WorleyParsons
resources & energy

EcoNomics

WYONG SHIRE COUNCIL

The Entrance Dredging Project
Review of Environmental Factors

301015-00962(7291) – rp7291oam091112_REF_Rev0_FINAL.doc

12 November 2009

141, Walker St, North Sydney NSW 2060, Australia
Tel: +61 2 8456 7200
Fax: +61 2 8923 6877

Disclaimer

PROJECT 301015-00962(7291) - THE ENTRANCE MAINTENANCE DREDGING PROJECT REF

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
B	Draft issued for client review	O Murray	G Britton	G Britton	30-Jun-09	N/A	
B	Draft issued for client review	O Murray	G Britton	G Britton	30-Jun-09		
C	Draft issued for client review	O Murray	G Britton	G Britton	25-Sep-09		
0	Final	O Murray	G Britton	G Britton	30-Oct-09		11-Nov-09

SUMMARY

The natural shoaling of sands within The Entrance Channel causes the intermittent closing of the channel. This shoaling has necessitated the management of the channel through maintenance dredging to maintain tidal flows and reduce flood risks to life and property in low-lying areas of the estuary. Maintaining a more open channel prevents degradation of water quality in the Tuggerah Lakes, and preserves the existing ecological value of the estuary including the health and abundance of seagrasses, preservation of fish stocks, and the preservation of existing foreshore vegetation communities which have adapted to the this regime.

The maintenance dredging was first undertaken by Wyong Shire Council in 1993 as part of the Tuggerah Lakes Restoration Project. Maintenance dredging takes approximately three to four months to complete and has been carried out on an "as needs" basis, approximately yearly since.

The proposed works involve the removal of approximately 30,000m^3 to 80,000m^3 per annum (up to 100,000m^3) of clean sands from a footprint extending from The Entrance Channel sand spit westward to Picnic Point and northward to the northern end of the Terilbah Channel.

The sand deposited in the channel, while of both marine and alluvial sources, is considered compatible with the sands of adjacent beaches which are susceptible to erosion. The dredging allows for a sustainable and local supply of material suitable for nourishment of the depleted beaches including North Entrance Beach and the estuary eastern beach adjacent to Karagi Park Foreshore. Nourishment of these areas minimises the potential for erosion to the adjacent dunes and reduction of impacts to associated ecosystems, infrastructure and property.

Some minor and temporary impacts may occur during the dredging activity. However, based on the findings of this REF and associated investigations, it is considered that provided the safeguards recommended in this document are implemented, any impacts would be outweighed by the long-term beneficial impacts provided by the dredging and beach nourishment activities. Survey and monitoring programs have also been recommended to ensure the ongoing protection of the environment and to allow for the identification of any improvements that may be incorporated into future dredging campaigns.

Approvals required to carry out the proposed works have been identified as follows:

Department of Primary Industries (Fisheries):

- permit to harm marine vegetation under Section 205 of the *Fisheries Management Act 1979*; and

Department of Lands:

- licence for the use of Crown land under Section 34A of the *Crown Lands Act 1989*.

An Environmental Protection Licence (EPL3200) is currently in place for the dredging and beach nourishment works. The EPL is continuous and independent of any other approvals. The EPL does not require any renewal or modifications for the works proposed in this REF Council is seeking

permission for a temporary dredge haul-out area in Terilbah Reserve. The haul-out area will be considered in a separate process to this REF and would involve an amendment to the existing licence.

CONTENTS

1. INTRODUCTION 1
1.1 Background 1
1.2 Site Location 3
1.3 Scope of Works 3
2. DESCRIPTION OF THE EXISTING ENVIRONMENT 6
2.1 Sediment Dynamics 6
2.2 Hydraulics 6
2.3 Water Quality 8
2.4 Bed Sediments 8
2.5 Condition of the Beaches 11
2.6 Land and Waterway Use 11
2.6.1 Zoning 11
2.6.2 Recreational and Commercial Uses 12
2.7 Ecology 12
2.7.1 Flora 13
2.7.2 Fauna 16
2.7.3 Ecological Communities 19
3. DESCRIPTION OF THE PROPOSED WORKS 20
3.1 Proposed Dredging Works 20
3.1.1 Production Rates and Quantities 21
3.2 Proposed Beach Nourishment 21
3.3 Rehabilitation of Work Areas 26
3.4 Plant and Equipment 26
3.4.1 Dredging and Beach Nourishment 26
3.5 Project Timing and Duration 27
4. PROJECT JUSTIFICATION AND CONSIDERATION OF ALTERNATIVES 29
4.1 Alternatives to the Project Proposal 29

4.1.1 Alternatives to Dredging....29
4.1.2 Alternative Placement Options....29
4.1.3 The Do-Nothing Option....30
4.2 Ecologically Sustainable Development....30
4.3 Justification for the Project....32
5. ENVIRONMENTAL PLANNING FRAMEWORK....34
5.1 Commonwealth Approvals Process....34
5.2 NSW Planning and Approvals Process....34
5.3 Other Relevant State Legislation....35
5.4 Licences and Approvals....37
5.5 Other Relevant Plans....37
5.6 Consultation....37
5.6.1 Stakeholder Consultation....37
5.6.2 Community Consultation....45
6. ASSESSMENT OF THE ENVIRONMENTAL IMPACTS & RISKS....48
6.1 Coastal and Estuarine Processes....48
6.1.1 Bank Erosion....48
6.1.2 Bridge Foundations....49
6.1.3 Dune System....49
6.2 Hydrodynamics/Flooding....50
6.2.1 Water Quality....50
6.3 Fuel Storage and Handling....51
6.4 Ecology....52
6.4.1 Flora....52
6.4.2 Fauna....53
6.5 Threatened Species Assessment....55
6.6 Commercial and Recreational Fishing....56
6.7 Operational Noise....56
6.8 Heritage....57

6.9 Air Quality 57
6.10 Amenity 57
6.11 Access and Safety 58
6.12 Waste and Disposal 58
7. ENVIRONMENTAL CONTROL MEASURES 59
7.1 Summary of Control Measures 59
7.1.1 Erosion 59
7.1.2 Water Quality 60
7.1.3 Fuel Storage and Handling 60
7.1.4 Ecology 60
7.1.5 Noise 61
7.1.6 Heritage 61
7.1.7 Air Quality 61
7.1.8 Amenity 62
7.1.9 Access and Safety 62
7.1.10 Waste 63
8. SUMMARY OF IMPACTS 64
8.1 Clause 228 Factors 64
8.2 Consideration of Clause 228 Factors 64
8.3 *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Factors (Commonwealth Legislation) 67
8.3.1 Consideration of Commonwealth EPBC Act (1999) Factors 67
9. AMENDMENTS 69
10. REFERENCES 70

Tables

TABLE 2.1 THREATENED FLORA SPECIES LISTED UNDER THE COMMONWEALTH EPBC ACT

TABLE 2.2 THREATENED AND MIGRATORY MARINE SPECIES LISTED UNDER THE COMMONWEALTH EPBC ACT, THE NSW TSC ACT AND THE NSW FM ACT

TABLE 2.3 THREATENED AND MIGRATORY MARINE AND WETLAND BIRD SPECIES LISTED UNDER THE COMMONWEALTH EPBC ACT AND THE NSW TSC ACT

TABLE 5.1 LICENCES AND APPROVALS REQUIRED

TABLE 5.2 COMMENTS RECEIVED FROM STAKEHOLDERS DURING THE CONSULTATION PROCESS

TABLE 5.3 COMMENTS RECEIVED DURING THE COMMUNITY CONSULTATION PROCESS

Figures

FIGURE 1 SITE LOCATION

FIGURE 2 PROPOSED DREDGE FOOTPRINT AND BEACH NOURISHMENT AREAS

FIGURE 3 INDICATION OF ACID SULFATE SOIL RISK

Appendices

APPENDIX 1 SEDIMENT INVESTIGATION

APPENDIX 2 SEAGRASS FIELD REPORT

APPENDIX 3 EPBC ACT PROTECTED MATTERS SEARCH REPORT

APPENDIX 4 CONSULTATION

APPENDIX 5 REVIEW OF CURRENT AND PROPOSED DREDGING AND BEACH NOURISHMENT PRACTICES AT THE ENTRANCE

APPENDIX 6 THREATENED SPECIES – ASSESSMENT OF SIGNIFICANCE

ABBREVIATIONS

AHD	Australian Height Datum
ANC	Acid Neutralising Capacity
ANZECC	Australian New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australian and New Zealand
ASS	Acid Sulfate Soils
ASSMP	Acid Sulfate Soil Management Plan
BOM	Bureau of Meteorology
CAMBA	China-Australia Migratory Bird Agreement
CD	Chart Datum
CMA	Catchment Management Authority
Council	Wyong Shire Council
CSD	Cutter Suction Dredge
DECC	NSW Department of Environment and Climate Change
DCP	Development Control Plan
DO	Dissolved Oxygen
DPI	NSW Department of Primary Industries
DLWC	NSW Department of Land and Water Conservation
DoP	NSW Department of Planning
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	NSW Environmental Protection Authority
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EP&A Reg	NSW *Environmental Planning and Assessment Regulation 2000*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

