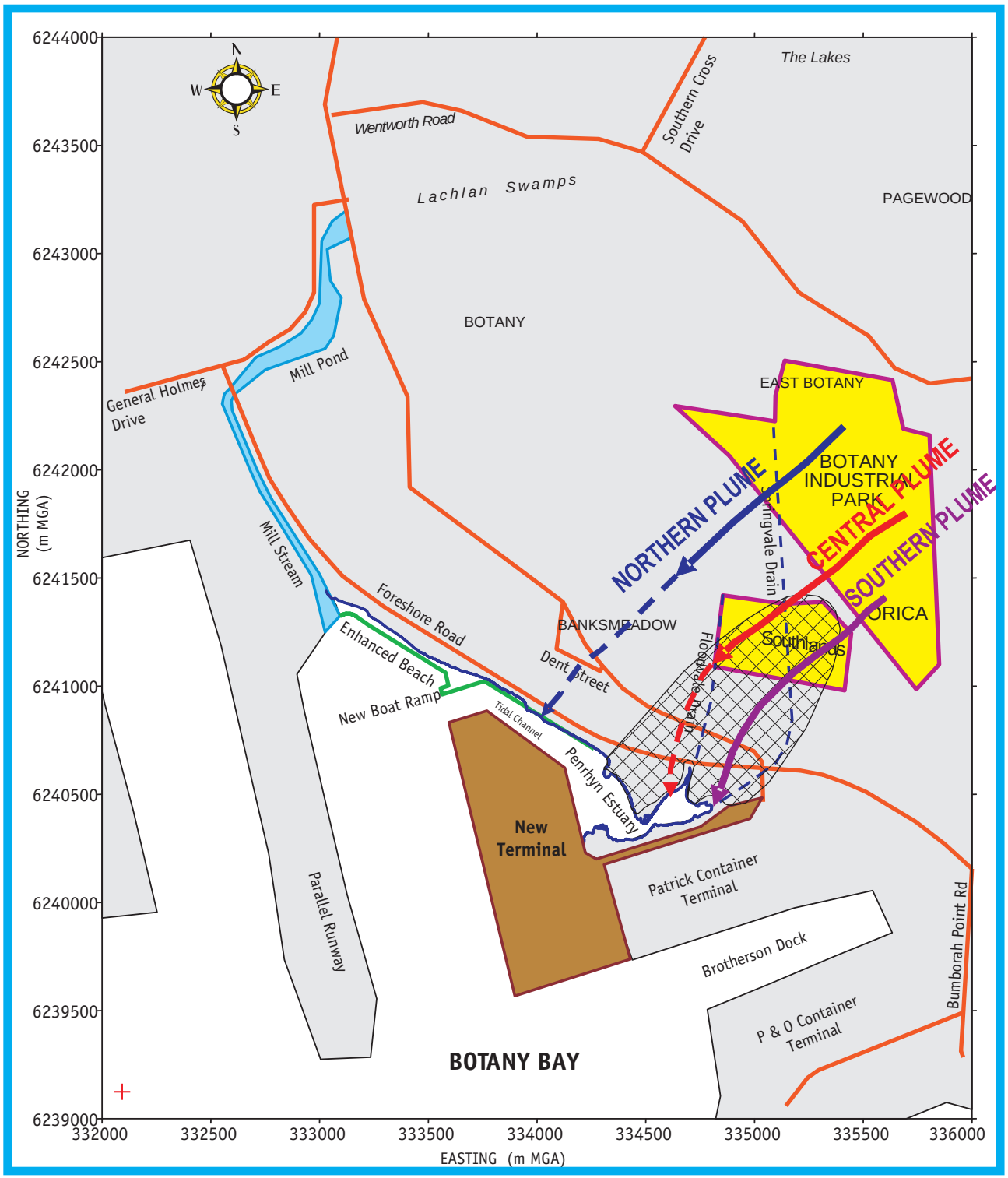
Measurement Point

Groundwater Contour Levels(mAHD)

Composite 2000-02 Observed Groundwater Levels (mAHD)

Figure 17.1



Source: accessUTS Pty Ltd 2003

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Groundwater Protection Zone

Designated Groundwater Protection Zone and Contamination Plume Projected Paths

Figure 17.2

The NSW EPA has recently issued a Clean Up Notice to Orica under the POEO Act. This notice requires Orica to establish a containment area to prevent further discharge of contaminated groundwater into Penrhyn Estuary and Botany Bay. The notice requires that this containment area be established by 31 October 2004.

17.3 Methodology

Two separate modelling approaches were followed in the groundwater study:

- simulation of detailed cross sections by finite difference method (using MODFLOW software); and
- simulation of areal extent with a finite element method (using AQUIFEM-1 software).

Each method simulates groundwater flow by computing groundwater levels for a large number of cells which are assigned surficial and aquifer properties. The models do not specifically simulate the transport of contaminants.

The simulations are focused on equilibrium or steady state response of the aquifer to constant recharge and discharge stresses using long term median rainfall. This approach isolates the impact of the reclamation activity from water level variations due to natural climatic changes. The models have been calibrated against the spatial distribution of observed groundwater levels.

As the impact on groundwater may extend landward of the foreshore, the area covered by the numerical model includes the entire northern zone of the Botany Sands Aquifer as shown on **Figure 17.3**. By extending the model coverage over the entire aquifer, inputs such as rainfall and abstraction are properly taken into account.

The results of the numerical model are summarised below, emphasising the effects of the proposed Port Botany Expansion on groundwater levels and groundwater quality.

17.4 Assessment of Impacts on Groundwater Levels

17.4.1 New Container Terminal Area

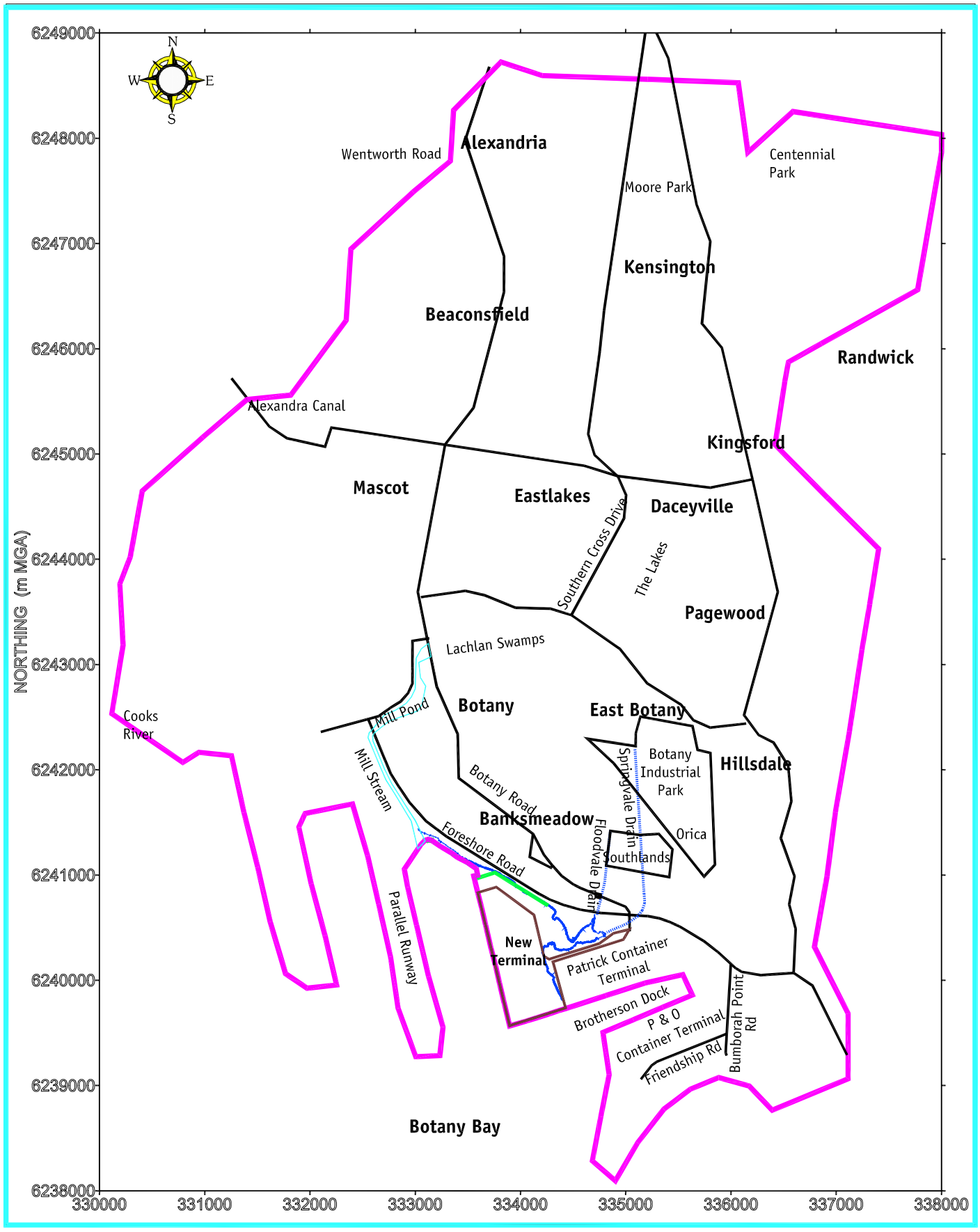
The model shows that the new container terminal area would not cause a change in groundwater levels on the landward side of the present shoreline as shown in **Figure 17.4**.

A small groundwater mound would develop under the new container terminal, with slight rises in the water table at the western end of the Patrick Stevedores terminal as shown in **Figure 17.4**. The expected rise in this area would be less than 0.01 m and would therefore be negligible.

17.4.2 Boat Ramp and Beach Enhancement

The new boat ramp and the enhancement of Foreshore Beach would result in minor localised increases in groundwater levels in the following areas (**Figure 17.5**):

- 0.01 to 0.04 m in residential areas to the north of the enhanced beach and new boat ramp;
- up to 0.06 m in the ponds at Sir Joseph Banks Park; and
- up to 0.10 m at the western end of Foreshore Beach.



Source: accessUTS Pty Ltd 2003

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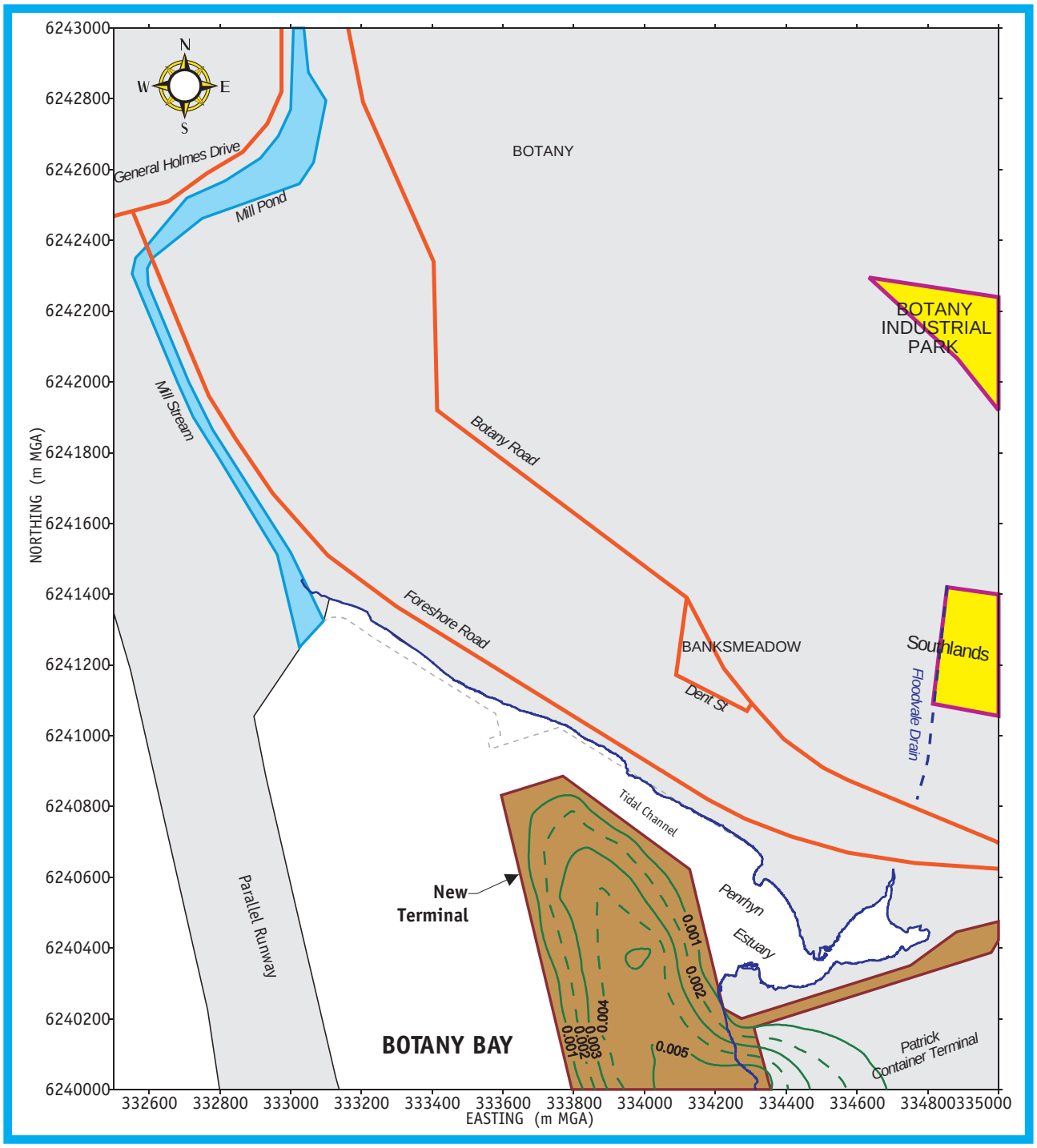
Model Boundary

Extent of Botany Sands Aquifer Groundwater Model

Figure 17.3



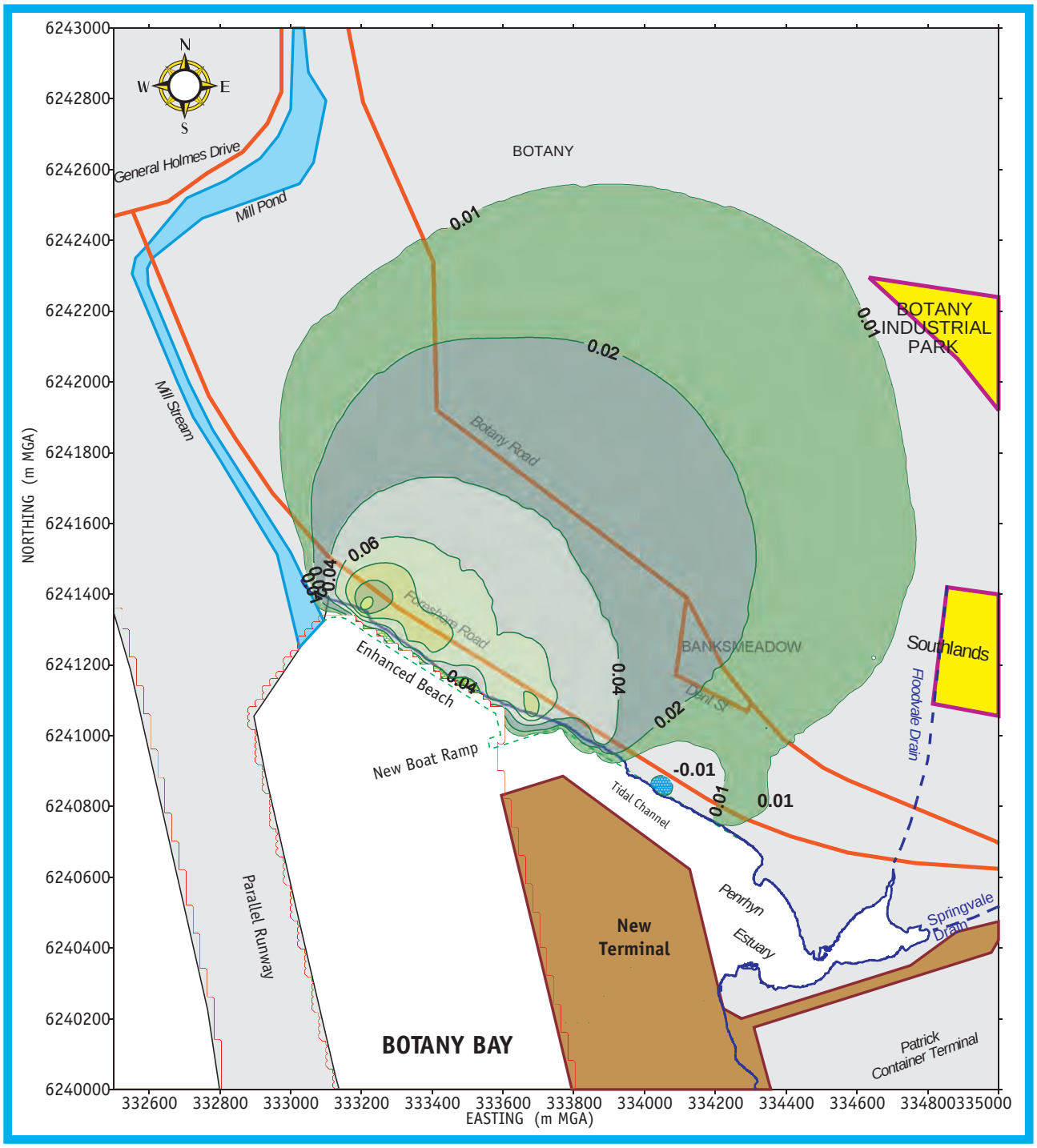
Source: accessUTS Pty Ltd 2003

0 500m

Simulated Change in Groundwater Level (m)

Simulated Change in Groundwater Levels for Terminal Reclamation Only

Figure 17.4



Source: accessUTS Pty Ltd 2003

0 500m

Simulated Change in Groundwater Level (m)

Simulated Change in Groundwater Levels for Terminal Reclamation with Proposed Foreshore Works

Figure 17.5

Natural variations in groundwater levels of 1 m have been measured in the residential areas to the north of the new terminal as a result of rainfall and variations in abstraction rates. In some parts of the aquifer, these variations are up to 5 m. The rises predicted by the model are insignificant and are one or two orders of magnitude less than the natural variations. Hence, it would not be possible to distinguish the small groundwater rises predicted from the proposed foreshore works from natural variation.

A rise of 0.06 m in the ponds in Sir Joseph Banks Park is well within the normal range of fluctuation and no impacts on ecosystem health would be expected. Measurements of the level of the ponds in Sir Joseph Banks Park from April 2002 to January 2003 show a natural variation of 0.54 m, which is 9 times greater than the predicted rise in this area.

To further assess the impact on groundwater levels due to the Port Botany Expansion and foreshore works, modelling of continuous extreme rainfall conditions and varying aquifer parameters, abstraction rates and tidal inputs was carried out. The results indicate that:

- for extreme low and high rainfall events groundwater levels would fluctuate naturally by about 0.50 m due north of the new container terminal at Botany Road and about 1.7 m at the northern boundary of the Botany Industrial Park;
- for king tide events (2.2 m LAT) groundwater levels near the shoreline would vary by about 0.50 m, by about 0.15 m at Dent St and by about 0.06 m at Botany Road;
- if groundwater abstraction is stopped groundwater levels would rise about 1 m at Botany Road and by about 0.60 m at Dent Street; and
- changing the aquifer parameters by up to 50% had minimal effect on the results especially in comparison with the above.

The modelling results for these events clearly demonstrate that the impact of the Port Botany Expansion on groundwater levels would be negligible compared to the influence of other factors.

As Foreshore Beach has eroded up to 30 m in some locations since 1980, the predicted groundwater level increase attributed to the proposed enhancement of Foreshore Beach to address these existing erosion issues reflects a restoration of groundwater levels to what they were before the erosion of the existing foreshore.

17.4.3 Penrhyn Estuary

As part of the proposed Penrhyn Estuary habitat enhancement works, the sand dune immediately west of Floodvale Drain would be removed. This would be replaced by a strip of saltmarsh along the shore at an elevation of about 1.8 m LAT and intertidal sand/mud flats at about 0.9 m LAT.

This would effectively move the present shoreline in that area back towards Foreshore Road by a maximum of 200 m. As a result, the landward groundwater level would decrease as the groundwater flow path is reduced in length.

Between Foreshore Road and the new shoreline, groundwater levels would decrease by 0.04 to 0.06 m. Between Foreshore Road and Botany Road (i.e. beneath Botany Golf Course), the decrease in groundwater levels would be between 0.01 and 0.03 m. This is a small change that would not be noticed within the context of much larger natural variations of at least 1 m.

The likely decrease in groundwater levels as a result of the habitat enhancement works in Penrhyn Estuary is shown in **Figure 17.6**.

17.4.4 Other Infrastructure

Excavation and pile driving associated with the construction of the road and rail bridges would occur below the water table. It may be necessary to install temporary cut off walls if culverts, rather than bridges, are selected as the means of crossing Springvale and Floodvale Drains for the rail line. However, it is not expected that any of these works would significantly impede groundwater flow, and as a result, groundwater levels would not be affected during construction irrespective of the construction method.

Services for the proposed Port Botany Expansion would be installed underground in shallow trenches (up to approximately 1.2 m deep) along Foreshore Road and Penrhyn Road. It is expected that in these areas the groundwater would be below the depth of the trenching activities. Therefore, the construction of services would generally not involve excavation below the water table. Service trenches would be backfilled using excavated material or sand bedding, and therefore, even if excavation did intercept the water table, it is expected that groundwater levels would not be affected.

17.5 Assessment of Impacts on Groundwater Quality

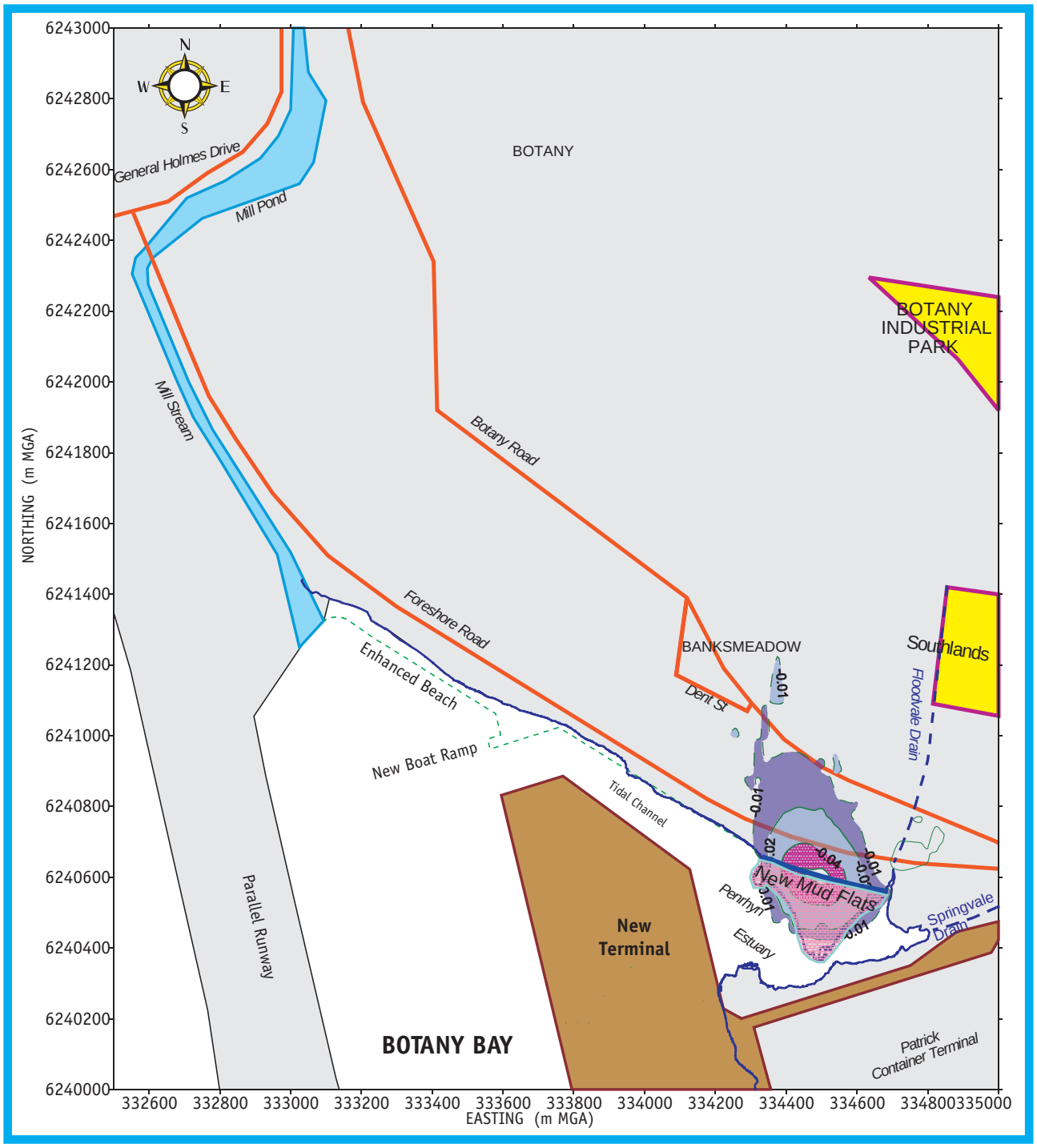
Dredging of the Bay would not result in the release of groundwater contaminants into the Bay. As discussed in Section 17.2.2**,** the contaminated groundwater discharges close to the shoreline, primarily due to the differences in density between the salt water and groundwater. Very little (if any) groundwater would flow out under the Bay to the area where dredging is proposed. Therefore, the risk of the dredging resulting in ingress of contaminated groundwater into the Bay is negligible.

The construction of the proposed Port Botany Expansion would, however, have the potential to cause minor localised contamination of groundwater from fuel and oil spills/leaks from construction equipment or machinery.

The groundwater modelling shows that the discharge volumes, direction and rate of migration of the identified groundwater contamination would be unaltered by the construction of the new terminal.

Following the construction of the boat ramp and the beach enhancement works, there would be a slight reduction in groundwater discharge volumes of about 20 % in these areas. This is due to a reduction in the hydraulic gradient which occurs when additional land is created adjacent to the foreshore. Notwithstanding this, the total groundwater discharge volume to the Bay would remain the same, as a corresponding increase in groundwater discharge volume would occur in adjacent areas (i.e. the Mill Steam and the channel between Foreshore Beach and the new terminal).

There would be no change in groundwater discharge volumes to Penrhyn Estuary. Therefore, the reclamation would not cause any change in concentration of the groundwater contaminants destined for the Estuary via the Central Plume or the Southern Plume. Where the Northern Plume enters the tidal channel, groundwater discharge volumes would increase by about 5%. This means that contaminant concentrations should reduce a little, but the contaminant mass that would enter the channel should remain the same.



Source: accessUTS Pty Ltd 2003

0 500m

Simulated Change in Groundwater Level (m)

Simulated Change in Groundwater Levels for Shoreline Re-alignment due to the Penrhyn Estuary Habitat Enhancement Works

Figure 17.6

The Penrhyn Estuary habitat enhancement works would reduce the length of the flow path of the Central Plume, so that the Plume would travel a distance of some 50 m to 100 m less to the modified shoreline. This translates to an arrival time of the Plume at Penrhyn Estuary some 6 to 12 months earlier than currently predicted. The drop in groundwater level due to the habitat enhancement works would cause a negligible acceleration of the core of the Plume as the flow path clips the edge of the zone of increased hydraulic gradient. The western flank of the Plume could also accelerate marginally.

The terminal and foreshore works of the port development, as distinct from the habitat enhancement works, would not affect the progress of the plumes nor would they affect the exit points to open water, as the groundwater salinity interface would still occur at the intertidal zone. There would be no change in plume concentrations with time for the Central Plume and the Southern Plume, but there is likely to be some dilution of the Northern Plume.

Overall, the Port Botany Expansion would have a minimal effect on the progress of the plumes and groundwater quality would not be altered.

17.6 Mitigation Measures

17.6.1 Groundwater Levels

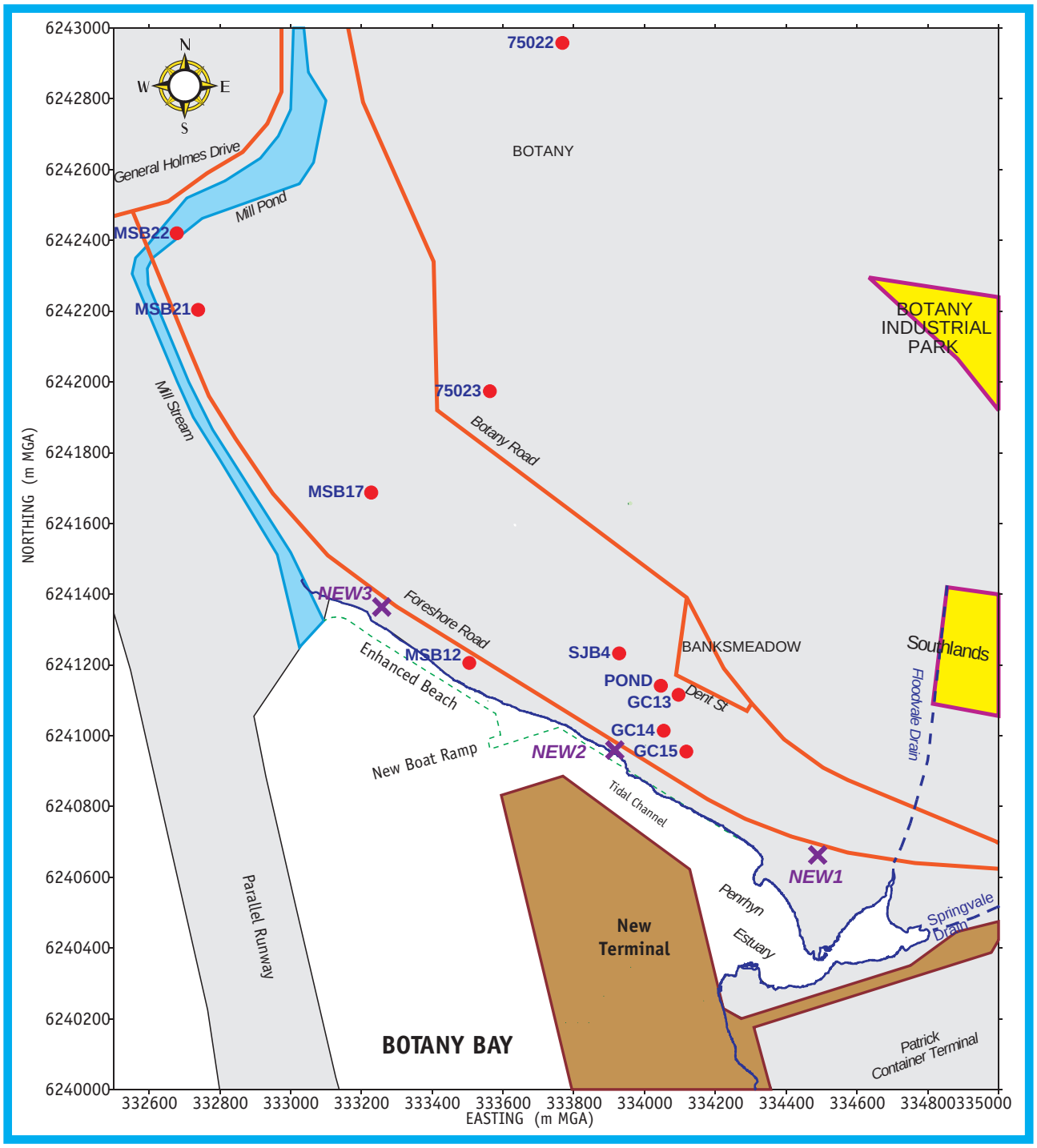
A groundwater interceptor drain could be constructed behind the new boat ramp and western section of Foreshore Beach to minimise any increases in groundwater levels as a result of the construction of the boat ramp and the enhancement of the beach. However, the results of the modelling show that the installation of such a drain would only marginally reduce the predicted increases in groundwater levels from:

- 0.02 m to 0.01 m in residential areas to the north of the enhanced beach and new boat ramp;
- 0.06 m to 0.02 m in Sir Joseph Banks Park; and
- 0.10 m to 0.01 m at the western end of Foreshore Beach.