EPI	Environmental Planning Instrument
EPL	Environmental Protection Licence
ISQG	Interim Sediment Quality Guidelines
JAMBA	Japan-Australia Migratory Bird Agreement
LALC	Local Aboriginal Land Council
LEP	Local Environmental Plan
MHWM	Mean high water mark
MSDS	Material Safety Data Sheet
NAGD	National Assessment Guidelines for Dredging
NEPC	National Environment Protection Council
NSW	New South Wales
OCP/ OC Pesticides	Organochlorine Pesticides
PBP	Patterson Britton and Partners Pty Ltd
POEO Act	NSW *Protection of the Environment Operations Act 1991*
REF	Review of Environmental Factors
REP	NSW Regional Environmental Plan
SEPP	NSW State Environmental Planning Policy
SIS	Species Impact Statement
sPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate
SREP	Sydney Regional Environmental Plan
TOC	Total Organic Carbon
TSC	NSW *Threatened Species Conservation Act 1995*
TSS	Total suspended solids
WM Act	NSW *Water Management Act 2000*
WSC	Wyong Shire Council

1. INTRODUCTION

1.1 Background

Tuggerah Lakes estuary is located on the Central Coast of NSW between Newcastle and Sydney. The estuary comprises three shallow lakes (Lake Munmorah, Budgewoi Lake and Tuggerah Lake) which exit to the ocean from Tuggerah Lake via a single opening, The Entrance Channel. The Entrance Channel is therefore the keystone in the management of the tidal flow of the estuary.

The estuary has a surface area of 78 km^2 and drains a much larger catchment of approximately 670 km^2 (PBP, 1992). The estuary provides valuable resources to the community in terms of recreation, tourism and fisheries. The entrance to the estuary has closed through the accumulation of sand in The Entrance Channel at least 13 times in the past 100 years and can remain closed for several months (WSC, 2004).

In the mid 1900's the estuary experienced a progressive degradation in water quality due to increased farming, urbanisation and the use of non-reticulated sewerage systems. These developments resulted in eutrophic conditions in the estuary (Roberts & Dickinson, 2005) with the once sandy foreshore instead dominated by decaying weed, algae and a layer of black ooze (PBP, 1992).

Wyong Shire Council (Council) commenced dredging to maintain The Entrance Channel opening in 1993 as a component of the Tuggerah Lakes Restoration Project. The dredging aimed to improve tidal exchange and resulted in the following key outcomes:

- Reduction in nutrient levels in the estuary taking it from a eutrophic to mesotrophic state (eutrophication leads to excessive aquatic plant growth which reduces dissolved oxygen). Water quality improvements were also achieved though connection of urban areas to the reticulated sewerage system in the 1990s (Dickinson et. al., 2006).
- Reduction in flood water retention times and therefore the longevity of flood risks to life and low-lying property.
- Maintenance of the coastal dune system within the vicinity of The Entrance as well as addressing erosion of the estuary eastern beach by placement of the dredged sands for nourishment purposes while retaining sand within The Entrance sand system.

A major dredging campaign of The Entrance Channel and surrounds was undertaken in 1993. Maintenance dredging has been undertaken approximately every 12 months since.

The current permit to dredge from the NSW Department of Primary Industries (Fisheries) has expired. Recent advice from the Department of Primary Industries (Fisheries) indicated may be undertaken in accordance with a licence for the use of Crown land issued by the Department of Lands, and a licence to harm marine vegetation issued by the Department of Primary Industries. An environmental assessment of the dredging and reclamation practices is required to obtain these approvals. This Review of Environmental Factors (REF) considers matters raised by relevant authorities and reviews

potential environmental impacts associated with the proposed maintenance dredging and beach nourishment activities. Where appropriate, safeguards to mitigate any potential adverse effects are recommended.

1.2 Site Location

The site is located at the entrance of the Tuggerah Lakes estuary. Relevant areas are depicted in **Figure 1**.

The Entrance Channel is located between the two urbanised areas of The Entrance and The Entrance North. These areas are connected via The Central Coast Highway bridge.

The proposed area of dredging spans from the northern end of Terilba Channel, downstream to The Entrance sand spit extending from Karagi Point (also known as Dunleith Point). Dredging to the west of the bridge to the vicinity of Picnic Point is also proposed. Two sand Islands are located adjacent to the proposed dredge footprint including Terilbah Island to the west of Terilbah Channel, and Yellawa Island immediately downstream of the bridge.

Beaches within the study area considered for beach nourishment purposes include:

the Karagi Foreshore Park and Caravan Park Foreshore (termed the estuary eastern beach);

Town Beach within the estuary;

and North Entrance Beach and The Entrance Beach on the open coastline immediately to the north and south of The Entrance Channel respectively; and

islands within the estuary such as Yellawa Island and Terilbah Island.

1.3 Scope of Works

The following investigations were carried out in preparing this REF:

A review of existing information including the following documents:

Tuggerah Lakes Estuary Management Study (Roberts & Dickinson, 2005).

Tuggerah Lakes Estuary Management Plan (Dickinson et. al., 2006).

Revised Review of Environmental Factors – Entrance Channel Dredging and Beach Nourishment. Report prepared by Wyong Shire Council, August 2004.

Wyong Shire Council's Draft Coastline Management Study and Plan – Hazard Definition Studies Report – Appendix B.

Several technical reports previously prepared for improvement of The Entrance channels by the Public Works Department and/or Patterson Britton and Partners (now WorleyParsons) between 1988 and 1994.

The Dredge Procedures Manual. Prepared by Wyong Shire Council, 1996.

Advice on Dredging Related Matters – Tuggerah Lakes Entrance. Prepared by WorleyParsons Incorporating Patterson Britton & Partners Pty Ltd, April 2008.

Wyong Shire Council's existing permits/ licenses.

Site visits undertaken on 17th December 2008 and 4th February 2009.

Analysis of the photographic record of the dredging and beach nourishment practices.

A hydrographic survey of the proposed dredge footprint accessible by boat was carried over 15-17th December 2008 and 4th May 2009 by Harvey Hydrographic Services. The survey assisted in the identification of areas that would require dredging in the next five years and hence areas in which investigation was required.

A desktop search of online databases to determine any threatened species, populations or ecological communities protected under State and Commonwealth legislation that are likely to be present or have habitat within the study area. Databases searched included the Environment Protection and Biodiversity Conservation (EPBC) Protected Matters search tool, the NSW Atlas of NSW Wildlife database, the Department of Environment and Climate Change (DECC) threatened species database, the NSW Department of Primary Industries (DPI) (Fisheries) database; and a search of the Commonwealth of Australia (2009a) Australian Wetland Database.

A seagrass survey covering the proposed dredged areas and a 50 m buffer either side.

A vibrocoring and sediment sampling investigation of the proposed dredge areas including testing for acid sulfate soils, sediment contamination and particle size analysis.

Consultation with relevant stakeholders and community groups for comment on the project proposal.