Given that the reductions in groundwater levels achieved are insignificant when compared with the natural variations in groundwater levels and at the limit of capability of the model to predict change, a groundwater interceptor drain would not be required.

As a precaution, however, groundwater levels would be monitored during construction, and for one year after completion of the reclamation, to confirm the modelling predictions that there would be no discernible change in the pattern of groundwater level variations. Given the predicted small rises and falls in the groundwater levels due to port development, it is most unlikely that it would be possible to extract a “port effect” from groundwater level measurements. If this proves to be the case, then that would provide confirmation that the port development is not having any real impact on groundwater conditions.

An additional three groundwater monitoring locations were recommended and have recently been established by Sydney Ports Corporation to augment the existing groundwater monitoring network as shown in **Figure 17.7**. These locations are just south of Foreshore Road and will provide valuable monitoring data to assess the impacts of the proposed foreshore works and the habitat enhancement works within Penrhyn Estuary.



Source: accessUTS Pty Ltd 2003

0 500m

● Existing Groundwater Monitoring Locations

✕ New Groundwater Monitoring Locations (approximate only)

Existing and New Groundwater Monitoring Locations

Figure 17.7

17.6.2 Groundwater Quality

An SWMP would be developed in the detailed design phase to ensure that an adequate standard is applied to the control of contaminants which could impact groundwater quality during the construction of the Port Botany Expansion.

The SWMP for construction would be based on the *Managing Urban Stormwater- Soils and Construction Manual* (Department of Housing 1998) and would be incorporated in the Construction EMP. All work would be carried out to avoid contamination of the site and the surrounding areas. Contamination control measures would include:

- storage and handling of all dangerous goods in accordance with Australian Standards, NSW Dangerous Goods (General) Regulations 1999 and NSW EPA guidelines;
- an emergency response plan to control fuel, oil and chemical spills;
- machinery would be inspected regularly to identify any leaks;
- provision of spill containment equipment (e.g. spill kits) located around the construction site; and
- training of staff in spill clean-up procedures and use of spill kits.

Further details of the measures to be included in the construction SWMP are provided in **Chapter 16** *Hydrology and Water Quality*.

The operation of the new terminal is expected to have minimal effect on groundwater quality. Once operational, all terminal activities would be conducted in a manner to prevent contamination of surface or groundwater from operational activities. An Operational EMP would be developed in the detailed design phase to ensure an adequate standard is applied to contamination control for the operation of the new terminal.

17.7 Conclusion

The results of the numerical groundwater modelling demonstrate that the proposed reclamation for the new terminal would have no effect on groundwater levels on the landward side of the present shoreline and would have no effect on the volume or flow directions of groundwater. Hence, there would be no interference with the natural migration of contaminants already present in the groundwater to the north of the site.

The reclamation for the new boat ramp and the planned enhancement of sections of Foreshore Beach, to address existing beach erosion, would result in minor localised increases in groundwater levels in the following areas:

- 0.01 to 0.04 m at residential areas to the north of the enhanced beach and new boat ramp;
- up to 0.06 m in the ponds at Sir Joseph Banks Park; and
- up to 0.10 m at the western end of the Foreshore Beach.

The habitat enhancement works within Penrhyn Estuary would result in minor localised decreases in groundwater levels in the following areas:

- 0.01 to 0.03 m beneath Botany Golf Course; and
- 0.04 to 0.06 m south of Foreshore Road adjacent to Penrhyn Estuary.

The small anticipated changes in groundwater levels are insignificant when compared with the natural variations in groundwater levels of between 1 m and 5 m due to rainfall variability, tidal influence and variations in groundwater abstraction (i.e. pumping out of groundwater) in the Botany area and are at the limit of the capability of the model to predict change.

The results also demonstrate that the reclamation for the new boat ramp, the planned enhancement of sections of Foreshore Beach and the habitat enhancement works in Penrhyn Estuary would have minimal effect on the direction of flow or the natural migration of contaminants already present in the groundwater to the north of the site.

Groundwater levels would be monitored during construction, and for one year after construction, as a precautionary measure.

The proposed development would not contribute to existing groundwater contamination with the implementation of standard mitigation measures.

Summary of key outcomes:

Assessment of estuarine sediment in the area to be dredged indicates that contaminant concentrations are generally low compared to sediment quality guidelines. Disturbance of sediment during the proposed dredging operations and remobilisation of existing low concentrations of contaminants are unlikely to cause a significant risk to human health or the environment.

Some limited disturbance of potential acid sulphate soils may occur as a result of construction of the Port Botany Expansion, however, with the implementation of appropriate mitigation measures any impacts would be minimal.

Geotechnical investigations have indicated that the area to be reclaimed is suitable for the proposed expansion. The sand fill to be dredged from Botany Bay is also suitable for reclamation.

Dredging would not affect the stability of the existing Parallel Runway.

18.1 Introduction

The description of geomorphology and geology and the assessment of soil and geotechnical issues are based on site inspections and several previous studies including:

- groundwater and sediment surveys undertaken in 1990, 1992, 1996 (Woodward-Clyde 1990, 1992, 1996);
- geotechnical investigations undertaken for the site in 1999 (Coffey Partners International 1999); and
- geotechnical reviews undertaken in 2002 and 2003 (GHD-Longmac 2002, Douglas Partners 2003).

The Douglas Partners (2003) geotechnical review is contained in **Appendix M**. Sediment quality issues discussed in this chapter are based on detailed assessment in **Appendix AA** and **Chapter 31** *Ecotoxicology and Human Health Risk*.

18.2 Existing Environment

The northeastern embayment of Botany Bay consists of the waterway north of a line between the Parallel Runway and Molineux Point (about 210 ha or 5% of the total Bay area) and has been extensively modified to accommodate industrial, port and airport facilities. The area comprises:

- Foreshore Beach - a sandy beach approximately 1.6 km long, constructed from sand dredged from Botany Bay in the late 1970's;
- Penrhyn Estuary - a shallow, intertidal inlet at the southeastern end of Foreshore Beach formed in the late 1970's by construction of the existing facilities at Port Botany;
- Mill Stream - a constructed channel at the northwest end of Foreshore Beach formed during construction of the Parallel Runway;
- two areas of relatively undisturbed sandy seabed, to the east and west of the area dredged for the Parallel Runway; and
- several dredged areas with surficial sediment consisting of mud and sandy muds.

18.2.1 Geology

Botany Bay is located in the Sydney Basin, a late Palaeozoic to Mesozoic north south trending trough (>50,000 km^2) between the New England Fold Belt to the northeast and the Lachlan Fold Belt to the west. The Botany Basin is a sub unit (80 km^2) of the Sydney Basin and is bounded by Centennial Park to the north, Randwick and Matraville to the east, Alexandria and Rockdale to the west, the Kurnell Peninsula and part of the Sutherland Shire to the south.

The regional geology at the proposed Port Botany Expansion site consists of bedrock of Triassic Hawkesbury Sandstone overlain by Quaternary sediments (*1:100,000 Sydney Geological Sheet*, NSW Department of Mineral Resources 1983). The Hawkesbury Sandstone consists predominantly of crossbedded, medium to coarse quartz sand and resists weathering to crop out as prominent headlands that create Sydney's distinctive steep foreshores and rocky islands. Thin, steeply dipping, Jurassic basaltic

dykes, trending approximately east west, have intruded the Hawkesbury Sandstone to the north of Penrhyn Estuary. There are no known geological faults within the investigation area.

Quaternary sediments (up to 80 m thick) have infilled drowned river valleys incised into Hawkesbury Sandstone bedrock. These sediments comprise sand, silty sand, clayey sand, sandy clay and clay with lenses of peat, which in some parts have been consolidated to lignite. Much of the Bay, including parts of the project site, is covered with well sorted sand deposits with the exception of silty sands present in previously dredged areas.

18.2.2 Geomorphology

Numerous, open barrier-type, or deeply incised embayments are located along the southeastern Australian coastline. Botany Bay and Port Jackson to the north are "drowned-valley" estuaries created by fluvial and marine erosion (Roy 1984). The estuarine valleys probably developed during the Tertiary period with a gradual uplift of the Sydney Region. Rivers eroded channels in the coastline during glacial periods and the deeply incised river valleys were flooded during interglacial periods.

Steep rocky shores near the Bay mouth comprise Hawkesbury Sandstone and contrast strongly with the low-lying coastline and originally swampy ground on the western shoreline of Botany Bay. Prominent headlands form a narrow (1.1 km) entrance to Botany Bay, which is open to ocean swell from the southeast. Despite the wave influence and small tidal range, Botany Bay may be classified as tidally dominated. The Bay is open and shallow, in contrast to the irregular bathymetry and narrow channel in Port Jackson. The Bay shoals uniformly shoreward from depths of 16 to 21 m at the dredged channel entrance and averages about 5 m deep. Deep depressions in Botany Bay are the result of dredging for reclamation projects and shipping access.

Penrhyn Estuary was formed by construction of the Port in the 1970's. Floodvale and Springvale Drains discharge into the Estuary and create incised channels into intertidal sand and mud flats. Extensive sand dunes surrounding the Estuary are up to 3 m in elevation and vegetated with coastal scrub.

18.2.3 Sedimentology

Postglacial marine transgressions and fluvial deposition at lower sea levels have controlled sedimentation within Botany Bay during the Quaternary period. The majority of sediments in the Bay were probably deposited during the last interglacial period.

Mean sediment grain size of surficial sediment varies little in the Bay and comprises >95% sand at the Bay mouth. Sediment at the mouth and the central area of Botany Bay is a mixture of modern and relict sand and biogenic material. Sand in Botany Bay, largely derived from Hawkesbury Sandstone, is composed mainly of quartz, but carbonaceous material is more abundant towards the Bay mouth. Gravel generally forms only a minor component of surficial sediment in the Bay and consists of gastropod and bivalve shells, rock fragments and rare man-made debris. Low energy environments, including embayments on the southern shoreline of Botany Bay, are characterised by muddy sediment.

Quaternary sediment at the proposed dredge site consists of a lower clay unit interbedded with sandy layers and shells, suggesting a marine origin. The upper clay unit, containing numerous peat and organic silt and sand layers, is typical of deltaic depositional environments. Surficial sediment is well sorted "clean" sand, typically containing less than 7% of silt and clay. No cemented units that could hinder dredging have been

identified. The upper sand unit was successfully used for reclamation of the Parallel Runway and is generally considered suitable for dredging using standard equipment (**Appendix M**). The sand has been used for the construction of the Parallel Runway and the Port, and is suitable for use in the proposed reclamation.

Previous geotechnical investigations at the proposed dredge site conducted for the Brotherson Dock and Parallel Runway proposals have shown that the sediment is predominantly sand to about 22 m below LAT and underlain by fissured clays as shown in **Table 18.1**.

Table 18.1 Summary of Sedimentary Units

UNIT	DESCRIPTION	DEPTH BELOW LAT (M)
1	"Very soft/ very loose" seabed materials	Seabed
2	"Dense" sands	12 to 22
3	Intercalated peat, sand and fissured clays	23 to 26
4	Fissured clays	31 to 37
5	Residual soils	46 to 73
6	Sandstone bedrock	47 to 74

Source: Coffey Partners International 1999

18.2.4 Soils

The soils in the Botany area are predominantly derived from aeolian (wind-blown) sand deposits. The natural soil profile is primarily heavily leached infertile grey sand with minimal organic material. This profile has been altered along the north and northeast coast of Botany Bay by land reclamation and filling.

Foreshore Beach is comprised of estuarine sands dredged from Botany Bay during the construction of Port Botany and Sydney Airport. Penrhyn Estuary was formed from the reconfiguration of the northern shores of the Bay in the late 1970's as a result of the construction of Port Botany. It is composed of sand (outer Estuary) and mudflats (upper Estuary).

The soil characteristics at Port Botany, as reported by SMEC (2001), are summarised in **Table 18.2**

Table 18.2 Summary of Soil Horizons at Port Botany

UNIT	DEPTH	DESCRIPTION
1	0 to 0.1 m	topsoil, silty sand, sandy silt and sand
2	0.1 to 0.3 m	light brown to grey silty sand, sandy silt and rock fragments
3	Below 0.3 m	brown silty sand, sandy silt, shells and rock fragments

Source: SMEC 2001

18.2.5 Acid Sulphate Soils

In low lying coastal areas, inundation of iron rich soils by saline waters containing sulphate can lead to the formation of iron sulphides (e.g. pyrite). Sulphides form predominantly in two environments:

- saline and brackish lowlands including tidal flats, salt marshes and mangrove swamps; and

- sediments of saline and brackish estuaries, rivers, lakes and creeks.

Soils containing sulphides that remain undisturbed, submerged, or buried in anoxic conditions do not pose a threat to the environment and are known as potential acid sulphate soils (PASS). However, if PASS are disturbed and exposed to oxygen, the sulphides may oxidise to produce sulphuric acid and iron rich leachate. Soils affected by the oxidation of sulphides are described as actual acid sulphate soils (AASS). The resulting low pH conditions in soil and local groundwater can subsequently leach metals from soil, and cause adverse environmental effects in nearby waterways.

The identification of areas at high risk of PASS can be assessed based on geology, geomorphology, topography and ground cover. High risk areas for PASS include estuarine embayments and fine sediments of marine and terrestrial origin, usually within tidal influence. The Department of Land and Water Conservation (DLWC 1995) has produced maps (1:25,000 scale) that identify coastal areas of NSW at risk of PASS. The Botany Bay Acid Sulphate Soil Risk Map indicates that land below the mean high water mark is at high risk of containing PASS. Low lying land immediately north of Penrhyn Estuary and in dunes behind Foreshore Beach are classified as disturbed soils due to previous reclamation activities and would have a lower risk of containing PASS as shown in **Figure 18.1**.

18.2.6 Sediment Quality

Sediment quality has been assessed in the vicinity of the proposed development for previous construction activities in the area, for example, relocation of the boat ramp in Penrhyn Estuary *ca* 1997 and reclamation for the Parallel Runway in 1991. Sediment contamination in the area proposed to be dredged is generally low, however, higher concentrations of contaminants have been identified in Penrhyn Estuary sediment.

Contaminants are usually associated with the fine grain size component of sediment with high adsorptive capacity. Well sorted sands, typical of surficial sediment in the northeastern embayment of Botany Bay have low adsorptive capacities. In comparison with sediment concentrations from other parts of Botany Bay (Birch 1996) and Port Jackson (Taylor 2000), surficial concentrations of contaminants between Brotherson Dock and the Parallel Runway are low, due partly to a paucity of fine grained material.

Contaminant concentrations of sediment in the proposed dredge area are also generally low compared to ANZECC (2000) interim sediment quality guideline (ISQG) values. However, concentrations of organotin compounds exceeding ANZECC (2000) ISQG values have been reported in sediment in the proposed dredge area (Coffey Partners International 1999). These compounds can be highly toxic to marine life, but degrade in natural environments over time. The major contemporary source of these compounds is likely to be antifouling paints applied to commercial vessels. Concentrations of organotin compounds in sediment are expected to decrease as new restrictions on the use of organotin based products come into effect.

Mercury, chromium and hexachlorobenzene (HCB) present in Penrhyn Estuary sediments originated from historical sources in the Floodvale and Springvale Drain catchments. These contaminants are generally affiliated with fine grained particulate material in sediment deposited below the mean high water mark within Penrhyn Estuary.

Source: Department of Land and Water Conservation

Acid Sulphate Soil Risk Map **Figure 18.1**

Acid Sulphate Soil Risk Category

- High Risk
- Low Risk
- Disturbed Soil

Concentrations of mercury (maximum 183 mg/kg) present in sediment in Penrhyn Estuary commonly exceed the ANZECC (2000) ISQG high value (1 mg/kg). HCB is present in sediment in Penrhyn Estuary at concentrations up to 2.2 mg/kg, but ANZECC (2000) ISQG does not provide a trigger value for this contaminant. Some sediments contain concentrations of chromium (maximum 130 mg/kg) that exceed the ANZECC (2000) ISQG low guideline value (80 mg/kg). However, chromium concentrations are generally low and are therefore unlikely to cause a significant risk to human health or the environment.

Historical contamination of sediment in Penrhyn Estuary and contemporary contamination of the Estuary from groundwater sources are assessed from a human health and ecological risk perspective in **Chapter 31** *Ecotoxicology and Human Health Risk* and **Appendix AA**.

18.3 Assessment of Impacts During Construction

18.3.1 Geotechnical Issues

The area of reclamation for the new terminal is approximately 60 ha. The reclamation would be in two stages; firstly, hydraulic filling of dredged Bay sediment behind a series of rock embankments, followed by construction of the berths and port infrastructure. The western portion of the proposed reclamation area was dredged to 20 m below LAT for the construction of the Parallel Runway. Final reclamation level has been set at 3.5 m above LAT and the dredged seabed in the navigation channel has been nominated to at least 16.0 m below LAT.

Laboratory tests have been conducted to determine geotechnical parameters, such as strength and deformation of filled material under load, relevant to the design of the reclamation. General conclusions from the geotechnical investigations are that ground conditions are suitable for the proposed reclamation and that embankments and berth structures would be stable given appropriate design and construction techniques (**Appendix M**). Vibro-compaction has been suggested as an appropriate method of increasing stability by increasing the density of the sand fill within the rock embankment. The proposed rock embankment angle (2H: 1V) with (vibro) compaction of sand fill would be a viable means of maintaining adequate long term factors of safety for the stability of the new terminal structure. Some settlement of the fill (200 mm) would occur over the construction period.

Dredging for the berthing basin would be a sufficient distance (>35 m) from the Parallel Runway to ensure no adverse effects on runway stability (**Appendix M**).

18.3.2 Soil Erosion

The majority of the construction works would involve reclamation and construction of the hardstand, berths and port infrastructure with expected negligible impact on soil erosion. However, construction of other infrastructure in the vicinity of Penrhyn Estuary would involve removal of vegetation and other activities that would disturb soils with the possibility of soil erosion.

Proposed construction activities that have the potential to disturb soil include:

- road infrastructure - including a bridge over the proposed channel from Foreshore Road to the new terminal, traffic signals and signage;

- rail infrastructure - including a railway siding adjacent to Penrhyn Road, railway line adjacent to Foreshore Road including culverts or bridges over the drains, and a railway bridge over the proposed channel to the new terminal;
- recreational areas - including a boat ramp, car park and pedestrian walkways / cyclepaths;
- movement of construction equipment and other vehicles within the construction zone; and
- installation of services, e.g. sewer, water etc.

18.3.3 Acid Sulphate Soils

Dredge Area

Organic-rich, fine grained sediment in the proposed dredged area may contain concentrations of sulphides that, if oxidised, could release acid leachate and heavy metals. However, this material is also geotechnically unsuitable for use in the reclamation. Large volumes of unsuitable fine grained sediment, identified in the geotechnical investigations, would therefore not be used for reclamation, but rather redeposited in Botany Bay below water level under stable, anoxic conditions.

Interpretation of logged boreholes has shown that the stratigraphy of the proposed dredge area consists of discontinuous lenses of fine-grained sediment that are spatially variable and difficult to selectively extract using standard dredging methods. As the dredging process extracts large volumes of sediment in a short period of time any small or discontinuous lenses of PASS would be thoroughly mixed with coarse sandy sediments during the dredging process. The mixed material would then be deposited in the reclamation area below water level under stable non-oxidising conditions.

Once the reclamation is above the water level, any sulphide contained within the sandy sediment matrix may be subject to oxidation. However the overall risk of adverse ecological effects from these oxidised PASS is considered to be low.

Penrhyn Estuary

Small areas containing yellow-brown, iron rich, cemented sands, typical of oxidised sulphides have been identified in sand dunes and salt marshes in Penrhyn Estuary during field inspections by URS personnel (20 June 2002). As the sand dunes in Penrhyn Estuary were created from medium to coarse sands dredged from Botany Bay, iron staining and cementation of the sand is probably related to oxidation of sulphides originally deposited in the Bay. Therefore, this material would no longer pose an environmental risk even if disturbed. However, the possibility of (unoxidised) sulphides remaining deeper in the sand dunes cannot be entirely discounted. Fine-grained sediment stockpiled prior to use in the habitat enhancement works within Penrhyn Estuary, may also have potential to produce limited amounts of acid leachate.

Some construction activities would be undertaken within Penrhyn Estuary, including the construction of the proposed rail line, earth works associated with the shorebird habitat enhancement and culverts. The proposed habitat enhancement for shorebirds would involve disturbance to the sand dune within Penrhyn Estuary. Sand in dunes elevated above the existing water table is at low risk of PASS conditions. However, sediment and soil currently below the water table disturbed during the earthworks for the proposed habitat enhancement activities in Penrhyn Estuary may have acid generating potential. Other proposed works in

Penrhyn Estuary would involve only minor disturbances to soil and sand dunes and are not likely to create a risk from PASS.

18.3.4 Sediment Contamination

Dredge Area

Sediment-bound contaminants in the proposed dredge area are generally low in concentration, therefore disturbance of sediment during the proposed dredging operations and remobilisation of existing low concentrations of contaminants is not likely to cause a significant risk to human health or the environment.

Some samples taken during the geotechnical investigations contained organotin compounds exceeding ANZECC (2000) ISQG values. However, these contaminants are not likely to cause a significant impact due to:

- natural degradation of these compounds over time;
- the strong affinity of these compounds to particulate material;
- analytical uncertainty (probable overestimation) of the reported concentrations;
- irregular spatial distribution;
- probable limited vertical extent of contamination; and
- concentrations of organotin compounds are expected to decrease over time as new restrictions on the use of organotin based products come into effect for commercial shipping.

Given the irregular spatial distribution and probable limited vertical extent of organotin contamination, and the fact that any contaminants would be thoroughly mixed with clean sand during the proposed dredging and reclamation activities, the presence of organotin in some samples would not pose a significant risk to human health, or the environment.

Penrhyn Estuary

Significant contamination of sediment has been identified in Penrhyn Estuary. These contaminants are generally affiliated with fine grained particulate material deposited below the mean high water mark within the Estuary. Contaminated sediment in Penrhyn Estuary would not be disturbed by the reclamation of the new terminal, although some construction activities would be undertaken within Penrhyn Estuary as previously described.

The proposed habitat enhancement for shorebirds would involve disturbance to the sand dunes within Penrhyn Estuary. However, the sand in these dunes is above mean high water mark and is at low risk of containing contaminated sediment. Sand from the dunes may be spread over the top of areas with existing contamination, capping and causing little disturbance to any contaminated sediment which may be located beneath.

Some activities may result in disturbance to sediment below the mean high water mark. These activities would include construction of culverts at Springvale and Floodvale Drains and creation of the main flow path through the Estuary. Disturbance of sediment during the proposed construction activities would result in only

localised and temporary remobilisation of contaminated sediment and is therefore not likely to cause a significant risk to human health or the environment.

18.4 Assessment of Impacts During Operation

18.4.1 Seismicity

The Australian record of seismic activity is short and the frequency of earthquakes is low, therefore predictions of the frequency and magnitude of earthquakes are imprecise. The largest historical earthquake in southeast Australia including the Greater Sydney Region was the Newcastle earthquake in 1989, which measured 5.6 on the Richter scale.

In a study of the seismic risk in NSW, the average recurrence interval of an earthquake generating velocities of 5 cm/s is between 300 and 1,500 years (McCue, 1978). Greig Fester (1997) estimated that the largest predicted earthquake for the Sydney Region is 5.6, within a timeframe of 500 to 1,000 years.

Geotechnical investigations have considered the impact of seismic disturbance on the proposed new terminal structure. Earthquake loadings of 0.08 g horizontally and 0.04 g vertically have been adopted from the *Australian Standard for Earthquake Loads* (*AS 1170.4*). There are no known faults or regional structural features at the site that create additional risks to stability of the new terminal construction.

Conclusions of preliminary stability analyses indicate that construction of the new terminal using hydraulically-filled sand contained in a rock embankment is feasible under predicted maximum earthquake disturbance, subject to certain requirements, including that the rock embankment slopes should not exceed 2H :1V and that (vibro) compaction of the sand fill be undertaken. Adequate minimum safety factors for the stability of the new terminal constructed using rock embankments would be maintained under earthquake loads (**Appendix M**).

18.4.2 Soil Erosion

The operations at the new terminal would take place on reclaimed and hard-surfaced pavement. There is no requirement for soil removal or disturbance during operation of the terminal. Stormwater collection and treatment systems would be designed to capture surface water runoff from all impervious surfaces. Therefore, the operation of the new terminal is expected to have minimal effects on soil erosion.

Soil in the vicinity of facilities outside the new terminal area, such as the proposed railway, boat ramp and car park, would be stabilised and erosion in these areas would be low.

18.4.3 Sediment Contamination

The proposed new terminal would significantly reduce wave energies, particularly local sea waves, and sediment transport at the existing mouth of Penrhyn Estuary (**Appendix H**). The resultant lower ambient energy would allow fine-grained sediment that is currently remobilised to accumulate in the extended area of Penrhyn Estuary. A reduction of ambient energies in Penrhyn Estuary would therefore likely increase the total area of the estuary enriched in sediment-bound contaminants.

Sediment-bound contaminants such as mercury and HCB have potential to accumulate in biota and are therefore considered to be contaminants of concern in Penrhyn Estuary. However, despite existing high concentrations of sediment-bound contaminants in Penrhyn Estuary, the risks posed to human health are considered to be low due to the limited exposure pathways. Additionally, mercury and HCB were derived from historical sources in the catchment that have ceased contribution to the Penrhyn Estuary. Maximum concentrations of these contaminants are expected to gradually decrease in surficial sediment from dilution by new material of lower concentration. Sediment traps being considered for Springvale and Floodvale Drains may assist in reducing any sediment bound contaminant influx to the Estuary.

Leaks and spills from operations at the new container terminal would be contained by the proposed stormwater detention and treatment system. There is low potential for leaching of contaminants through the hard stand areas. Environmental management measures would be included in the Operational EMP.

18.5 Mitigation Measures

18.5.1 Construction

Acid Sulphate Soil

The overall risk to human health and the environment from ASS is considered to be low for the proposed development. Risks of adverse effects would be managed as appropriate and mitigation of PASS from dredged estuarine sediment would be achieved by:

- ensuring that large areas of organic-rich, fine grained sediment PASS identified from the geotechnical assessments would be returned below water level in Botany Bay under stable anoxic conditions; and
- sediment with high acid generating potential, if any, would not be allowed to oxidise in onshore stockpiles (e.g. any material set aside for Penrhyn Estuary enhancement works).

On the basis of the requirements of the *Acid Sulphate Soil (ASS) Manual* (NSW Acid Sulphate Soil Management Advisory Committee, 1998), an acid sulphate soil management plan (ASSMP) would be prepared to mitigate PASS and AASS within Penrhyn Estuary.

A preliminary assessment of the risks associated with the disturbance of soils within Penrhyn Estuary would be conducted prior to the development of any excavation works in accordance with the ASS Manual to:

- obtain an indication of the severity of PASS and AASS in soils potentially disturbed by habitat enhancement and along the rail line route; and
- provide appropriate procedures for testing and disposal (if required).

Assessment of the extent, distribution and severity of PASS and AASS within Penrhyn Estuary would include:

- the collection of soil samples in areas where the soil is expected to be exposed (if any) by construction activities and field screening for in-situ pH and pH following oxidation, using a 30% hydrogen peroxide solution;
- logging of the soil profile at each sampling point; and

- laboratory analysis of selected samples for total actual acidity (TAA), total potential acidity (TPA), chromium reducible sulphur (CRS) and "POCAS" analysis. Samples would be selected for laboratory analysis on the basis of field screening results.

The laboratory analytical results would then be compared with Action Criteria provided in the ASS Manual. The adopted Action Criteria would be dependent upon the nature of material likely to be disturbed during construction.

If laboratory results were found to exceed the Action Criteria, an ASSMP would be prepared. The ASSMP would detail the approach to treatment of disturbed AASS and PASS and would be included in the Construction EMP. The primary approach in the ASSMP would be to place PASS below the water table to prevent oxidation. Should AASS be encountered, they would be treated with lime and disposed of off site, or placed below capping layers. Validation sampling would be undertaken on treated AASS, to confirm the adequacy of the treatment process prior to disposal.

Soil Erosion

An SWMP would be developed in the detailed design phase to ensure an adequate standard is applied to erosion and sediment control for the construction of the Port Botany Expansion.

The SWMP for construction would be based on the *Managing Urban Stormwater- Soils and Construction Manual* (Department of Housing 1998) and would be incorporated in the Construction EMP. All work would be carried out to avoid erosion and sedimentation of the site and the surrounding areas. Erosion and sediment control measures would include:

- temporary structures to prevent offsite movement of sediment such as sedimentation ponds and silt fences surrounding stockpiles;
- control of drainage from areas adjacent to construction areas using earth bunds and diverting structures such as earth drains;
- dust minimisation using collected stormwater where possible;
- cessation of work, or implementation of further suppression measures if excessive fugitive dust emissions are observed;
- minimisation of traffic in construction zones and a dedicated parking area;
- removal of soil from vehicle wheels and undercarriages; and
- sealing and revegetation of all disturbed surfaces as soon as practical to prevent extended exposure to erosion.

Erosion and sediment control planning and implementation would apply to all areas which may be disturbed. Regular inspections would occur after heavy rain and during periods of prolonged rainfall.

Contamination

To reduce the potential for dispersion of existing sediment-bound contaminants in Penrhyn Estuary, disturbance of sediment would be limited. Construction works would not be undertaken during periods of high flow in Floodvale and Springvale Drains, or during heavy rainfall events. Erosion control measures outlined above would also be implemented to control dispersion of sediment in disturbed areas.

18.5.2 Operation

The operation of the new terminal would have minimal effects on geology, soils and geotechnical issues. Once operational, all terminal activities would be conducted in a manner to prevent soil erosion and contamination from operational activities.

A SWMP would be developed as part of an Operational EMP to ensure an adequate standard is applied to sediment control for the operation of new terminal. This plan would also address stormwater management and be prepared in accordance with NSW EPA requirements. The SWMP for operations would be incorporated in the Operational EMP. Management measures would include:

- a first flush system to capture sediment and contaminants from surface water runoff from the new terminal;
- treatment of surface water runoff from potential pollutant areas on the new terminal by a wastewater treatment system prior to discharge to sewer;
- investigation of the feasibility of installation of sediment traps on Floodvale and Springvale Drains to reduce influx of sediment to Penrhyn Estuary;
- emergency response plan for fuel, oil and chemical spills; and
- storage and handling of all dangerous goods in accordance with Australian Standards, Dangerous Goods Regulations and NSW EPA requirements.

18.6 Conclusion

Geotechnical studies have assessed the suitability and seismic stability of the reclamation area. Ground conditions are suitable for the proposed reclamation and berth structures given adoption of appropriate design and construction techniques. Stability of the reclaimed area for the new terminal would be managed by appropriate design of the rock embankment and compaction of sand fill. Dredging activities would not impact on the stability of the Parallel Runway.

Erosion and subsequent transportation of sediment would be managed as part of a Soil and Water Management Plan and is unlikely to create significant environmental impact.

Any PASS within the dredged area would be contained within the reclamation, or kept below the water level to prevent oxidisation. Some limited disturbance of PASS may occur within Penrhyn Estuary, however, with the implementation of appropriate mitigation measures, any impacts associated with construction activities in this area would be minimal.