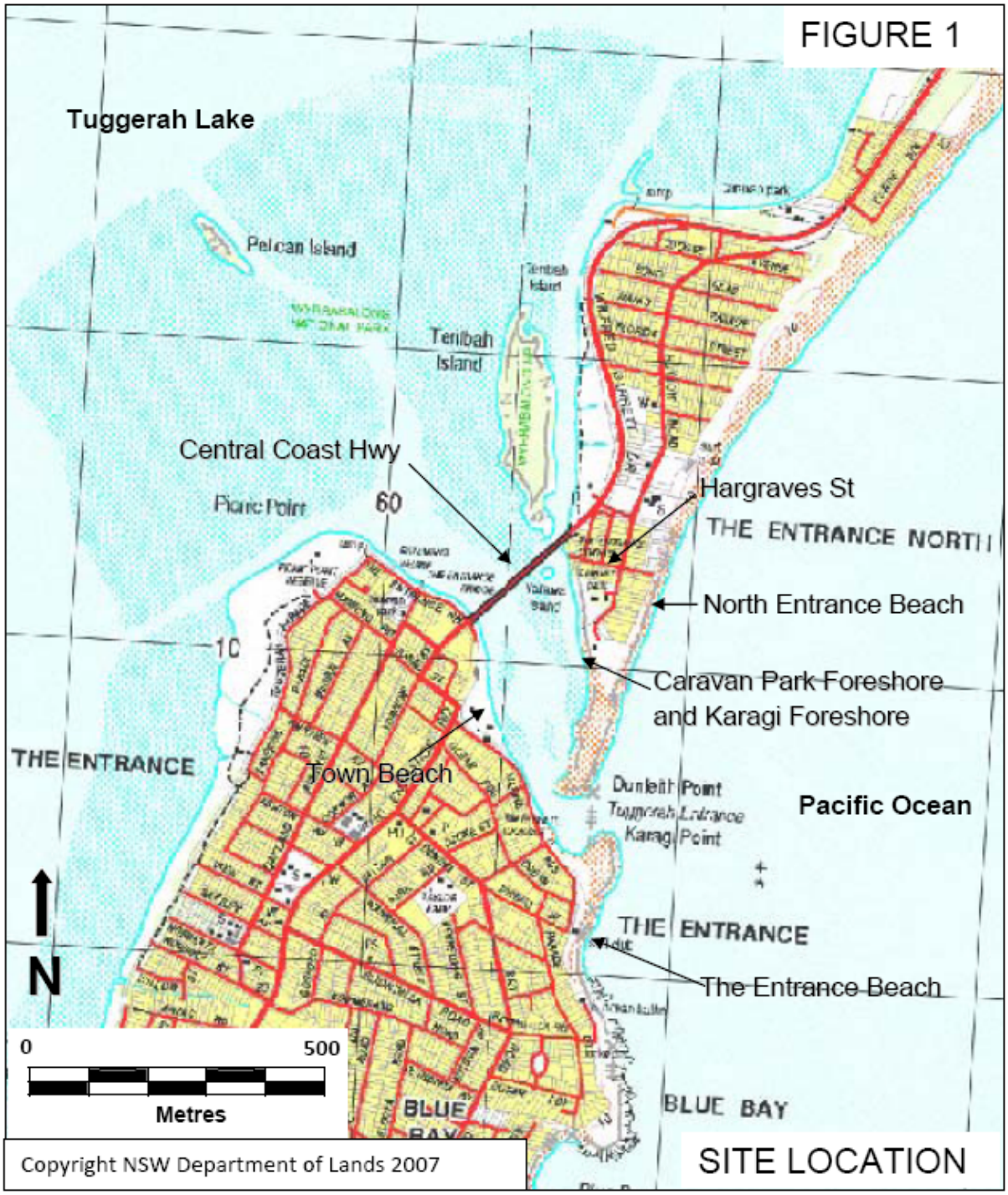


FIGURE 1
Tuggerah Lake
Pelican Island
Tenibah Island
Central Coast Hwy
Picnic Point
60
10
Hargraves St
THE ENTRANCE NORTH
North Entrance Beach
Caravan Park Foreshore and Karagi Foreshore
THE ENTRANCE
Town Beach
Dunleith Point
Tuggerah Entrance
Karagi Point
Pacific Ocean
THE ENTRANCE
The Entrance Beach
N
0
500
Metres
BLUE BAY
Copyright NSW Department of Lands 2007
SITE LOCATION

2. DESCRIPTION OF THE EXISTING ENVIRONMENT

2.1 Sediment Dynamics

Tuggerah Lakes estuary is classified as a barrier estuary formed during the last post glacial marine transgression which ended approximately 6000 years ago. The estuary is characterised by a shallow flat bottomed bed with a sandy barrier (the entrance sand spit), migratory tidal channels, and mobile sand shoals which prograde into the estuary. Wave energy and flood tide currents constricted by the narrow estuary mouth carry coarse marine quartzose sands into the flood tide dominant southern channel where they are deposited on the flood tide shoal (refer **Figure 2**).

The flood tide shoal generally extends westward up until the Central Coast Highway Bridge although high tidal velocities can carry the sands further into the estuary.

The ebb tide moves sand from the flood tide shoal and channels back out through the estuary mouth where it is deposited on The Entrance sand bar. The lower velocity ebb tide predominantly flows in the area of least deposition along the northern channel. As the ebb tide is ineffective at removing the same volume of sand transported into The Entrance Channel by the flood tide, a build up of sand in the form of a fan shaped flood tide shoal eventually causes closure of the estuary mouth.

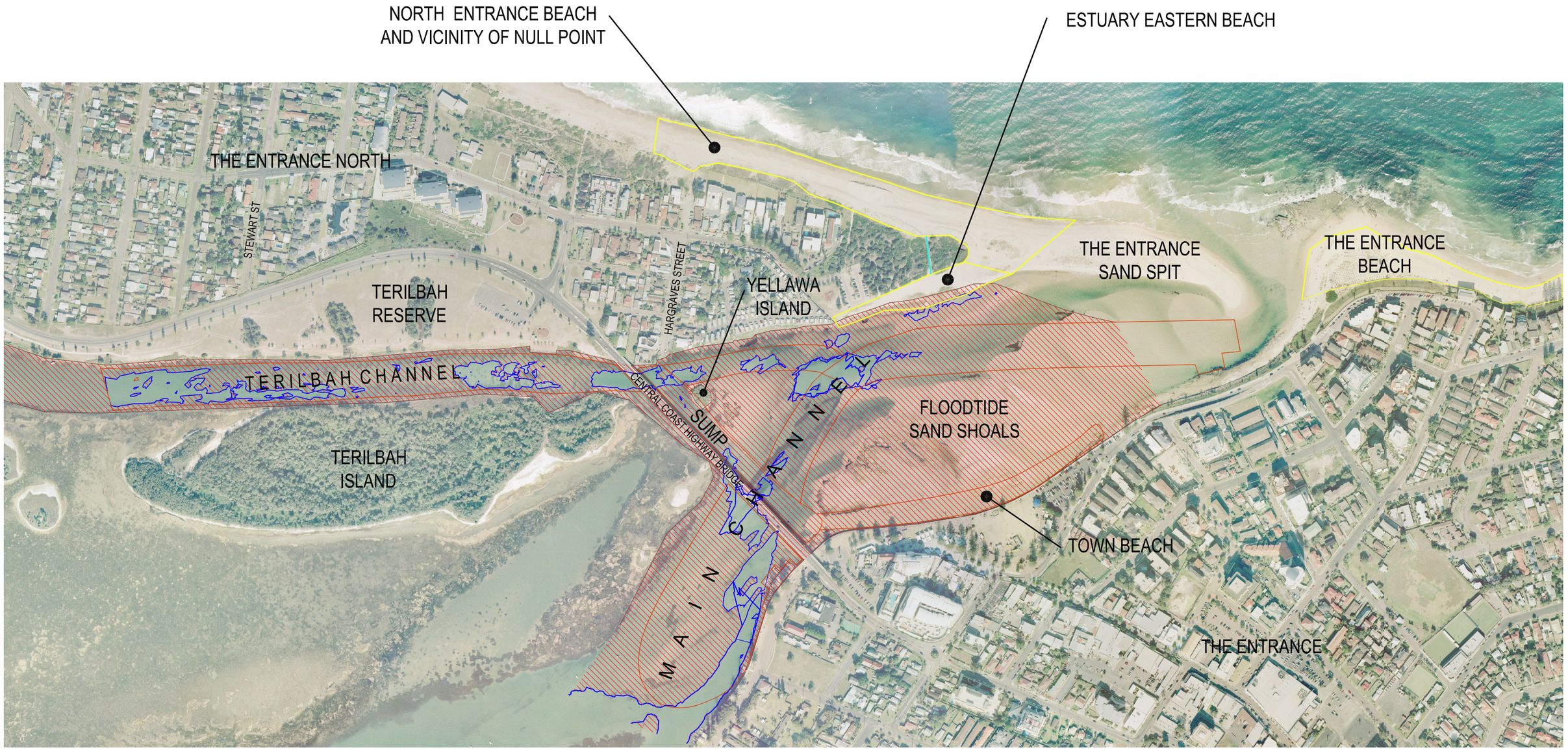
Flooding can restore tidal flows to the estuary by scouring the surface of the flood tide shoals and scouring a wide channel (of up to several hundred metres in width on occasions) through The Entrance sand spit. However, following flooding, the significantly increased tidal flows encourage rapid migration of sand through the mouth of the estuary and the reduction of tidal exchange is recommenced (PBP, 1994).

2.2 Hydraulics

The main tributaries that flow into the Tuggerah Lakes estuary include the Wyong River, Ourimbah Creek and Wallarah Creek. These tributaries, along with numerous stormwater drains located within the catchment input significant volumes of freshwater to the estuary. The narrow entrance channel, which is approximately 23-35 m wide and 2 m deep at mid-tide (PBP, 1994), provides the only ocean exit for catchment inputs.

Freshwater inputs to the estuary exceed tidal inputs (Ryan et. al., 2003). This is as a result of high freshwater inputs from the estuary's tributaries and drains, the narrow width of the estuary mouth, and the large volume of water in the Tuggerah Lakes. A small tidal range is experienced under average conditions. This is in the order of a few centimetres around the elevated average water level of The Entrance Channel, which is approximately 0.06 m AHD.