Summary of key outcomes:

The proposed Port Botany Expansion would result in the following broad scale changes within the study area:

- a large increase in the amount of solid artificial structure with opportunities to enhance some of the structures to increase their biodiversity;
- a significant increase in the amount of saltmarsh habitat representing an increase of about 4% in area in Botany Bay;
- an initial loss of about half the remaining seagrass in the core study area, but in the longer term creation of up to twice as much seagrass habitat as will be lost by the development;
- a small decrease in intertidal beach habitat, but a large increase in sandy intertidal flats at Penrhyn Estuary;
- loss of a small stand of mangroves in Penrhyn Estuary representing less than 0.1% of mangroves within Botany Bay; and
- loss of a previously dredged hole and some areas of shallow subtidal sand habitat with the corresponding creation of a deep basin as an extension to the existing navigation channel.

An assessment of the likely impacts from the Port Botany Expansion concluded that a Species Impact Statement was not required for the proposal in respect of threatened species, populations or communities, as listed under the NSW *Fisheries Management Act 1994,* the NSW *Threatened Species Conservation Act 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Apart from levelling some high spots within the existing navigation channel, there would be no physical changes to the Bay outside the study area. In addition, aquatic habitats elsewhere in the Bay would not be affected by the Port Botany Expansion. Changes in wave energy and direction are predicted to be small, with negligible effect on sensitive habitats such as Towra Point Aquatic Reserve.

There would be no change to freshwater ecosystems associated with the Mill Stream or Sir Joseph Banks Park and fish passage would not be impeded. There would be no impact to commercial fishing, however, there would be a loss of about 1.5% of Bay waters for recreational fishing. The new boat ramp and recreational area would, however, enhance the fishing amenity in this area.

The proposed port expansion has been designed with the aim of minimising damage to aquatic habitats and, where possible, enhancing habitats. Monitoring and feedback to manage impacts of the proposal would be undertaken before, during and after construction of the new terminal.

19.1 Introduction

The impacts of the proposed Port Botany Expansion on the aquatic environment and fishing activities in the study area and Botany Bay as a whole were assessed and mitigation measures identified to ameliorate any potential impacts.

This chapter describes: the existing aquatic environment; the effect of human activities on the aquatic environment; and the threatened species, populations and communities present. It also assesses the impact of the proposed Port Botany Expansion on the aquatic environment and fishing activities. This chapter is based on a report by The Ecology Lab Pty Ltd titled *Port Botany Expansion Aquatic Ecology, Conservation & Fisheries,* which is presented in full in **Appendix N**.

19.2 Methodology

Assessment of impacts on the aquatic environment of Botany Bay was based on literature reviews of biota listed as occurring, or potentially occurring, at the site or in the vicinity, a program of field mapping and sampling and liaison with tertiary research organisations. The methodology employed in the study is outlined below.

The study area, for the purpose of the aquatic assessment, is defined as that part of Botany Bay between the southern tip of the Parallel Runway and the southwestern tip of Molineux Point. The study area was generally limited to those areas that would be impacted upon as a result of the proposed works. However, issues associated with wetlands in the catchment of the Mill Stream, some high spots within the current navigation channel that are proposed to be dredged and, more generally, the whole of Botany Bay, were also considered as they may be affected by changes in physical or ecological processes. Towra Point Aquatic Reserve was given special consideration due to its high conservation value.

19.2.1 Literature Review

The results of previous ecological studies conducted within Botany Bay and in the vicinity of the study area were reviewed to assist with describing the aquatic environment of the Bay for the purposes of assessing the effects of the proposed Port Expansion on this environment.

The FM Act, the TSC Act and the Commonwealth EPBC Act were reviewed to determine the likely presence of threatened species and their habitats, as well as threatened populations and ecological communities, which may occur within Botany Bay and the study area.

19.2.2 Site Inspections

During the investigations for this study, several sites were inspected with the objective of providing a description of the presence and distribution of habitats within the study area. All areas inspected were within or very close to the study area, with the exception of Quibray Bay, which was considered to have some of the ecological features that might develop in Penrhyn Estuary as a result of the proposed port expansion.

Each site was visited by boat between April and June 2002. Notes were made of aquatic habitats present and water quality parameters were measured at some locations. Parameters included dissolved oxygen, pH, salinity, temperature, turbidity and redox potential. Water quality results were compared to the ranges of

default trigger values recommended in the ANZECC (2000) water quality guidelines. Water depths were also measured.

19.2.3 Mapping of Seagrass

Mapping of seagrass off Foreshore Beach from the entrance of the Mill Stream to Penrhyn Estuary, and along the eastern edge of the Parallel Runway was undertaken to determine their present composition and extent and to assess the impact of the Port Botany Expansion on seagrass habitat within the study area.

19.2.4 Supplementary Intertidal and Subtidal Investigations

Due to the lack of information on benthic invertebrates in Penrhyn Estuary, additional surveys were undertaken in sandy intertidal and shallow subtidal habitats. Sediment samples were taken at five locations along the intertidal portion of Foreshore Beach and subtidal samples were collected from Penrhyn Estuary, Quibray Bay and near Towra Point. All samples were analysed for benthic fauna. Samples were collected in October 2002. These studies were primarily undertaken to contribute to the baseline of information for assessing, and later monitoring, the effects of the proposed Port Botany Expansion. The results of the intertidal and subtidal investigations are discussed in Section 19.6.2.

19.2.5 Survey of Oysters in Relation to TBT

A survey of wild oysters was undertaken on 18 July 2002, to determine if the proportion of wild oysters showing deformities consistent with tributyltin (TBT) toxicity was greater at sites close to the existing Port Botany container terminals compared to other parts of Botany Bay. The number of live oysters and the number of oysters showing deformities were recorded at four sites:

- the seawall at the front of the Patrick Stevedore container terminal, on the northwestern side of Brotherson Dock;
- the seawall at the southwestern end of Molineux Point;
- the end of the third groyne from the western end of Silver Beach; and
- the southern breakwater at the entrance to the Cooks River.

The results of the survey of oysters in relation to TBT are discussed in Section 19.6.1.

19.3 Existing Aquatic Environment

19.3.1 Aquatic Habitats in Botany Bay

Botany Bay contains a diverse array of aquatic habitats which potentially could be affected by the proposed port expansion. These habitats include:

- *The water column.* The water column provides a habitat for a highly diverse assemblage of plants and animals within Botany Bay. Plants include the seeds of seagrass and mangroves, spores of macroalgae and phytoplankton. Animals include permanent inhabitants and transient forms, such as fish and prawn

eggs and larvae. Apart from supporting a large variety of plants and animals, the water column is responsible for transporting essential items, such as food and oxygen to various habitats and for transporting wastes away from habitats.

- *Unvegetated soft sediments*. Soft, unvegetated sediments comprise the largest and most widespread habitat type within Botany Bay. These sediments provide habitat for mainly invertebrate animals (polychaete worms, amphipods and molluscs), which in turn are a supply of prey for wading birds and food for fish in deeper water. Shallow, soft-sediment habitats provide habitat for transient fish species of commercial value (tailor, southern herring, sand mullet, flat-tailed mullet and sea mullet) and non-commercial species including bait fish, gobies, hardyheads, perchlets, sprats and toad fish.

- *Hard substrata*. Originally, most of the northern shoreline of Botany Bay consisted of sandy substratum. The amount of hard substratum in the Bay has increased over time with the developments of Port Botany and Sydney Airport replacing sections of natural sandy shoreline with artificial hard structures. Limited information is available on the ecology of hard-substrata communities within the Bay, although much is known about the ecology of rocky intertidal and subtidal habitats at the entrance to the Bay (Cape Banks). Species lists available for these habitats suggest that communities on artificial surfaces are similar to those on natural rocky reefs, but often differ in the structure of the assemblage.

- *Algae*. A variety of algae occur in the Bay, including larger plants such as kelp and sargassum, smaller forms that attach to other algae or seagrass, weakly attached or drifting forms and forms that grow in soft sediments. The latter includes some introduced species, including the pest species, *Caulerpa taxifolia*.

- *Seagrass*. Seagrass are flowering plants adapted for subaquatic life and are considered of ecological importance. The most common seagrass in the study area is *Zostera capricorni*, while two species of *Halophila* and *Posidonia australis* are present but less common. The ecological functions of seagrass includes a significant contribution to the productivity of the ecosystem (King 1981; Zieman and Wetzel 1980), stabilising sediments (Keough and Jenkins 1995), providing food and habitat for fish and invertebrates (Zieman and Wetzel 1980; Bell et al 1987) and providing “nursery habitats” for recreationally and commercially important species of fish and invertebrates such as prawns and crabs (Pollard 1984; Bell and Pollard 1989; Larkum and West 1990; Smith and Pollard 1999).

  As part of this study, mapping of seagrass off Foreshore Beach from the entrance of the Mill Stream to Penrhyn Estuary, and along the eastern edge of the Parallel Runway was undertaken to determine their present composition and extent. The total area of seagrass in the study area was estimated to be about 9.7 ha. The majority of this area was comprised of *Zostera capricorni*. Three small patches of *Posidonia* were also present (**Figure 19.1**). *Halophila ovalis* was frequently present mixed with *Zostera* in the main bed, and *Caulerpa filiformis* and *Caulerpa taxifolia* were also present toward the southern end of the main bed. Seagrass were observed to grow in depths ranging from 0.72 m LAT to -2.65 m LAT.

- *Saltmarshes and mangroves*. Saltmarshes and mangroves occur at several places in Botany Bay. Currently, saltmarshes and mangroves are most common at Towra Point and Woolooware Bay. There are also large stands of mangroves and some small saltmarsh areas within Cooks River. Within the study area, saltmarsh and mangrove habitat is confined to Penrhyn Estuary. Anecdotal and pictorial evidence suggest that the mangroves in Penrhyn Estuary are currently expanding into areas of saltmarsh. Saltmarshes and mangroves used to exist at the entrance to the Mill Stream but were removed during construction of the Parallel Runway.

Source: the Ecology Lab Pty Ltd 2003

0 500m

Seagrass in the Study Area **Figure 19.1**

Areas of Seagrass (mainly *Zostera*)

Presence of *Posidonia australis*

- *Freshwater ecosystems*. The main flow of surface freshwater into Botany Bay is via the Georges River, of which the Woronora River is a large tributary. The catchment of these rivers is well to the west of the proposed port expansion and would not be affected by the proposal. Similarly, Cooks River and its current entrance are to the west of the airport runways and effectively isolated from the proposed development. The current entrance to the Mill Stream is to the northeast of the Parallel Runway. The mouth of the stream is subject to sedimentation from sand transported westwards along Foreshore Beach (The Ecology Lab 2001). The "estuarine" portion of the Mill Stream is effectively restricted to the main stream channel; further upstream a weir inhibits penetration of saline water. This weir also prevents movement of most biota, with the likely exception of eels (*Anguillidae*).

  The two creeks that flow into Penrhyn Estuary (Floodvale Drain and Springvale Drain) have freshwater habitat in their upper catchments. These drains are highly disturbed by surrounding development and contaminants from industry and their value as freshwater habitat is considered to be very limited.

19.3.2 Aquatic Habitats within the Study Area

Penrhyn Estuary

Penrhyn Estuary is a small tidal inlet to the north of Brotherson Dock. The Estuary is not a natural feature of Botany Bay, as it was formed from the reconfiguration of the northern shores of the Bay in the late 1970's as a result of the construction of Port Botany.

Penrhyn Estuary is essentially comprised of an inner estuary and an outer estuary. The inner estuary comprises a small shallow lagoon (approximately 1.4 m deep) with two drains (Floodvale and Springvale) flowing into the Estuary, from the industrial and residential catchments of Banksmeadow and Matraville, forming two distinct deltas. Sand and mud flats cover most of the shore and in some areas there are oysters on the mud flats. There is a derelict boat ramp on the eastern side of the inner estuary, with some rock rubble at the base of the ramp.

Towards the back of Springvale Drain, there are areas of mangroves ranging from juvenile seedlings to mature mangrove trees. Saltmarsh plants, *Sarcornia* spp and *Suaeda* are abundant on the shore fringing the more stable rush grass *Juncus kraussii* and *Isolepsis nodosus*. No seagrass were recorded in the inner estuary.

The inner and outer estuaries are connected via a narrow channel which has reduced in width in recent years due to the accretion of sand from Botany Bay. The outer estuary comprises four habitats:

- sand and silty intertidal flats on both sides of the estuary;
- unvegetated subtidal habitats ranging from sand in the shallows to dark silty mud in deeper areas to at least –3 m LAT;
- vegetated subtidal habitats, including seagrass and some algae, occurring from the low tide mark around the edges of the Estuary (seagrass beds (*Zostera capricorni*) are approximately 0.2 ha in area); and
- artificial substratum, including the new boat ramp and jetty on the eastern side of the outer estuary and a derelict rock groyne and wharf pilings at the western end of the Estuary (areas of seagrass (*Zostera capricorni*) surround these rocky structures).

The Mill Stream

The Mill Stream connects a large series of wetlands and ponds extending from Centennial Park to the Mill Pond. A weir several hundred metres upstream of the mouth forms a barrier to tidal exchange hence the estuarine portion is extremely limited. The presence of sewer overflows leads to very poor water quality during periods of rainfall.

The estuarine portion of the Mill Stream is completely channelised and contains soft sediment. There are no seagrass, mangroves or saltmarshes within the channel, although seagrass occur offshore from its mouth. A sand bar has accumulated at the mouth of the stream due to movement of sand westwards along Foreshore Beach. The presence of a weir upstream within the channel prevents movement of many species between Botany Bay and the wetlands further upstream. This habitat has been highly altered and is of limited ecological value.

Foreshore Beach

Foreshore Beach is a newly formed beach comprised of estuarine sands dredged from Botany Bay during previous Port Botany and Sydney Airport construction activities. The beach is currently eroding towards its eastern end, with sand migrating to the west and depositing at the mouth of the Mill Stream. The beach is significant in that groundwater from the surrounding aquifer enters the Bay via the beach. There are no mangroves growing along the beach.

Previous Dredged Areas and "High Spots" within the Navigation Channel

A deep hole previously dredged to provide fill for the Parallel Runway, and which would be reclaimed as part of the proposed port expansion, was inspected. Generally, the drop-off to the hole and the slope of the hole were similar to the surrounding sediments, being sandy, pale coloured and containing numerous burrows of invertebrates.

Several "high spots" within the existing navigation channel and turning basin for the port were also inspected to determine if there were any particular features of ecological significance present (beds of seagrass or macroalgae). Generally, the sea bed of the sites inspected consisted of fine sediments with animal burrows. No seagrass, algae (attached or drifting) or reef was observed.

19.3.3 Aquatic Habitats of Significance Elsewhere in Botany Bay

Towra Point Aquatic Reserve, a marine protected area, is situated on the southern shores of Botany Bay. This reserve, declared in 1987, contains most of the seagrass, mangroves and saltmarshes within Botany Bay and contains refuge areas from fishing. Previous programs of capital works, especially dredging the entrance to Botany Bay, have affected patterns of erosion at Towra Point, leading to the loss of seagrass beds. Studies conducted by NSW Fisheries (2001) and The Ecology Lab (1995) have provided a good basis for understanding changes in seagrass distribution at Towra Point Aquatic Reserve.

Quibray Bay, situated within the Towra Point Nature Reserve, contains extensive areas of mangroves and seagrass, particularly *Posidonia australis*. To the north of the Bay mangroves encroach on inactive oyster leases. Sediment on the bottom of the Bay is generally heavily bioturbated (has invertebrate burrows and mounds) and is covered in brown filamentous algae.

A small lagoon, similar in size to the inner lagoon at Penrhyn Estuary, is situated at the eastern end of Quibray Bay. At the mouth of the inlet to the lagoon there are extensive, dense mangrove stands and the floor of the inlet contains beds of *Zostera capricorni* amongst mangrove pneumatophores. Large beds of *Posidonia australis* are located on the north side of the lagoon and in the mouth of the entrance to the lagoon.

Silver Beach, to the east of Towra Point, supports large areas of seagrass, including *Zostera*, *Halophila* and *Posidonia*. In particular, there are large beds of *Posidonia* towards the western end of the beach. Other areas of interest that need to be considered are Lady Robinsons Beach, which has been subject to erosion/accretion as a result of previous capital works, and Cape Banks Scientific Marine Research Area, a highly valued area of scientific research into intertidal and subtidal reef ecology.

19.4 Human Activities and their Effects on the Aquatic Environment of Botany Bay

Botany Bay has been subject to many changes around its shoreline and within its catchment over the past two centuries. An understanding of the major changes is important for two reasons: it provides a framework for assessing the significance of impacts likely to occur as a result of the proposed port expansion and it assists in identifying where cumulative effects may occur. The broad issues related to previous human activities include:

- *Creation and removal of habitats*. Major physical changes within Botany Bay, primarily as a result of past port and airport activities and the construction of groyne fields at Lady Robinsons Beach and Silver Beach, have included realignment of streams entering the Bay, deepening of subtidal areas as a result of dredging for navigation and to obtain fill for large scale reclamations, and the introduction of hard surfaces to many intertidal and subtidal areas of the Bay. These physical changes have created and removed aquatic habitat and hence changed the occurrence, diversity and abundance of many assemblages.
- *Water quality and sediment contamination from industrial activities*. This includes catchment wide processes as well as specific issues related to industrial contamination. **Chapter 16** *Hydrology and Water Quality* and **Chapter 31** *Ecotoxicology and Human Health Risk* provide more detail on water quality and sediment contamination in Botany Bay and within the study area.
- *Introduced species*. These include toxic dinoflagellates which are associated with commercial shipping, and others whose origin is less clear such as the pest species *Caulerpa taxifolia*.
- *Fishing activities*. Including exploitation of stocks and habitat modification.
- *Shipping operations*. Potential hazards associated with the existing operations at Port Botany and Caltex Oil Refinery at Kurnell include berthing, loading and unloading of ships carrying dangerous goods and storage and handling of those goods. Impacts to the aquatic environment could include spillages, release of ballast water from ships, introduction of exotic species on ship hulls and antifouling paints, such as TBT, associated with container vessels and tugs that are based at the existing terminals.

19.5 Threatened Species, Populations and Communities

19.5.1 Threatened Species

Thirty-nine species of aquatic fauna listed under the FM Act, TSC Act and/or the Commonwealth EPBC Act have been recorded from the site or the vicinity. The status and habitat details of these species are described in **Table 19.1.**

Table 19.1 Significant Aquatic Species Recorded in the Study Area

SPECIES	STATUS *	HABITAT	CONSIDERATION#
Caretta caretta Loggerhead Turtle	E[2, 3]	Marine and bays	8-part test (generic)
Carcharias taurus Grey Nurse Shark	E[1] C[3]	Marine and bays	8-part test (specific)
Craterocephalus fluviatalis Murray Hardyhead	E[1]	Freshwater	Not relevant
Maccullochella ikei Eastern Freshwater Cod	E[1]	Freshwater	Not relevant
Maccullochella macquariensis Trout Cod	E[1]	Freshwater	Not relevant
Nannoperca oxleyana Oxleyan Pygmy Perch	E[1]	Freshwater	Not relevant
Notopala sublineata River Snail	E[1]	Freshwater	Not relevant
Pristis zijsron Green Sawfish	E[1], UC	Marine, bays and estuaries	8-part test (specific)
Balaenoptera musculus Blue Whale	E[2,3]	Marine	8-part test (generic)
Archaephyla adamsi Adams Emerald Dragonfly	V[1]	Freshwater	Not relevant
Bidyanus bidyanus Silver Perch	V[1]	Freshwater	Not relevant
Brachinella buchananensis Buchanans Fairy Shrimp	V[1]	Freshwater	Not relevant
Carcharodon carcharias Great White Shark	V[1, 3]	Marine, bays and estuaries	8-part test (specific)
Epinephelus daemelii Black Cod	V[1], UC	Marine, bays and estuaries	8-part test (specific)
Nannoperca australis Southern Pygmy Perch	V[1]	Freshwater	Not relevant
Chelonia mydas Green Turtle	V[2, 3]	Marine and bays	8-part test (generic)
Dermochelys coriacea Luth, Leathery or Leatherback Turtle.	V[2, 3]	Marine and bays	8-part test (generic)
Balaenoptera borealis Sei Whale	V[3]	Marine	8-part test (generic)
Balaenoptera physalus Fin Whale	V[3]	Marine	8-part test (generic)
Eubalaena australis Southern Right Whale	V[2] E[3]	Marine and bays	8-part test (specific)

SPECIES	STATUS *	HABITAT	CONSIDERATION#
Megaptera novaeangliae Humpback Whale	V[2, 3]	Marine and bays	8-part test (specific)
Physeter catadon Sperm Whale	V[2]	Marine	8-part test (generic)
Rhincodon typus Whale Shark	V[3]	Marine	8-part test (generic)
Eretmochelys imbricata Hawksbill Turtle	V[3]	Marine and bays	8-part test (generic)
Epinephelus lanceolatus Giant Queensland Grouper	P	Marine, bays and estuaries	Separate
Epinephelus coioides Estuary Cod	P	Marine, bays and estuaries	Separate
Anampses elegans Elegant Wrasse	P	Marine and bays	Separate
Paraplesiops bleekeri Eastern Blue Devil	P	Marine, bays and estuaries	Separate
Macquaria australisica Macquarie Perch	V[1]	Freshwater	Not relevant
Chaetodontoplus ballinae Ballina Angelfish	P	Marine.	Not relevant
Odontaspis ferox Herbst's Nurse Shark	P	Marine	Not relevant
Phyllopteryx taeniolatus Weedy Sea Dragon	P	Marine, bays and estuaries	Separate
Brachaelurus colcloughi Colclough's Shark	UC	Marine	Separate
Brachionichthys hirsutus Red Handfish	UC	Marine	Separate
Sympterichthys sp. Zeibell's Handfish	UC	Marine and bays	Separate
Centrophorus moluccensis Endeavour Dogfish	UC	Marine	Separate
Centrophorus uyato Southern Dogfish	UC	Marine	Separate
Cheilinus undulatus Humphead Maori Wrasse	UC	Tropical and subtropical reefs	Separate
Raja sp. Maugean Skate	UC	Marine and bays	Separate

Note:
#Specific = species identified as requiring an individual Eight part test, Generic = species tested as part of a group of species, Separate = not subject to an 8 part test but requiring further assessment, Not Relevant = assessed at this stage not to be affected by the proposal (not relevant).
** Conservation Status is as follows: C = Critically Endangered, E = Endangered, V = Vulnerable, UC = Fauna under consideration (EPBC Act). These species are not currently subject to Eight Part Tests. P = Protected (FM Act). These species are not subject to Eight Part Tests. Where: 1 = listing under FM Act 1994, 2 = listing under TSC Act 1995, 3 = listing under EPBC Act 1999*

Of the 39 species in the vicinity of the study area listed as having conservation significance, seven are listed as Endangered, seven are listed as Vulnerable and seven are listed as Protected under the FM Act. Two are listed as Endangered and five are listed as Vulnerable under the TSC Act. One is listed as Critically Endangered, three are listed as Endangered, eight are listed as Vulnerable and nine are listed as "fauna under consideration" under the EPBC Act.

Fauna listed as Protected under the FM Act or as fauna under consideration under the EPBC Act are not subject to eight part tests.

Assessment of whether there is likely to be a significant effect on threatened aquatic fauna species or their habitat from the proposal as required by section 5A of the EP&A Act (i.e. eight part tests) has been applied to the seven marine species, namely the Grey Nurse Shark, Great White Shark, Green Sawfish, Black Cod, Southern Right Whale, and the Humpback Whale. Species which were considered in terms of generic eight part tests were within two groups, namely marine turtles and marine mammals plus whale sharks. For the purposes of the generic eight part tests, the ecological requirements of these groups were considered to be similar enough that several species could be evaluated together. The study area does not represent suitable habitat for the remaining species. These species are consequently not considered further in this assessment.

The eight part tests concluded that preparation of an SIS was not required for the proposal in respect of any of these species or groups of species, but that environmental management could and should accommodate the potential for threatened species to occur within Botany Bay from time to time. A full section 5A assessment is provided in **Appendix N**.

Species likely to be of some concern include Southern Right Whales and Humpback Whales. Both these species enter Botany Bay from time to time and their occurrence is often well documented, but so far there do not appear to have been any adverse incidents with commercial shipping.

The Black Cod often utilises rocky structures within estuaries. The emplacement of rubble seawalls would therefore represent an increase in suitable habitat that may favour the species.

Ghost pipefishes, pipefishes and seahorses occur on rocky reefs and seagrass beds (Kruiter 1993) and would therefore be affected by the proposal, due to disturbance of seagrass. The management of pipefishes and seahorses would be linked to that for seagrass and macroalgae.

All the other species considered in the eight part tests are most unlikely to show any effect as a result of the proposed port expansion.

19.5.2 Threatened Populations

Under the TSC Act, there is an endangered population of little penguins at Manly Point, in Sydney Harbour. Adults from this population could be expected to range 10 to 30 km from Manly while hunting prey (NSW NPWS 2002) and it is possible that they could travel as far as Botany Bay.

It is unlikely that the habitat within the area proposed for the expansion would be particularly significant for the Manly population of little penguins. Moreover, the types of impacts associated with the project such as shipping and dredging would be similar to disturbances that have occurred or are currently occurring in Sydney Harbour, where the endangered population exists. On this basis, it is considered that the Manly population of little penguins does not require special consideration in relation to the proposed port expansion.

19.5.3 Threatened Ecological Communities

Under the TSC Act, Sydney Freshwater Wetlands in the Sydney Basin Bioregion are scheduled as an endangered ecological community. The Mill Stream forms a series of interconnecting ponds extending northeast from Sydney Airport to Eastlakes, Pagewood and Daceyville. Ponds also exist within Sir Joseph Banks Park which extends along the northern side of Foreshore Road from Botany to Banksmeadow.

Under the proposed expansion of Port Botany, there would be no direct impact on the wetlands associated with the Mill Stream or Sir Joseph Banks Park.

One potential risk to the wetlands associated with the Mill Stream, or Sir Joseph Banks Park is that the construction of the new facilities may affect groundwater levels, which could then affect water levels within the wetlands. Groundwater issues have been addressed for the proposed port expansion in **Chapter 17** *Groundwater* and **Appendix L**. Modelling shows no change to groundwater within the Mill Stream. At some of the ponds within Sir Joseph Banks Park there would be a maximum predicted increase in water level of 0.06 m. This increase is small compared to the natural variation in pond water level (at least 0.54 m) and hence is unlikely to affect the distribution of aquatic habitat, or aquatic flora and fauna, within these ponds.

19.5.4 Key Threatening Processes

The FM Act, the TSC Act and the EPBC Act provide for the identification and listing of Key Threatening Processes. These are processes that threaten the survival, abundance or evolutionary development of a native species or ecological community.

Key Threatening Processes listed under the FM Act that may operate on site include:

- introduction of fish to freshwaters in a river catchment outside natural range;
- removal of large woody debris; and
- degradation of native riparian vegetation along NSW water courses.

Key Threatening Processes listed under the TSC Act that may operate on site include:

- predation by mosquito fish *Gambusia holbrooki*.

Key Threatening Processes listed under the EPBC Act that may operate on site include:

- injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.

In most, if not all cases, the key threatening processes identified under the TSC Act, FM Act and EPBC Act are unlikely to be associated with the proposed expansion of the port facilities.

Under the FM Act, a key threatening process is the introduction of fish to freshwaters outside their natural range. The potential for species that can tolerate freshwater being introduced via ballast water or ships' hulls has been considered in this assessment in terms of managing exotic species.

There would be no removal of woody debris or degradation of riparian vegetation as part of the proposal.

Given that groundwater changes are insignificant, the effect on the distribution of mosquito fish is not relevant to the Port Botany Expansion.

Harmful marine debris consists of plastic garbage washed or blown from land into the sea, fishing gear abandoned by fishers and solid non-biodegradable floating materials (such as plastic) disposed of by ships at sea. Disposal of plastics by ships at sea is prohibited by the *International Convention for the Prevention of Pollution from Ships*. Therefore, ships visiting the Port Botany Expansion would not increase the risk of injury and/or fatality to vertebrate marine life within Botany Bay. Furthermore, waste management protocols would be adopted during the construction and operation of the Port Botany Expansion in accordance with Waste

Management Plans to minimise the potential for harmful marine debris to enter Botany Bay as described in Chapter 34 *Waste*.

19.6 Assessment of Impacts

19.6.1 Potential Physical, Chemical and Biological Stressors

There are a number of potential stressors associated with the proposed port expansion that may affect the aquatic habitats, flora and fauna within the study area or even throughout Botany Bay. Many of these have been addressed elsewhere in this EIS, particularly in **Chapter 15** *Hydrodynamics and Coastal Processes*, **Chapter 16** *Hydrology and Water Quality*, **Chapter 17** *Groundwater* and **Chapter 18** *Geology, Soils and Geotechnical.*

Wave Energy and Water Circulation

Predicted changes to wave energy and direction as a result of the Port Botany Expansion were modelled by Lawson and Treloar (2003) (**Chapter 15** *Hydrodynamics and Coastal Processes* and **Appendix H**). The modelling showed that changes in waves, currents and coastal processes would generally be confined to the area of the Bay between the Parallel Runway and Molineux Point, that is, the study area. The predicted changes in wave energy and direction are not predicted to impact upon the aquatic ecology of the study area. Any changes at potentially sensitive areas, such as Silver Beach, Towra Point and Lady Robinsons Beach would be imperceptible in relation to the existing conditions and hence are not of concern in relation to aquatic ecology.

Modelling by Lawson and Treloar concluded that there would be very little change in the tidal prism of the Bay due to the proposed expansion. Tide heights in Penrhyn Estuary are, and would be, the same as in the rest of Botany Bay. Since these heights are unchanged, the tidal penetrations in Springvale and Floodvale Drains would also remain the same.

Water and Sediment Quality – Dredging and Reclamation

The physical and chemical characteristics of water and sediments can be affected by dredging and reclamation in several ways, including:

- decreases in water clarity related to increased concentrations of suspended sediments. This issue is particularly important for the present proposal in order to protect the remaining seagrass (other than those that would be directly affected) from potential damage;
- changes in chemical properties, such as pH and dissolved oxygen;
- mobilisation of nutrients and toxicants present within disturbed sediments. Potentially, nutrients could trigger algal blooms (either planktonic or benthic) whilst toxicants could:
  - cause direct mortality to aquatic biota;
  - impede the ability of biota to withstand or avoid other stressors (natural or anthropogenic); and
  - bioaccumulate and therefore affect organisms that may consume plants or animals that have accumulated those toxicants.

The extent to which these effects would actually occur is largely dependent on the type of sediment being dredged, the presence of potential contaminants and the method of dredging, including any containment devices used. In addition, there may be similar impacts on water quality in locations where dredge spoil is to be disposed of.

Assessment of the material to be dredged indicates that most of it is sandy with low levels of contamination. Most of the dredging would be done hydraulically, which means that there would be limited potential for a plume to develop at the dredge head (most of the slurry is drawn up into pipes and pumped to the reclamation point (refer to **Chapter 8** *Construction*).

At the terminal site, the dredged material would be deposited above the seabed. The reclamation would be bounded by a rock perimeter which would essentially form a sill around the sand. Using this methodology, it is predicted that any plumes generated by the operation would have low turbidity. A silt curtain would also be used to further reduce any sediment plumes associated with the dredging and reclamation.

Geotechnical investigations have concluded that there is some potential for acid-generating soils to be disturbed by the dredging process (refer to **Chapter 18** *Geology, Soils and Geotechnical*). The investigations concluded that this would not be problematic because most of the material would remain underwater and hence have reduced capacity for oxidation. For sediments deposited above the water level (i.e. at the top of the reclamation and estuary enhancement works), any acids generated would tend to permeate through the sands below. The natural buffering capacity of estuarine water would help to neutralise any acids.