While tidal flows are strong when the estuary mouth is open, the tidal exchange is limited to within 1km of The Entrance Channel. Therefore numerous tidal cycles are required, estimated at 100 days (Roberts and Dickinson, 2005) for full tidal exchange of the estuary waters to occur. As a result, the estuary has a limited capacity to assimilate nutrients, contaminants and sediment inputs.



LEGEND:

- APPROXIMATE DREDGE FOOTPRINT
- LOCATION OF BEACH NOURISHMENT AREAS
- LOCATION OF FIXED DISCHARGE PIPELINE
- DEPTH BELOW AHD < 2m (SURVEYED ON 17/12/08 & 4/4/09)
- DEPTH BELOW AHD > 2m (SURVEYED ON 17/12/08 & 4/4/09)

0 200 m
SCALE

WorleyParsons
resources & energy

EcoNomics

File Identity : N:\7291 Tuggerah Lake Entrance\11.0 Drawings\Drgs\COASTAL\Figure_2.dwg

Source : HYDROGRAPHIC SURVEY 15-17 DEC 09 & 04 APR 09

Base Photo: Copyright WSC 2006

Date Modified : 07/07/2009 03:35:58 PM

NORTH

PROPOSED DREDGE FOOTPRINT AND BEACH NOURISHMENT AREAS

FIGURE 2

This capacity is further reduced when The Entrance Channel becomes constricted. Tidal exchange is reduced resulting in degrading water quality and increased flood risks.

The peak discharges of major floods affecting the estuary are in the order of forty times greater than peak ebb tide discharges under average entrance conditions. When The Entrance Channel is initially restricted or closed, thousands of low-lying properties along the foreshore of the estuary (particularly within the upper estuary) are at increased risk of flooding.

2.3 Water Quality

A water quality investigation undertaken for the Tuggerah Lakes Estuary Process Study (Roberts, 2001) indicated that lower levels of total nitrogen, oxidisable nitrogen and total phosphorus were found within The Entrance channels in comparison to the open waters of Tuggerah Lake.

Without sufficient tidal exchange through The Entrance channels, accumulation of such nutrients and contaminants from runoff into the estuary can lead to the excessive growth of aquatic plants, particularly algae, along the foreshores of the lakes.

Salinity levels also have a significant impact on species composition in the estuary. For example, brackish waters are favoured by the seagrass *Ruppia Megacarpa* (stackweed) which has experienced prolific growth and die-back cycles, whereas saline conditions are preferable for the growth of the seagrass *Zostera Capricorni* (Scott, 1999).

Excessive plant growth leads to significantly reduced concentrations of dissolved oxygen (DO) and subsequent impacts to all aerobic (i.e. oxygen dependent) marine life in the lakes. The resulting die-off and decomposition of plant growth results in a thick layer of foul smelling ooze.

2.4 Bed Sediments

A sediment sampling and testing program was undertaken to characterise the physical and geochemical characteristics of the proposed dredge material in order to determine the suitability of reusing the material for beach nourishment.

The investigation was undertaken on 21st April 2009. Vibrocoring was undertaken to 0.5 m beyond the proposed depth of dredging (where feasible) at ten locations within the dredge footprint. Analysis undertaken included;

- particle size grading;
- testing for a suite of heavy metals;
- testing for organochlorine pesticides (OC Pesticides) and total organic carbon (TOC); and
- acid sulfate soil field screening and Chromium Reducible Sulfur testing.

A full report on the investigation is provided in **Appendix 1**, the findings of which are summarised below.

Physical Properties

The sediments within the dredge footprint vary in physical composition. The sandy shoals prograding northwest from the entrance comprise light coloured, clean marine sands. These sands have been reworked through The Entrance Channel from the adjacent beaches on the open coast and therefore have low (<5%) mud content.

The remaining sediments within the dredge footprint are interbedded grey sands and silty sands with a slightly higher mud content (typically <10%) likely to be influenced by the deposition of alluvial sediments during high flows events.

Organic matter was found in limited amounts at depth within a core taken in the lee of the entrance sand spit and also at depth within a core from the main channel, immediately upstream of the bridge. This material primarily consisted of decaying seagrass and seaweed. Several of the cores also contained sediment which emitted varying degrees of a hydrogen sulfide (ie. rotten egg) odour.

Sediment Contamination

Results of the geochemical analysis were statistically analysed and compared to the Screening Levels provided in the National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009b). These levels are equivalent to the Interim Sediment Quality Guidelines (ISQG) – Low in the ANZECC/ARMCANZ Guidelines for Fresh and Marine Water Quality. Both guidelines are far more stringent than the human use Health Investigation Levels (HILS) provided in the National Environment Protection (Assessment of Site Contamination Measure) Measure 1999 (NEPC Guidelines). Where contaminant concentrations are below the NAGD Screening Levels, adverse impacts to both humans and marine organisms are considered unlikely.

All sediment results were below the NAGD Screening Levels. Concentrations of antimony, cadmium, silver, and OC pesticides were all below laboratory detection levels.

Acid Sulfate Soils

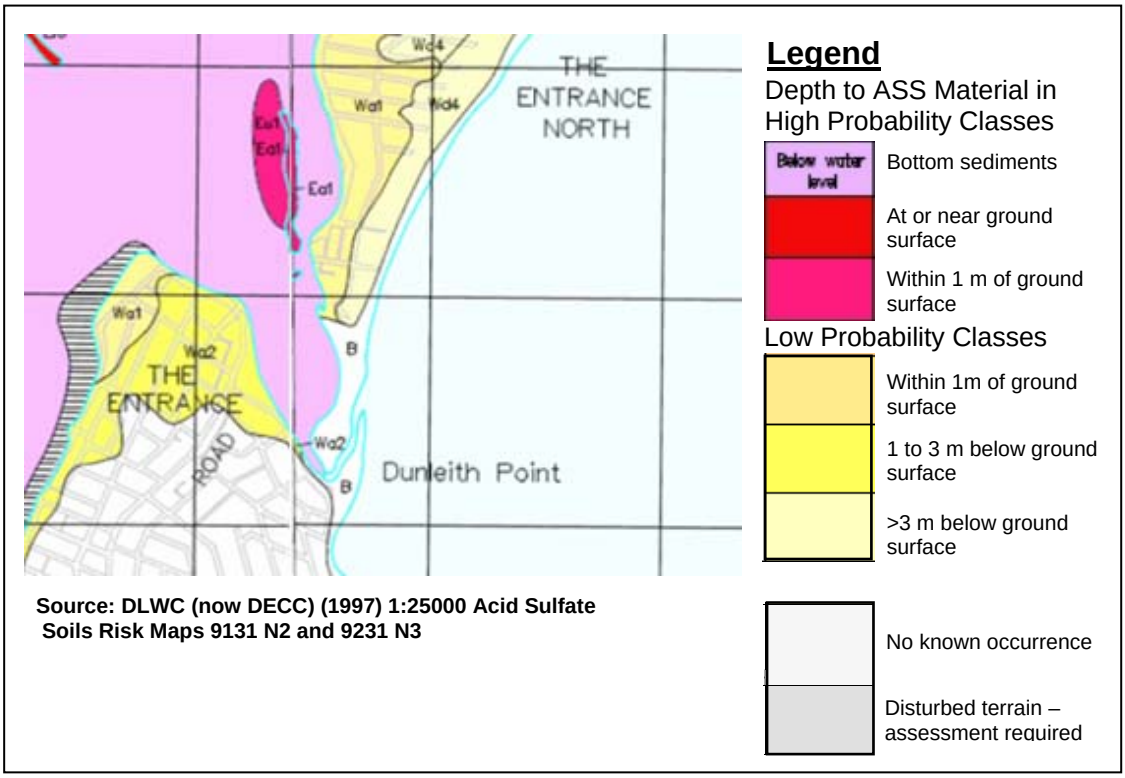
Sediment and soil containing iron sulphide are known as acid sulfate soils (ASS) due to their ability to generate sulfuric acid when exposed to air. The first stage in identifying the ASS risk is to view the 1:25000 Acid Sulfate Soils Risk Maps for NSW coastal areas published by the Department of Land and Water Conservation (DLWC) (now DECC) in 1995. The risk maps identify three risk classes (high, low and zero) based on the probability of acid sulfate soils being present.

The relevant maps for The Entrance Channel and surrounds are the Wyong and Toukley Map Sheets (Sheets 9131 N2 and 9231 N3) (DLWC, 1997). These maps (refer **Figure 3**) show a high probability of the presence of acid sulfate soils materials in the estuarine bottom sediments of the dredge footprint. Acid sulfate soils were dredged from the nearshore shallows of the lakes in the early 1990's during the Tuggerah Lakes Restoration Project (Sutas, 1996).

While acid sulfate soil material would likely be encountered upstream of the influence of marine sands, the proposed dredge footprint is expected to contain little sulfidic material due to the marine nature of the sands.

Based on the desktop assessment, dredging The Entrance Channel and the exposure of the dredged sediments to air during beach nourishment activities would not be expected to carry any risk of disturbing acid sulphate soils. Nevertheless, acid sulfate soil testing comprising field screening and Chromium Reducible Sulfur testing was undertaken to support this assumption and is discussed below.

The results of the acid sulfate soil field screen testing indicated that no actual acid sulfate soils are present but that potential acid sulfate soils may be present. Accordingly, Chromium Reducible Sulfur testing was undertaken on five selected samples to identify any risk of sulfidic activity from unoxidised inorganic sulphur (as opposed to organic sources such as decomposing seagrass and vegetation).



Source: DLWC (now DECC) (1997) 1:25000 Acid Sulfate Soils Risk Maps 9131 N2 and 9231 N3

Figure 3 Indication of Acid Sulfate Soil Risk

The results indicated that each sample had significant potential sulfidic acidity levels which were greater than the "action criteria" specified in the Acid Sulfate Soils Manual guidelines (ASSMAC, 1998). However, sediments had sufficient acid neutralising capacity (ANC) to maintain a pH above 5.5 upon oxidation. Consequently, no acid sulfate soil management plan is required for the removal, handling and placement of the proposed dredge sediments.

2.5 Condition of the Beaches

Emplacement of dredged sand for beach nourishment was considered for several beaches in the vicinity of the dredge footprint, including beaches within The Entrance Channel and along the open coast.

The existing environment of beaches along the coastline is described in WP (2008). The predominant direction of longshore drift of sand is from south to north. Swell waves propagating from the south to south-east sector refract around a submerged reef (Bombora) situated just to the south of the estuary mouth, causing a reversal in longshore drift immediately to the north of The Entrance Channel. This process has created a null point along North Entrance Beach (refer **Figure 2**). North of this null point sand is transported northwards, whereas south of this point sand is worked back towards The Entrance causing the southward growth of The Entrance sand spit. Depending on prevailing wave conditions the position of the null point can vary by several hundred metres, up or down the coast in the vicinity of Hargraves Street. The null point does not appear to locate further south than the fixed dredging discharge pipeline outlet, approximately 370 m south of Hargraves Street.

The estuary eastern beach is located on the eastern shoreline of The Entrance Channel, fronting the Caravan Foreshore Park and the Karagi Foreshore Park. This area has a small sand buffer which is susceptible to erosion, particularly when a beach has formed on the southern foreshore of The Entrance Channel causing focusing of the flood tide currents towards the estuary eastern beach.

The Entrance Beach is located south of the estuary mouth between a rocky headland and the Bombora offshore the mouth of The Entrance Channel. Moderate erosion results in the exposure of rocks on the beach and within the surf zone. The loss of amenity at The Entrance Beach is a primary factor in the consideration of beach nourishment at this location.

Town Beach is not discussed in this section for reasons detailed in **Section 4.1.2**,

2.6 Land and Waterway Use

2.6.1 Zoning

The bed of the estuary, The Entrance Beach, and North Entrance Beach are Crown land under the control of the NSW Department of Lands.

Significant areas of the adjacent foreshores are zoned 6(a) (Open Space and Recreation) and are Crown Reserves under the care, control and management of Council. This includes Terilbah Reserve, Karagi Foreshore Park (including the estuary eastern beach), Yellawa Island, Picnic Point Reserve, and the southern foreshore of the estuary behind the seawall in the vicinity of Marine Parade.

Terilbah Island is zoned 8(a) (National Parks) and is part of the “Protected Area” of Wyrrabalong National Park, gazetted in 1991, and is under the control of the NSW Department of Environment and Climate Change (DECC).

2.6.2 Recreational and Commercial Uses

The Entrance Channel is a major holiday destination. The significant natural amenity of The Entrance is highly regarded by the communities of The Entrance and North Entrance townships and tourists alike. Both tourists and the local community use the foreshore of the channel for recreational pursuits such as walking, cycling, bird watching and picnicking. Depending on the condition of the channel, recreational activities such as sailing, water skiing, boating, wading and swimming are also popular. Recreational fishing is popular at The Entrance and there is high angler patronage, particular during peak tourism times such as the school summer holidays. The eastern foreshore of the Terilbah Channel is particularly popular for anglers.

The Dunleith Caravan Park is located on the northern foreshore of the channel and is frequented by tourists staying in mobile holiday homes, cabin users and campers.

Navigation of The Entrance Channel by boat is restricted due to the shallow, shoaling nature of the Channel. During high tide, it is possible for small craft with experienced local skippers to navigate the mouth of The Entrance Channel (PBP, 1994).

The proposed beach nourishment areas on the open coast are used by the general public for passive recreational activities including walking, fishing, swimming and surfing.

The Tuggerah Lakes are a major commercial fishery in NSW and provide a significant economic input to the Central Coast and Hunter region. Commercial fished stocks in the lakes include bream, flathead, luderick, mullet and prawns. The estuary supports farming and industries associated with power generation and boating.

During closure of The Entrance Channel, water quality and scenic values of the areas are degraded, impacting on the environment, community usage, tourist amenity and the commercial fishery.

2.7 Ecology

A desktop study was undertaken of available information and included searches of several online databases:

Australian Wetland Database (http://www.environment.gov.au/water/publications/environmental/wetlands/database/);

Environmental Protection and Biodiversity Conservation Act 1999 Protected Matters Search Tool (http://www.environment.gov.au/erin/ert/epbc/index.html);

NSW Atlas of NSW Wildlife database (http://wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas/watlas.jsp); and

Department of Environment and Climate Change Threatened Species Database (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/browse_geo.aspx).

Two site inspections were undertaken on 17th December 2008 and 4th of February 2009. A seagrass survey was conducted by WorleyParsons on 20th January and 16th April 2009 to assess the existing aquatic and terrestrial environments in the vicinity of the study area.

The results of these investigations determined that Tuggerah Lake is a wetland of National Significance as listed in the Directory of Important Wetlands in Australia (DIWA) (Commonwealth of Australia, 2009a), the key ecological features of which are discussed below.

2.7.1 Flora

Seagrasses

Seagrasses provide key habitat for many marine and estuarine species including wading and foraging birds, invertebrates and fish which use them for shelter and as nursery areas. Seagrasses also assist in reducing current velocities and consequently the settling and accretion of sediment, leading to improved water clarity, oxygen levels and nutrient content.

Extensive seagrass beds have developed within the flat, nearshore shallows of The Tuggerah Lakes. The lakes provide the third largest area of estuarine seagrass meadows in NSW, accounting for 7% of the total area (DoP, 2007). The majority of these areas, excluding the study site, are either protected under State Environmental Planning Policy No 14 – Coastal Wetlands (SEPP 14) or are zoned 7(g) Wetland Management under the Wyong LEP 1991.

According to the Tuggerah Lakes Estuary Process Study (Roberts, 2001), the area of seagrasses on the lakes has declined substantially. This deterioration is thought to be due to damage and removal, from activities such as anchor dragging and from deterioration in water quality. It should be noted that the distribution of seagrasses can also be affected by natural factors, such as severe storms, floods and natural siltation in estuaries.

Seagrass species have been recorded within the estuary including *Halophila ovalis* (paddleweed), *Ruppia megacarpa* (Sea Wrack) and *Zostera capricorni* (ribbonweed or eelgrass). A seagrass mapping survey undertaken for the NSW Department of Primary Industries (Fisheries) in 2005/2006 indicated that meadows of these species cover approximately 17.7 km^2, with mangroves and saltmarsh covering approximately 0.001 km^2 and 0.108 km^2 respectively (Williams *et. al.,* 2006). The mapping indicated that within the proposed dredge footprint, seagrasses are present along:

- both banks of the Terilbah Channel,
- the eastern shoreline of the main channel downstream to the vicinity of the caravan park, and
- the south-west side of Yellawa Island.

Field surveys were undertaken to:

- identify any seagrass beds within The Entrance Channel;
- review and verify existing information; and

identify and record any syngnathids (seahorses, seadragons, pipefish etc) or other threatened or endangered species that might be present in the study area.

Survey work excluded areas of the main channel downstream of the caravan park, as the channels and shoals were considered too mobile to allow colonisation by seagrasses. A full survey report is provided in **Appendix 2** and summarised below.

The proposed dredge footprint primarily consists of unvegetated sediment with some seagrass present. Areas of seagrass differ to that shown in the recent 2005/2006 DPI mapping exercise.

Two small beds of *H. ovalis* were recorded outside the dredge footprint, along the western shorelines of the northern end of Terilbah Channel. The remaining western shoreline of Terilbah Channel supports a continuous bed of *Z. capricorni*. The eastern shoreline of Terilbah Channel supports numerous discrete beds of *Z. capricorni*. Numerous small beds of *Z. Capricorni* are also present within Terilbah Channel itself.