Water and Sediment Quality - Operation of the Port

Activities during port operations which have the potential to affect water and sediment quality could result from chemical spills, fuel or oil leaks from port equipment, spill or leak from onsite diesel storage, and contaminated firewater runoff. Chapter 16 *Hydrology and Water Quality* discusses environmental management measures that would be implemented to minimise the impact of the operations of the Port Botany Expansion on water and sediment quality.

As outlined in **Chapter 32** *Emergency and Incident Management*, Sydney Ports Corporation is required to have established management plans for dealing with spillages in relation to commercial shipping. In addition, there would be a boom permanently placed at the entrance to Penrhyn Estuary that would protect the Estuary in the event of an oil spill.

Water and sediment quality could also be affected through the use of antifouling paints. Antifouling is required to ensure the efficiency of vessels, by maintaining low water resistance and to reduce the risk of transferring biota from one port to another. Approximately 70% of the world fleet is currently protected with modern TBT based antifouling paint. Therefore, most of the ships visiting Port Botany use TBT antifouling paints. An increase in the number of vessels using the new terminal would likely lead to an increase in TBT concentrations in Botany Bay.

In November 1999, the International Maritime Organization (IMO) agreed that a treaty be developed by the MEPC (Maritime Environmental Protection Committee) to ensure a ban on the application of TBT based antifouling paints by January 1, 2003, and a ban on the use of TBT by January 1, 2008. It is, therefore, reasonable to predict that existing impacts in relation to TBT will dissipate as the global ban is implemented and alternatives become more widely used.

A survey of oysters was undertaken to determine if the proportion of wild oysters showing deformities consistent with TBT toxicity is greater at sites close to the existing Port Botany compared to other sampled parts of Botany Bay. The study found that the percentages of deformities within the Bay are relatively small compared to areas elsewhere known to be heavily affected by TBT. Nevertheless, it would appear that past use by recreational vessels, commercial vessels and/or the tugs based in Port Botany are leaching TBT, which is affecting oysters and possibly other components of the aquatic environment.

Under the proposed port expansion, Penrhyn Estuary and the Mill Stream would continue to discharge water from the surrounding catchments, as at present. Given that there would be no changes to the catchment of the Mill Stream as a result of the Port Botany Expansion and that changes to the entrance of the channel would be relatively small, no changes to water or sediment quality are predicted as a result of the proposal.

Water quality in Penrhyn Estuary was modelled by Lawson and Treloar (2003) (**Appendix J**) for TN, TP and Fc in ambient and transient conditions. The results predicted that at most locations, concentrations under transient conditions would exceed ANZECC (2000) guidelines, as they already do. Under ambient conditions, TP and TN would increase compared with existing levels but are well within the ANZECC (2000) guidelines at all locations.

It is not possible to predict with precision the effects of changes in nutrient concentrations on algal blooms, however, the changes are likely to increase the probability of blooms. The likelihood of a bloom occurring at any one time would depend on conditions, including the presence of species capable of rapid response, light intensity, rainfall, and temperature. Given the relatively small size and shallowness of the estuary, blooms of phytoplankton are unlikely to be problematic. Blooms caused by toxic algae from ballast water (e.g. species such as *Alexandrium tamarense*, *A. minutum*, or *Gymnodinium catenata*) would be unlikely given that very little deballasting occurs at the container berths (refer to **Chapter 16** *Hydrology and Water Quality*). Ballast water discharged into Botany Bay must be considered “low risk”, otherwise ballast water must be treated on-board or released at sea.

A more plausible effect of increased nutrients would be to increase the amount of macroalgae growing on the floor of Penrhyn Estuary. Such “nuisance” algae could include several groups, including *Ulva*, *Enteromorpha*, *Chaetomorpha*, *Colpomenia* and *Gracilaria*. These cause blooms, particularly during late winter and spring in other estuaries in NSW e.g. Narrabeen Lagoon, Quibray Bay, Shoalhaven River (The Ecology Lab, pers. obs.). Typical impacts of these algae are to smother seagrass and, when they rot, to cause offensive odours. This issue would be addressed as part of the Operational EMP and is considered further in Section 19.7.

As a result of the proposed Port Botany Expansion, there would be an increase in volatile hydrocarbons (VHCs) upstream of the channel between the inner and outer parts of Penrhyn Estuary and the area where VHCs occur at concentrations above the laboratory reporting level would increase. This issue is discussed in detail in **Chapter 31** *Ecotoxicology and Human Health Risk*.

Noise, Vibration and Light

Noise barriers and restricted lighting would be installed to minimise effects of the proposed port expansion on shorebirds. It is likely that these devices would also be suitable for minimising effects on fish and invertebrates. Vibration would occur as a result of construction and operation of the new terminal. Most aquatic animals would tend to habituate to the changes in noise and vibration, therefore, impacts could be considered as low.

A possible exception to this could be effects on marine mammals during construction. For example, if Southern Right Whales enter the port during construction their behaviour may be affected by noise associated with dredging and pile driving. At such times, the underwater noise associated with pile driving may be acute in relation to Southern Right Whales. However, given the intermittent occurrence of this species in Botany Bay a Marine Mammal Management Plan would be developed to respond to the presence of whales within the Bay.

Introduced Species

There appear to be no aspects of the proposal likely to enhance the risk of the introduction of exotic species, other than an increase in risk associated with greater numbers of vessels using Port Botany. In terms of introduced species already in Botany Bay, there is some risk of changes in distribution associated with the proposed port expansion for:

- toxic dinoflagellates that are present as cysts in sediments that would be dredged; and
- *Caulerpa taxifolia* presently occurring along Foreshore Beach.

It is probable that toxic dinoflagellates were introduced originally into Botany Bay via commercial shipping. Dredging has the potential to mobilise cysts currently dormant within the sediments. The likelihood of this occurring is relatively small for two reasons. First, cysts are most likely to settle in deep areas with little water circulation. Most of the dredging would be in shallower water. In fact, the reclamation would cap a deep hole and so may bury cysts occurring within that hole. Second, the sediment would be transported via a pipeline and deposited via a discharge pipe below the water into the reclamation area. Once the dredging penetrates below the recent depositional zone of the sediments (i.e. greater than 1 m below the sediment surface) it is highly unlikely that there would be any more cysts present.

Caulerpa taxifolia was found along Foreshore Beach during the field studies for the proposed port expansion. The amount of growth was small, but it is known to be capable of increasing rapidly, with the potential to replace seagrass and other species of macroalgae. Dredging and reclamation activities could lead to fragmentation of plants which could then be transported to other areas and become established. This issue can be managed by a combination of chemical and mechanical treatment and appropriate disposal as discussed in Section 19.7.

19.6.2 Effects on Aquatic Flora and Fauna

The Water Column and Fish Passage

The water column is important for the transport of food, nutrients and propagules, transmission of light through the water and to the sea bed, removal of waste products of aquatic biota, and dispersal of contaminants from existing sources.

Aquatic habitats within the study area would have access to tidal waters, enabling exchange between these habitats and Botany Bay and the coastal environment. Springvale and Floodvale Drains would flow into Botany Bay via Penrhyn Estuary and the main channel into the Estuary.

Fish passage is important to enable fish and invertebrates access to spawning sites, nursery habitat and feeding grounds. Some fish species in NSW travel to and from freshwater and barriers can cause local

population extinctions. In Penrhyn Estuary, access needs to be considered in relation to movement between the Estuary and Botany Bay, and the movement between Springvale and Floodvale Drains and the Estuary and into Botany Bay. Fish passage would generally not be altered under the proposed port expansion.

The freshwater habitats of the drains are limited in size, restricted in diversity and polluted. They are also subject to very rapid flushing due to the highly cleared catchment. Therefore, there would be few fish that access the drains (e.g. some eels, mosquito fish, gudgeons and mullet) and fish passage is not likely to be a major issue into and out of the drains.

Fish sampling in the existing brackish portion of Penrhyn Estuary indicates usage by a variety of fishes such as sea mullet, sand mullet, flat-tail mullet, yellowfin bream, tarwhine and silver biddies. These species would use the Estuary for a variety of functions, including shelter and feeding. Currently, access to the inner Estuary is restricted to a narrow shallow channel at low tide, but with access at high tide unrestricted.

Under the proposed expansion, the main access to Penrhyn Estuary would be via a tidal channel parallel to Foreshore Beach, which would be about 1.5 m deep at low tide. Within the Estuary, there would be a small channel developed for the flow of water from the drains and a deeper lagoonal area to promote the growth of seagrass.

The access channel parallel to Foreshore Beach would be sufficiently deep to enable access by fish. It is possible that fish could be affected by any powerful lights shining on the channel at night. It would therefore be preferable to have strong lights facing away from the channel.

The flow channel within the Estuary would be large enough to permit access by freshwater fish, particularly at high tide. The extent to which fish can use the seagrass lagoons would depend on their depth. Anything more than about 1 m deep would be used by a variety of large and small fish. The design of the seagrass habitat takes this into account as it would be covered during low tide and water would be able to drain into the access channel to prevent any stranding of larger fish.

Soft, Unvegetated Sediments

Foreshore Beach forms a large, continuous habitat that extends from Penrhyn Estuary to the mouth of the Mill Stream. Under the proposed port expansion, the beach would be essentially cut in two at the location of the new boat ramp and recreation area. There would be a small loss of sandy intertidal habitat at the ramp, but the amount of similar habitat created in Penrhyn Estuary would be far greater than the small amount lost.

The beach to the east of the boat ramp would be adjacent to the new terminal and would become very sheltered from waves. Under these conditions, the pattern of erosion and accretion would cease at the eastern portion of the beach and be largely unchanged for the western portion.

Given that the western beach would have a similar aspect to the present condition, it is to be expected that similar types of benthic assemblages would be present following construction of the new terminal. Assemblages colonising the beach adjacent to the terminal and in Penrhyn Estuary would be likely to reflect a more sheltered, estuarine habitat. Surveys of benthic invertebrates in the intertidal zone indicate a relatively diverse assemblage of organisms, particularly in sheltered locations around Penrhyn Estuary.

Subtidally, dredging and reclamation would replace a large area of shallow sandy habitat with deeper soft sediments. The dredging would cause a temporary loss of benthic productivity whilst the reclamation would cause a permanent loss of productivity within the terminal footprint. Importantly, the area to be dredged

would not form an isolated, deep hole, but would be connected to the main navigation channel and hence to the Bay and adjacent coastal environment. Thus, there would be a good exchange of water and larval invertebrates available for colonisation. Notwithstanding this, it is likely that the benthic assemblages colonising the dredge hole would be different to those currently existing within the shallower areas (*cf.* AMBS 1993, 1998). Based on the studies done by the Australian Museum, colonisation of the dredge holes would be rapid, that is a timescale of months, but "recovery" to a condition that could be considered representative of this type of deep habitat could take in excess of two years (AMBS 1998).

In addition to benthic invertebrates, it is also likely that fish assemblages in the dredge hole would differ to the shallows.

In addition to the deep and shallow unvegetated habitat within the core study area, there would be a third habitat type, formed on the batter or slope of the dredged basin. The batter would be designed to prevent slumping, hence the habitat would be relatively stable. Sampling of both fish and benthic invertebrates in similar habitats within Port Hacking indicate that this habitat can be quite productive (Lincoln Smith 1991).

Surveys of benthic invertebrates in deeper areas of Penrhyn Estuary yielded a diverse and abundant fauna, despite the presence of contaminated sediments. This habitat would be replaced, as part of the habitat enhancement works, by intertidal flats and a narrow channel with waters from Floodvale and Springvale Drains. Results of the benthic surveys indicate that there would be a small reduction in biodiversity as a result of the loss of this deeper habitat in Penrhyn Estuary. However, as this habitat is common in other parts of Botany Bay, this reduction is not considered to be a significant impediment to the Port Botany Expansion and would be partly offset by gains in wetland and seagrass habitat.

Hard Substrata

The amount of hard substrata would increase substantially as a result of the proposed port expansion. This would include:

- an additional 1,850 m of wharf face and some 3,300 tubular steel piles;
- 500 m of seawall adjacent to seagrass habitat within the access channel and Penrhyn Estuary;
- 1,000 m of rock wall adjacent to intertidal habitat; and
- 500 m of seawall used for the tug berths and recreational boat ramp.

Unlike the smooth, vertical walls of the Parallel Runway and the Mill Stream, the structures associated with the proposed port expansion would generally be made of rock. This would provide habitat for a variety of invertebrates and animals.

Seagrass and Algae

Up to 4ha of the seagrass habitat in the study area would be lost as a result of the proposed port expansion (i.e. reduction in area from 9.7 ha to 5.7 ha) (refer to **Figure 19.2**) Most of this consists of *Zostera* of low to moderate density, but with some *Halophila* and mixed beds of these two species. A small patch of several square metres of *Posidonia* would be lost in the middle of Foreshore Beach whilst two other patches of a similar size occurring nearer the mouth of the Mill Stream channel would be retained. It is possible that there may be other small patches of *Posidonia* in the area and this would need to be confirmed prior to

commencement of construction. The loss of seagrass would be addressed by a combination of seagrass transplanting and creation of compensatory habitat, as discussed in Section 19.7.

The seagrass that would not be in the footprint of the proposed development are found mainly just to the east of the Mill Stream channel and on the shallow terrace adjacent to the Parallel Runway. The former comprises the largest single area of seagrass in the study area and it would be protected from any indirect effects of the construction process, such as reduction in water clarity due to sediment plumes and physical damage from construction vessels. The seagrass on the terrace adjacent to the Parallel Runway comprise a combination of seagrass transplanted from Lady Robinsons Beach and naturally colonising species (Gibbs 2001). The presence of the non-transplanted patches indicates that colonisation has occurred in time scales of less than a decade, as the terrace was created as part of the Parallel Runway construction. Preservation during construction would depend more on water clarity than effects of boat traffic.

Source: the Ecology Lab Pty Ltd 2003

0 500m

Areas of Seagrass to be Removed **Figure 19.2**

Areas of Seagrass (mainly *Zostera*)

Presence of *Posidonia australis*

Seagrass to be Removed

In the longer term, the new terminal would cause a small reduction in wave energy in some parts of the study area and have no effect in other parts. Importantly, there would be no increase in wave height in areas where seagrass would be retained (**Appendix H**).

The relocation of the boat ramp could potentially lead to an increase in recreational boat traffic along the beach, which may lead to damage of seagrass from boat propellers, hulls and wading. This problem would be addressed by the use of defined channels and signs indicating areas where care is required. This has been successful in the protection of seagrass elsewhere in the Sydney region (Smith et al 1997).

In addition to seagrass, there are also extensive areas of benthic algae in the core study areas. These include attached and drifting algae. The attached algae, such as *Ecklonia radiata* and *Sargassum* spp. occurs on some of the seawalls, on rubble near Brotherson Dock and on rubble and derelict pylons at the old Government Pier near Penrhyn Estuary. Most of this would be removed as a result of the proposed expansion (except for the Government Pier), but would colonise the new solid structures associated with the new terminal. There are also some algae that can attach to soft sediments. These include mainly *Caulerpa taxifolia* and *C. filiformis* and *C. scapeliformis*. The former two occur among seagrass within the study area, whilst the third species occurs on the southern side of Botany Bay. All three algae are probably introduced species. Management of the possible spread of *C. taxifolia* would form part of a Construction and Operational EMP and is discussed in Section 19.7.

Drift algae often occur in response to increased nutrients and are common in shallow sandy habitats in NSW estuaries and embayments. It is expected that drift algae would continue to form beds on the remaining shallow subtidal habitats and possibly the slopes of the dredged basin. They may also occur within Penrhyn Estuary and there is a possibility that an increase in nutrients in Penrhyn Estuary could increase the frequency of such blooms.

Saltmarshes and Mangroves

Under the proposed port expansion the small stand of mangroves that has become established in Penrhyn Estuary would be removed to facilitate the growth of saltmarshes and to enhance the value of the area as habitat for wader birds. The mangrove loss would represent about 0.1 % of the mangroves of Botany Bay (based on West *et al.* 1985). Saltmarsh habitat of approximately 6 ha would be incorporated as part of the habitat enhancement of Penrhyn Estuary, including newly planted areas and remnant saltmarsh.