Immediately downstream of the bridge a seagrass bed is present in the channel adjacent to Yellawa Island, with another outside the dredge footprint on the northern side of Yellawa Island. These beds are heavily fouled with epiphytes (organisms that grow on another plant for support). Further downstream, a discontinuous narrow bed of dense *Z. capricorni* with moderate epiphyte fouling is present along the eastern shoreline of the northern channel.

The main channel to the west of the bridge comprised nine distinct seagrass beds within the proposed dredge footprint and a narrow bed of *Z. capricorni* outside the footprint fringing the southern shoreline. Two small patches of *H. ovalis* were also recorded under moored boats at The Entrance Boathouse.

The southern shoreline of the channel downstream of the bridge (ie. in the vicinity of Town Beach) comprised five distinct beds up to 3 metres wide and three smaller patches of *Z. capricorni* were recorded in a gutter running adjacent to the seawall.

Numerous areas of wrack (i.e. decaying seagrasses and macroalgae) were observed, predominantly within deeper sections of the “sump” (hole previously dredged to act as a sediment trap) adjacent to the bridge, within the northern channel and also along the shoreline of the northern channel.

Macroalgae

Macroalgae was found to be in relatively low abundance when mapped and identified in the late 1990’s during the Tuggerah Lakes Estuary Process Study (Roberts, 2001). Eighteen species were identified including Chlorophyta (green algae), Rhodophyta (red algae) and Phaeophyta (brown algae).

A bed of live marine macroalgae was identified during the WorleyParsons 2009 seagrass survey, in the sump adjacent to the bridge. Species included *Ecklonia radiate*, *Sagassum* spp., and various other red and brown algae. Typically, macroalgae species are associated with subtidal rocky shores and reefs to which they attach via a holdfast. The macroalgae recorded were detached from the substrate and are likely to have entered the estuary from offshore reefs during the flood tide.

There was no evidence of the nuisance drift macroalgae which caused substantial blooms along the foreshore of the estuary during periods of eutrophication, seen in the 1980's. The abundance of macroalgae increases with the nutrient loading of the estuary.

Phytoplankton

Phytoplankton are microscopic aquatic plants that live in the water column and on the substratum of the estuary. Phytoplankton are primary producers that provide food for zooplankton and other invertebrates, which in turn are consumed by larger predators. The Tuggerah Lakes Estuary Process Study (Roberts, 2001) recorded 71 taxa of phytoplankton in the estuary with the highest diversity of species recorded at The Entrance (due to oceanic influences).

Saltmarsh

Saltmarsh is present within the study area along the eastern shoreline of Terilbah Island. Saltmarsh species recorded within the lakes include Samphire (*Sarcocornia quinqueflora*) and Saltwater Couch (*Paspalum vaginatum*) which fringe areas of the lakes which have not been reclaimed, and Sea Rush (*Juncus kraussii*) which is found in the understorey of Teatree swamps and Casuarina swamps (Commonwealth of Australia, 2009a). Saltmarsh provides an important role in the filtering of sediments from waters, the break-down of accumulating wrack along the lake foreshores and subsequent absorption of nutrients which would otherwise contribute to further growth of aquatic plants. Areas of saltmarsh in the estuary have been subject to extensive reclamations and disturbance, with less than 20% of the original saltmarshes now present (Roberts, 2001).

Terrestrial Vegetation

Adjacent to the channel, much of the area comprises residential or urban development and open space areas with little remaining vegetation.

Terilbah Island, part of Wyrrabalong National Park, is densely vegetated with vegetation communities comprising Teatree swamp, which is dominated by Broadleaf Paperbarks (*Melaleuca quinquenervia*), and Casuarina swamp, which is dominated by Swamp Oak (*Casuarina glauca*) (Commonwealth of Australia, 2009a). The relatively stable water level within the lakes has allowed terrestrial vegetation to establish close to the shoreline. Some littoral rainforest species such as tuckeroo have also been recorded on the island (NSW NPWS, 1995).

Terilbah Reserve, on the opposite bank of the Terilbah Channel, is a grassed recreational area which contains three stormwater treatment zones aimed at reducing sediment and nutrient loads entering the lake from urban runoff. Species present include Norfolk Island Pines (*Araucaria heterophylla*) *Phragmites* spp (which fringes the eastern shoreline of much of the reserve), *Casuarina* spp. and *Melaleuca* spp.

Yellawa Island is vegetated by several Casuarina trees, bitou bush (*Chrysanthemoides monilifera*) and other exotic weeds. An established Canary Island Date Palm (*Phoenix canariensis*) is a prominent feature of the western shore of the island and has a partially exposed root system. This palm is of cultural significance to the local community and concern has been raised as to the impact of dredging on the stability of the root system.

Immediately adjacent to the proposed beach nourishment area, the dunes that back North Entrance Beach are predominantly vegetated with groundcover such as Spinifex grass (*Spinifex sericeus*) and the introduced Pennywort (*Hydrocotyle bonariensis*). The more stabilised area at the crest of the dunes is vegetated with low shrubs including Coastal Wattle (*Acacia sophorae*), Coastal Banksia (*Banksia integrifolia*), and She-oaks (*Casuarina Spp*.)

A search of the NSW Wildlife Atlas which reports recordings of threatened plant species indicated that no threatened flora species have been recorded within the vicinity of the study area. A search of the EPBC protected matters database (**Appendix 3**) indicated that three threatened flora species listed under the EPBC Act are likely to occur, or have habitat that is likely to occur within the general Central Coast area as shown in **Table 2.1**. Areas immediately adjacent to the dredge footprint and beach nourishment areas do not provide habitat for these species.

Table 2.1 Threatened Flora Species Listed under the Commonwealth EPBC Act

Common Name	Scientific Name	EPBC Act Threatened Spp Listing
Leafless Tongue-orchid	*Cryptostylis hunteriana*	Vulnerable
Magenta Lilly Pilly	*Syzygium paniculatum*	Vulnerable
Camfield's Stringybark	*Eucalyptus camfieldii*	Vulnerable

2.7.2 Fauna

Marine and estuarine fauna

Common fish species found in the estuary include bream, flathead, luderick and mullet. These species, along with prawns are fished both recreationally and commercially.

A search of the EPBC Protected Matters database indicated 15 threatened and/or migratory marine fauna species, or habitat for those species are likely to occur within the study area (refer **Appendix 3**). The search results included eight cetaceans, one ray-finned fish, whale-shark, three sharks and two turtles. The cetaceans (whales) are not discussed further as neither the dredging or beach nourishment would affect these species as they migrate along the coast. The remaining species are listed in **Table 2.2**.

Several of the species included in **Table 2.2** are also listed under the NSW TSC Act and have been recorded both within Tuggerah Lake and offshore in the vicinity of The Entrance Channel.

Threatened species scheduled under the *Fisheries Management Act 1994* (FM Act) where identified via a search of the NSW DPI (Fisheries) online priorities action statement (PAS) for the Hunter-Central Rivers Catchment Management Authority region: (http://pas.dpi.nsw.gov.au/Species/Species_byRegionResult.aspx?Region=Hunter/Central+Rivers). This search returned four threatened species (refer **Table 2.2**).

No populations or communities scheduled under the FM Act were identified within the study area. Threatened ecological communities scheduled under the TSC Act are discussed in **Section 2.7.3**.

Table 2.2 Threatened and Migratory Marine Species Listed Under the Commonwealth EPBC Act, the NSW TSC Act and the NSW FM Act

Common Name	Scientific Name	EPBC Act Listing	EPBC Act Threatened Spp Listing	TSC Act Threatened Spp Listing	FM Act Threatened Spp Listing
Australian Grayling	*Prototroctes maraena*	Threatened	Vulnerable		-
Green Turtle	*Chelonia mydas*	Threatened/ Migratory	Vulnerable	Vulnerable	-
Leatherback Turtle	*Dermochelys coriacea*	Threatened/ Migratory	Endangered	-	-
Grey Nurse Shark	*Carcharias taurus*	Threatened	Critically Endangered	-	Critically endangered
Great White Shark	*Carcharodon carcharias*	Threatened/ Migratory	Vulnerable	-	Vulnerable
Green Sawfish	*Pristis zijsron*	Threatened	Vulnerable	-	Presumed extinct
Whale Shark	*Rhincodon typus*	Threatened/ Migratory	Vulnerable	-	-
Dusky Dolphin	*Lagenorhynchus obscurus*	Migratory	-	-	-
New Zealand Fur-Seal	*Arctocephalus forsteri*	-	-	Vulnerable	-
Australian Fur-Seal	*Arctocephalus pusillus doriferus*	-	-	Vulnerable	-
Black Cod	*Epinephelus daemelii*	-	-	-	Vulnerable

One pipehorse (protected under the FM Act) was recorded during the seagrass surveys adjacent to the dredge footprint in a small bed of *Z. capricorni* on the northern shore of Yellawa Island. Pipehorses are protected species under the FM Act. Other protected species identified in the database search included three fish and 31 syngnathiformes (i.e. seahorse, pipefish and seadragon, ghostpipefish and seamoths).