The removal of mangroves would require a permit from NSW Fisheries under the FM Act. Given the small size of the stand relative to other areas in Botany Bay, this loss is considered to be ecologically sustainable. On the other hand, the creation of additional saltmarsh habitat is considered a positive effect as it would represent a substantial increase of almost 4%, based on West *et al* (1985), in the area of this habitat within Botany Bay.. There is also good evidence that mangrove habitat has been replacing saltmarshes within the Sydney region at least over the last 50 years (Saintilan 1995, Williams and Watford 1997, Mitchell and Adam 1989, Saintilan and Hashimoto 1999, Saintilan and Williams 1999, 2000), possibly due to increased sedimentation and nutrient loads and sea level rise.

On balance, whilst the removal of mangroves would represent a relatively small ecological loss, the advantages associated with the opportunity to enhance Penrhyn Estuary with saltmarshes provides a strong justification for that loss.

In the longer term, it is likely that mangrove seedlings would become established within Penrhyn Estuary from time to time. In order to prevent stands from becoming established, a program of regular removal

would be necessary. This would be best done when mangroves were very small, to minimise disturbance of sediments and any surrounding saltmarshes.

Freshwater Ecosystems

Freshwater habitats associated with the Mill Stream and Sir Joseph Banks Park would not be subject to any change in hydrology or groundwater infiltration as a result of the proposed port expansion (**Appendix L**), therefore they would not be affected by the proposal. Freshwater sections of Floodvale and Springvale Drains are already highly degraded. Notwithstanding this, proposed changes to Penrhyn Estuary would still result in the preservation of connectivity and hence fish passage to and from these drains.

19.6.3 Effects on Fishing and Aquaculture

Commercial Fishing

Commercial fishing is no longer permitted within Botany Bay. Therefore, this activity would not be directly affected by the proposed port expansion. There is, however, commercial fishing at the entrance to the Bay and within adjacent coastal waters. Based on modelling of hydrology and coastal processes, it is highly unlikely that the proposed port expansion would affect the physical nature of fishing activities outside the Bay.

Given that many species of fish and invertebrates utilise the Bay waters as juveniles and then migrate into coastal waters, a possible concern is that that there would be some effect on fish stocks as a result of the proposal. Under the proposal there would be an overall increase in the amount of seagrass present in the core study area, hence it is expected that there would be no net loss in fisheries productivity related to seagrass beds, and potentially a small increase.

Recreational Fishing

The construction of a new boat ramp to replace the one in Penrhyn Estuary means that anglers would not be disadvantaged in terms of launching facilities. Penrhyn Estuary is currently closed to fishing and would remain so under the proposed port expansion. Notwithstanding this, there would be some loss of available area in which to fish, as the reclamation would reduce the total water area of the Bay by approximately 60 ha. There may also be some disruption to angling from increased commercial shipping associated with the port expansion.

Overall, the proposal has sought to accommodate the needs of recreational fishers in Botany Bay. Effects of the expansion would probably represent an inconvenience rather than a major disruption to their recreational amenity.

Aquaculture

Currently aquaculture (including oyster farming) occurs on the southern side of Botany Bay. Studies of coastal processes (**Appendix H**) indicate that there would be negligible change to Botany Bay outside the study area. Therefore, this activity would not be affected by the proposed port expansion. As far as is known, there are no plans to introduce aquaculture to parts of the northern section of Botany Bay, particularly within the study area.

19.7 Mitigation Measures

19.7.1 Construction

Minimising Incidental Damage to Aquatic Habitats

All areas of habitat that are to be retained as part of the port expansion would be clearly delineated as part of all construction plans and, where necessary, by using marker buoys to ensure that no dredging, reclamation, boat movement or other mechanical damage is done. Specific examples of these would include:

- the preservation of large areas of seagrass offshore from Foreshore Beach and to the west of the proposed reclamation area; and
- avoiding the potential for adverse water quality (as a result of dredging and reclamation activities) on the terrace adjacent to the Parallel Runway, where seagrass have been transplanted previously and which could be used to transplant some seagrass during construction.

The Construction EMP developed for the project would identify these issues and include appropriate training on the location and significance of seagrass.

Seagrass Transplanting

Prior to commencement of construction, seagrass within the study area would be remapped with appropriate ground truthing to identify changes in the distribution of seagrass in the intervening period between this EIS and the start of construction.

Under the proposed port expansion *Zostera* (with, in some cases, *Halophila*) would need to be removed from an area of about 4 ha and transplanted into compensatory habitat. Depending on the sequence of construction, some of the seagrass would be transplanted on the terrace on the eastern side of the Parallel Runway to allow for the compensatory habitat to be prepared.

At the time of the remapping, a detailed search would be concluded to identify any additional areas of *Posidonia*. Any areas that are likely to be affected by construction would be transplanted into other parts of the study area. Transplanting of *Posidonia* has previously been considered difficult if not impossible but recent work in Port Hacking by Meehan and West (2002) has shown that *Posidonia* can be successfully transplanted. It appears that the greatest success occurs when *Posidonia* is transplanted to gaps in beds of existing *Posidonia*, or to areas where *Posidonia* once existed, but where the cause of that loss is no longer present. Note that *Posidonia* could be placed at the western end of Foreshore Beach prior to construction.

Control of Caulerpa taxifolia

As part of the remapping of seagrass, the occurrence and extent of *Caulerpa taxifolia* would also be noted. The Construction EMP would need to be adapted depending on the extent of any *C. taxifolia* present in areas to be dredged. For example, small areas of this algae can be treated by application of pool salt, which kills it rapidly while leaving seagrass undamaged. Alternatively, it may be possible to bury *C. taxifolia* within the reclamation.

Marine Mammals

Depending on the time of year, there may be several species of marine mammals present within Botany Bay, the most likely being southern right whales, humpback whales or bottlenose dolphins. Dolphins are swift and hence would avoid most of the vessels associated with construction. They can also utilise numerous parts of Botany Bay. The whales are less mobile and have been observed within the study area but so far there do not appear to have been any adverse incidents with commercial shipping. Of some concern would be the presence of a southern right whale with a calf entering the study area during dredging operations. Under these conditions noise and vessel movements may cause stress or disorientation.

The main period over which southern right whales might be expected to occur in Botany Bay would be mid winter to mid spring. Humpback whales could be present during late autumn and winter (during their northward migration) and mid to late spring (southward migration). A Marine Mammal Management Plan would be developed in consultation with NPWS to respond to the presence of any whales in the Bay during construction.

19.7.2 Operation

Nuisance Algae

There is a potential for growth of nuisance algae in Penrhyn Estuary, due to runoff from Floodvale and Springvale drains. One suggested approach to address this issue is considered as a step stage process, outlined as follows:

Step 1: -
Initially monitor to determine if there is a problem with nuisance algae and determine the frequency of occurrence.

Step 2: -
If growth appears to be problematic on a short term basis, nuisance algae may be addressed by mechanical means, such as skimming algal growth from the mudflats or lagoonal area.

Step 3: -
If growth of nuisance algae is problematic on a broader scale, Sydney Ports Corporation may need to consider constructing wetlands at the entrance to Springvale and Floodvale Drains to enhance nutrient stripping.

Management of Mangroves

It is likely that mangrove propagules would be transported into Penrhyn Estuary from around the Bay. Therefore, although they may be removed as part of the habitat enhancement for the expansion, they would be likely to recolonise. This issue could be addressed by periodically removing mangrove seedlings before they become established. This could be achieved by pulling out the mangroves, either by wading or from a boat.

Marine Mammals

With the current operation of the port it appears that marine mammals are able to co-exist with the port operations. A Marine Mammal Management Plan would, however, be prepared to ensure that the occurrence of marine mammals in the vicinity of the port during operations is appropriately managed. This would form part of the Operational EMP and would be prepared in consultation with NPWS.

19.7.3 Enhancement and Restoration of Aquatic Habitat

Habitat Enhancement of Penrhyn Estuary

Extensive restoration works are proposed for Penrhyn Estuary as part of the port expansion, as shown in **Figure 7.2** (**Chapter 7** *Public Recreation and Ecological Plan*) and discussed in detail in **Chapter 20** *Terrestrial Ecology*. Habitat enhancement of Penrhyn Estuary involves the following:

- expanding saltmarsh habitat to up to 6 ha (by levelling existing fore dune) and removing mangroves (larger mangroves with extensive root systems would be cut down in a way that would minimise disturbance of sediment);
- expanding intertidal sand and mud flats to about 12.5 ha with a substratum suitable for prey species, created by filling deeper areas of the Estuary;
- creation of up to 8 ha of seagrass habitat, distributed along the main tidal channel to the Estuary and in the entrance area to the Estuary (see below);
- ensuring suitable tidal flushing and provision for water dispersal during wet weather events; and
- limiting pedestrian access and preventing access by boat into the Estuary.

There may be an opportunity to construct sediment/litter traps at the mouth of Springvale and Floodvale Drains, however, this is subject to detailed assessment of any impact to drain hydraulics.

Compensation for Initial Loss of Seagrass Habitat

Up to 4 ha of seagrass habitat in the core study area would be lost as a result the proposed port expansion (i.e. reduction in area from 9.7 ha to 5.7 ha). This would be compensated for by the following:

- creating up to 8 ha of seagrass habitat within the access channel and new embayment of Penrhyn Estuary;
- relocating some seagrass to the terrace adjacent to the Parallel Runway and the majority of seagrass into the main tidal channel and in Penrhyn Estuary; and
- establishing or facilitating the establishment of seagrass (primarily Zostera capricorni) in these areas by a combination of transplanting and natural colonisation.

The areas to which seagrass would be transplanted are considered to be suitable for seagrass growth in terms of available light, depth and wave climate, however, there is a risk that transplanting would not be successful. In this event, modifications to the tidal flats within Penrhyn Estuary could be undertaken to make it more suitable for seagrass growth or a different type of habitat could be enhanced, such as the saltmarsh that would be created in Penrhyn Estuary. The need for such activities would only be determined after

monitoring the initial success or failure of the transplanting and would be discussed at that time with NSW Fisheries.

Notwithstanding the above considerations, there are good reasons to suggest that transplanting of seagrass for the Port Botany Expansion would have a high chance of success. First, the terrace on the eastern side of the Parallel Runway is the main area where previous transplanting has been successful and, as discussed in Chapter 15 *Hydrodynamics and Coastal Processes*, the energy regime at this site would become slightly more sheltered as a result of the proposed port expansion. Thus, it should be an appropriate area for further transplanting.

Second, the area prepared in Penrhyn Estuary and the tidal channel would be very sheltered and hence not subject to wave action, a major factor attributed to failures in transplanting. There is some risk that a major flood event and, therefore, a temporary reduction in salinity could affect transplanted seagrass, however, the configuration of the Estuary suggests that the intertidal flat would help to dissipate the energy of flood waters.

Third, the distance required to transport the seagrass is small, thereby, reducing the risk of damage during transit and of desiccation. Additionally, seagrass have been observed growing successfully in radically altered environments and new aquatic habitats, such as those found in canal estate developments (The Ecology Lab, pers. com).

Enhancement of Habitats Associated with Hard Surfaces

Recent investigations have shown that enhancement of hard, artificial surfaces can support a variety of intertidal biota. Similarly, subtidal wharf and breakwater structures support a diverse and abundant fish fauna (Burchmore *et al.* 1985, Lincoln Smith *et al.* 1993). As part of the proposed port expansion, habitats associated with wharf structures would be enhanced in the following areas:

- Penrhyn Estuary – that part of the perimeter comprising hard surfaces;
- main tidal channel between Foreshore Road and the new terminal; and
- container berths and wharfs.

Details of the nature of enhancement would be developed as part of the detailed terminal design and incorporated into the construction program.

19.7.4 Monitoring and Feedback

Baseline Monitoring

Monitoring of the effects of the proposed port expansion on aquatic ecology would require investigation during construction and operation. Monitoring would be required before construction begins to compile appropriate baseline data. The proposed monitoring would be described in the Construction and Operational EMPs for the project and would include the measures described below.

The Water Column

During the construction of the new terminal, water quality would be measured throughout the dredging and reclamation operations. Indicators measured would include turbidity, dissolved oxygen, temperature, salinity and pH. Sampling would be undertaken at sites inside and outside the silt curtain and at sites of sensitivity (particularly seagrass) and at reference locations. In addition to the above indicators, samples of water would be obtained to measure suspended solids, nutrients, heavy metals and organic contaminants. Finally, light would be measured at the seabed at several positions where seagrass beds occur.

Following construction, water quality would be measured on a regular basis within Penrhyn Estuary. Indicators would include turbidity, dissolved oxygen, temperature, salinity, pH, nutrients, heavy metals and organic contaminants. In particular, organic contaminants (e.g. VHCs) would be measured in relation to an influx of contaminated groundwater into Penrhyn Estuary.

Unvegetated Soft Sediments

Organisms inhabiting soft sediments would be used to provide an assessment of the following:

- recolonisation of the dredged shipping berth and changes (if any) in adjacent shallow habitats;
- recolonisation and success of habitat enhancement within Penrhyn Estuary; and
- impacts of the arrival of VHCs in groundwater.

Each of these components would require further baseline data to be collected. The supplementary survey of benthic organisms done as part of this EIS study indicates using the benthos as an environmental indicator would be a suitable monitoring approach.

Seagrass, Algae and Associated Fauna

Monitoring programs would be designed and implemented for seagrass during the construction and operational phases of the project. The seagrass indicators that would be considered include extent and coherence of beds (i.e. patchiness) and morphological characteristics, including shoot density, leaf length and width and extent of epiphytic growth. These indicators would be used to address the following issues:

- potential changes to seagrass not within the direct footprint of the proposed expansion occurring as a result of construction activities. This would involve sampling seagrass adjacent to the expansion and at control locations before, during and perhaps after construction of the terminal and associated works;
- survival and condition of seagrass, including *Zostera* and *Posidonia*, following transplanting from the footprint of the proposed expansion. This would involve sampling before removal and following transplanting; and
- the condition of the compensatory seagrass, including those transplanted to the designated areas, as well as any natural colonisation.

The occurrence and persistence of nuisance algae within Penrhyn Estuary as a result of nutrients from the catchments of Floodvale and Springvale Drains would be monitored to enable an appropriate management response.

Finally, organisms utilising the compensatory seagrass beds would be monitored to evaluate diversity and abundance. It is suggested that a good indicator of this would be fish and mobile invertebrates (e.g. prawns) which can be readily collected using standard sampling procedures (e.g. seine nets).

19.8 Conclusion

The proposed Port Botany Expansion would cause changes to the aquatic environment on the northern side of Botany Bay between the Parallel Runway and Molineux Point. Aquatic habitats that would likely be affected by the proposal include the water column, unvegetated soft sediments, hard substrata, algae, seagrass, saltmarshes, mangroves and freshwater ecosystems.

An assessment of the likely impacts to threatened species from the proposal, in the form of an Eight Part Test, concluded that a SIS was not required for the proposal in respect of any threatened species, populations or communities as any impacts on these species or groups of species would not be significant.

The proposed Port Botany Expansion would result in the following broad scale changes within the study area:

- an increase in the amount of solid artificial structure with opportunities to enhance some of the structures to increase their biodiversity;
- an increase in the amount of saltmarsh habitat representing an increase of about 4% in area in Botany Bay;
- an initial loss of about half the remaining seagrass in the study area, but in the longer term there would be creation of up to twice as much seagrass habitat as was lost by the development;
- a decrease in intertidal beach habitat but an increase in sandy intertidal flats at Penrhyn Estuary;
- loss of a small stand of mangroves in Penrhyn Estuary representing less than 0.1% of mangroves within Botany Bay; and
- loss of a previously dredged hole and some areas of shallow subtidal sand habitat with the corresponding creation of a deep basin as an extension of the existing navigation channel.

Apart from levelling some high spots within the existing navigation channel, there would be no physical changes to the Bay outside the study area. In addition, aquatic habitats elsewhere in the Bay would not be affected by the Port Botany Expansion. Changes in wave energy and direction are predicted to be small, with negligible effect on sensitive habitats such as Towra Point Nature Reserve.

The impacts of the proposal on the aquatic environment would be minimised, provided safeguard measures and monitoring activities outlined above are implemented during construction and operation of the new terminal.