Nearshore Infauna and Reef Communities

The nearshore faunal communities of North Entrance Beach are likely to be poorly developed as a result of the continually shifting sand substrate in this moderate to high wave energy environment. Previous studies in a similar environment at a southern Gold Coast Beach (AWC and PBP, 1994) indicate that small crustacea (amphipods, isopods, decapods and cumaceans) would likely dominate the mobile sands with polychaete worms also having a significant presence.

Tuggerah Reef is a submerged reef which extends off the southern side of the mouth of the estuary adjacent to The Entrance Beach. The reef is likely to provide habitat for adult and juvenile fish and invertebrates, such as urchins, barnacle and anemones, that are tolerant to high energy environments.

Marine and Wetland Birds

The intertidal flats, sand shoals and exposed seagrass beds in the vicinity of The Entrance Channel are part of several areas in the estuary which provide feeding habitat for shorebirds. Migratory waders also breed on Terilbah Island and the nearby Pelican Island which are within Wyrrabalong National Park.

The Entrance sand spit provides breeding and nesting habitat known to be utilised by the Little Tern which is listed as endangered under the TSC Act. Six other waders and one marine bird listed under the TSC Act have been recorded in the vicinity of The Entrance Channel and beach nourishment areas as shown in **Table 2.3**. Three of these species, including the Little Tern and the Lesser Sand-plover are also included in the 19 threatened or migratory marine and wetland bird species listed under the EPBC Act, see **Table 2.3**.

Table 2.3 Threatened and Migratory Marine and Wetland Bird Species Listed Under the Commonwealth EPBC Act and the NSW TSC Act

Common Name	Scientific Name	EPBC Act Listing	EPBC Act Threatened Spp Listing	TSC Act Threatened Spp Listing
Antipodean Albatross	*Diomedea exulans antipodensis*	Threatened/ Migratory	Vulnerable	-
Gibson's Albatross	*Diomedea exulans gibsoni*	Threatened/ Migratory	Vulnerable	-
Southern Giant-Petrel	*Macronectes giganteus*	Threatened/ Migratory	Endangered	Endangered
Northern Giant-Petrel	*Macronectes halli*	Threatened/ Migratory	Vulnerable	-
Kermadec Petrel (western)	*Pterodroma neglecta neglecta*	Threatened	Vulnerable	-
Australian Painted Snipe	*Rostratula australis*	Threatened	Vulnerable	-
Buller's Albatross	*Thalassarche bulleri*	Threatened/ Migratory	Vulnerable	-
Shy Albatross	*Thalassarche cauta cauta*	Threatened/ Migratory	Vulnerable	-
Salvin's Albatross	*Thalassarche cauta salvini*	Threatened/ Migratory	Vulnerable	-
White-capped Albatross	*Thalassarche cauta steadi*	Threatened/ Migratory	Vulnerable	-
Campbell Albatross	*Thalassarche melanophris impavida*	Threatened/ Migratory	Vulnerable	-
Fork-tailed Swift	*Apus pacificus*	Migratory	-	-
Great Egret, White Egret	*Ardea alba*	Migratory	-	-
Cattle Egret	*Ardea ibis*	Migratory	-	-
Sharp-tailed Sandpiper	*Calidris acuminata*	Migratory	-	-
Lesser Sand Plover	*Charadrius mongolus*	Migratory	-	Vulnerable
Latham's Snipe	*Gallinago hardwickii*	Migratory	-	-
Painted Snipe	*Rostratula benghalensis s. lat.*	Migratory	-	-
Little Tern	*Sterna albifrons*	Migratory	-	Endangered
Great Knot	*Calidris tenuirostris*	-	-	Vulnerable

Broad-billed Sandpiper	*Limicola falcinellus*	-	-	Vulnerable
Terek Sandpiper	*Xenus cinereus*	-	-	Vulnerable
Sooty Oystercatcher	*Haematopus fuliginosus*	-	-	Vulnerable
Pied Oystercatcher	*Haematopus longirostris*	-	-	Vulnerable

In addition to the migratory shorebird species listed in **Table 2.3** there are other species listed under bilateral migratory bird agreements between Japan and Australia (JAMBA), and between China and Australia (CAMBA). Migratory species listed under bilateral agreements are also considered a matter of national environmental significance under the Commonwealth EPBC Act. Species listed include the Bar-tailed Godwits (*Limosa lapponica*), Curlew Sandpiper (*Calidris ferruginea*), Sharp-tailed Sandpiper (*Calidris acuminate*), Red-necked Stint (*Calidris ruficollis*) and Red Knot (*Calidris canutus*), which frequent the estuary over spring/summer (Commonwealth of Australia, 2009a).

2.7.3 Ecological Communities

Terilbah Island may support several endangered ecological communities (EEC's) of the NSW North Coast, Sydney Basin and Southeast Corner bioregion which are protected under the NSW TSC Act. These include Coastal Saltmarsh, Littoral Rainforest, and Swamp Oak floodplain forest.

3. DESCRIPTION OF THE PROPOSED WORKS

3.1 Proposed Dredging Works

The dredging is generally to be undertaken as per previous dredging campaigns of The Entrance Channel and is predominantly designed to enhance the ebb tide flow (out flow) from the estuary. The dredge strategy was developed following trial dredging investigations in 1991 and has been refined following annual maintenance dredging that has been carried out in The Entrance Channel since 1993. The current strategy involves staged dredging by Council using a small (10/8) cutter suction dredger (CSD) (**Photo 1**). The typical arrangement of the dredge footprint covers approximately 2.5 km's of channels and sumps within The Entrance System as shown in **Figure 2** and **Photo 2**.

Dredging commences from the upstream end of the channels such that the ebb flows contribute to the dredging efforts. The channels are typically dredged to a width of 50 m and to a level of 2.0 m below water level except as note below. Water level in the lake is approximately 0.06 m above Australian Height Datum (AHD) in the vicinity of The Entrance which is roughly equivalent to mean sea level. Those areas determined by the recent hydrographic surveys of The Entrance Channel that are deeper than 2m (AHD) are shown in **Figure 2**. The surveys indicate that much of the proposed dredge footprint will require dredging in the next few years.

Dredging is generally undertaken as follows:

creation of a sediment trap (sump) across the main entrance parallel and adjacent to the eastern side of the road bridge. The low velocity environment created by the dredged sediment trap causes deposition of sands migrating with the flood tide, prolonging the timeframe required between maintenance dredging episodes and reducing the need to dredge channels upstream of the bridge. The sump adjacent to the bridge has previously been dredged to approximately 30 m in width in the vicinity of Yellawa Island. However, as discussed in **Sections 6.1.1** and **7.1.1**, it is proposed to exclude from the dredge footprint that portion of the sump immediately to the west of Yellawa Island to reduce any risk of foreshore erosion to Yellawa Island.

dredging the main channel to the east of the road bridge on a yearly basis.

dredging the ebb dominant northern channel (between the road bridge and the caravan park). This section of channel is dredged approximately every two years.

dredging the ebb dominant northern channel from the caravan park, downstream through the middle of the flood tide shoal to the mouth of the estuary. This channel is dredged to a width of approximately 80m. The southern tip of the sand spit is also dredged. Dredging is undertaken yearly in these areas.

Additional dredging is also undertaken on an 'as required' basis:

dredging of Terilbah Channel, from the northern end of Terilbah Island, approximately parallel to Stewart St, downstream to the road bridge. Terilbah Channel has been dredged three times since dredging began in 1993 and was last dredged in 2008.

occasional dredging of a sump, perpendicular to and south of the main channel, just to the west of the sand spit.

dredging of the main channel to the west of the road bridge to a width of approximately 80m. This area was significantly dredged in 1993 and was last dredged in 1995. The area has progressively shallowed and is likely to require dredging in 2010 to allow flushing of the ebb tide into The Entrance Channel.

dredging of a flood dominant southern channel (to 1.0 m below water level) along the southern foreshore of The Entrance Channel.

3.1.1 Production Rates and Quantities

Council's dredge was built to specification based on dredging trials undertaken in March/April 1991. The trials indicated that effective maintenance of The Entrance Channel would require a dredge capable of removing 60,000 m^3 of material over a 12 week period (PBP, 2004).

The most recent records of dredge quantities available are from the 2004 campaign. These records indicate that 81,300 m^3 (132,800t) of material was dredged from The Entrance Channel. Council's dredge crew have indicated that these records are typical of quantities dredged on a yearly basis over approximately a 3 to 4 month dredging campaign.

Dredging production rates of ~105 m^3/hr (170 t/hr) are generally achieved by the CSD. Slower rates are expected during dredging of the sump and in the vicinity of the ebb tide channel between the bridge and the caravan park due to the presence of old bridge supports and old Telecom cables within the channel. Similarly, dredging of the main channel downstream of the caravan park is often slowed due to the presence of fishermen and anchored boats within the channel.

3.2 Proposed Beach Nourishment

Dredged sand is beneficially reused to nourish areas where, through visual inspection, it is determined that maximum environmental benefit to the dune system and beach amenity would result. Council aims to nourish beaches and foreshores to:

renourish and protect dunes and foreshore areas and subsequently the ecosystems of these areas;

protect the recreational value of the beaches as areas of public recreation; and

retain sand as mobile beach sand circulating within The Entrance sand system and prevent a net reduction of sand from the system over time. This is necessary to maintain the sand spit, The Entrance sand bar and flood tide shoals which are the natural control on lake levels and which provide natural protection of upstream areas from ocean storms.

North Entrance Beach is nourished during each dredging campaign. The beach profile experiences erosion during significant storm events which can undermine the vegetated dunes (refer **Photo's 3** to **8**).

Approximately 50,000 m^3 of dredged sand is deposited on North Entrance Beach (as indicated by 2004 records). Placement to the south of a null point in the general vicinity of Hargraves St ensures that the sand is reworked back towards The Entrance Channel, thereby retaining sand within The Entrance sand system.

The estuary eastern beach is renourished on a regular basis. Recently, a small sand spur was also placed in the vicinity of the boundary of Karagi Foreshore Park and the Dunleith Caravan Park. **Photo's 9** to **12** show the effects of erosion and beach nourishment in this area.

The Entrance Beach is renourished on a less frequent basis. Nourishment has been undertaken approximately every five years (1994, 1999, and 2004). Approximately 30,000 m^3 of dredged sand was placed on The Entrance Beach in 2004. Nourishment generally takes place only following representations from the Surf Club. Council consider that the area is too dynamic for sand to remain in place for any considerable length of time. The nourishment process is often slower than that of adjacent beaches as a result of regular disruption to the floating discharge pipeline during strong flood tides through the throat[1] of The Entrance Channel or due to wave action across the rock platform to the north of The Entrance Beach.

Dredged sand is pumped from the CSD to the nourishment areas along a temporary submerged discharge pipeline. A permanent pipeline is also buried within the dune system and exits onto North Entrance Beach. The maximum pumping distance from the CSD to any nourishment area is 800 m. No booster pump is used. Sand dredged from upstream of the road bridge is therefore limited to placement on the estuary eastern beach. Dredged sand from the sump and from the ebb tide channel between the bridge and the caravan park is deposited on the estuary eastern beach, whereas sand dredged further downstream, from the main channel and from the flood dominant southern channel is pumped to North Entrance Beach or occasionally, The Entrance Beach.

To minimise localised erosion at the discharge location, the dredged sand is sprayed upwards to dissipate energy. This is undertaken from an elevated pipeline outlet onto the subaerial (above water) profile of the beach, below the edge of the erosion scarp where possible.

[1] The throat is that section of the channel near the southern tip of the sand spit having minimum cross-section dimensions.

Photo 1 - Wyong Shire Council's Cutter Suction Dredge

Photo 2 - The Entrance Channel – typical alignment of dredged channel with dredging commencing at the upstream extremities such that dredging effort is enhanced by the ebb tide.

North Entrance Beach – view north from Karagi Park beach access track

Photo 3 - 8th February 2008 – severely eroded beach profile

Photo 4 - 19th May 2008 – beach profile following beach nourishment and re-shaping

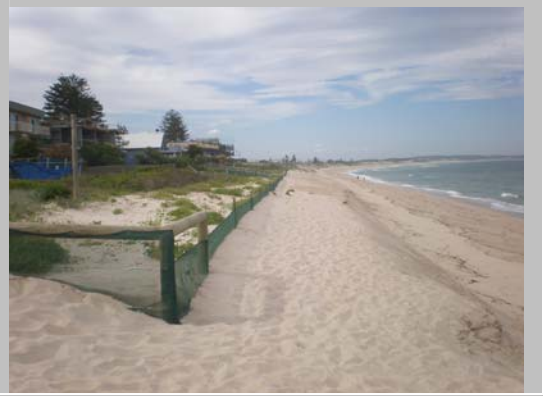


Photo 5 - 17th December 2008 – moderately eroded beach profile

North Entrance Beach – view south from Karagi Park beach access track

Photo 6 - 8th February 2008 – severely eroded beach profile with pipeline discharge prepared for beach nourishment acitivites

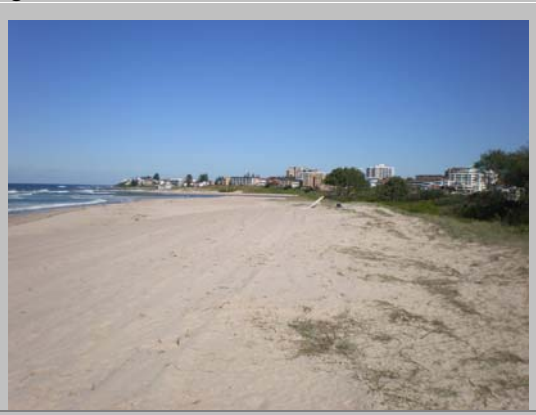


Photo 7 - 19th May 2008 – beach profile following beach nourishment and re-shaping

Photo 8 - 17th December 2008 – moderately eroded beach profile

Estuary Eastern beaches – view west from Karagi Foreshore Park towards Dunleith Caravan Foreshore Park

Photo 9 - 8th February 2008 – severely eroded beach profile – view west from Karagi Foreshore Park towards Dunleith Caravan Foreshore Park

Photo 10 - 17th December 2008 – severely eroded beach profile - view west from Karagi Foreshore Park towards Dunleith Caravan Foreshore Park several months after beach nourishment

Estuary Eastern beaches – view east from Karagi Foreshore Park towards the sand spit

Photo 11 - 8th February 2008 – severely eroded beach profile

Photo 12 - 17th December 2008 – moderately eroded beach profile several months after beach nourishment

3.3 Rehabilitation of Work Areas

Following placement at predetermined locations, the material is shaped into a natural pre-eroded beach profile by bulldozer and is left unvegetated as mobile beach sand.

The desired cross-shore and alongshore profile should be determined through land survey or photogrammetric data of the natural profiles under "beach full" or accreted conditions. In the absence of such survey information, re-shaping should aim to:

match the crest level of the emplaced material with the existing dune crest level;

achieve a stable seaward gradient of the foredune of not more than 1 in 5 (1 vertical : 5 horizontal); and

achieve a beach berm gradient of 1 in 20 to 1 in 30.

Any areas temporarily utilised for servicing, access etc would be rehabilitated by the Dredge Master to the satisfaction of Council.

3.4 Plant and Equipment

3.4.1 Dredging and Beach Nourishment

The following plant and equipment are generally used in the dredging and beach nourishment activities:

Council's cutter suction dredger;

floating or sunken discharge pipeline (in approximately 50 m sections);

permanent discharge pipeline which is located in the dunes between the estuary eastern beach and North Entrance Beach; and

a workboat – used for refuelling, towing of barge and pipelines into location.

Safety and Signage

Several safety measures are implemented during dredging and at the beach nourishment sites during discharge of dredged material and reshaping of the beach profile including:

fitting the dredge with navigation "obstruction signage";

marking the discharge pipeline with floats spaced every 30 to 40 m within the channel;

fencing off the outlet of the discharge pipe and erecting signs along the fence with either symbols indicating No Surfing/ No Walking or "Reclamation/ Keep Out"; and

continual monitoring of the discharge area during operational hours.

Refuelling

The dredge is refuelled every two days during the dredging operation. A fuel truck (with capacity to carry 2500L of distillate) is parked at the western end of Hargraves St (refer **Figure 1**) to refuel a workboat. The workboat is used to shuttle and pump fuel to the dredge.

The dredge is supplied with a spill kit containing booms, pads and absorbent material. In the event of a spill, procedures are in place to control the cause, contain the spill, notify the Supervisor and NSW Fire Brigade, and to clean-up the spill.

Service and Maintenance

Routine maintenance is occasionally undertaken to keep plant and equipment in operation.

Major maintenance and detailed inspection of the dredge for a NSW Maritime Certificate of Survey is required approximately every three years. It is necessary to remove the dredge to a dedicated on-shore work area to allow for dismantling, detailed inspection, cleaning, painting and repair works.

Council have in the past removed and dismantled the dredge at Picnic Point and transported the dredge to Council's work deport for maintenance. As this activity is no longer compatible with the land use at Picnic Point, alternatives are currently being investigated and would be subject to a separate environmental assessment.

3.5 Project Timing and Duration

Decision support tools available to determine when to initiate dredging include observations of the tidal gauge, examination of aerial photography, and direct visual observation. It is recommended that direct visual observations be undertaken by experienced personnel (such as the Dredge Master) using the triggers detailed below. This system should be adopted as a trial and re-evaluated over time (refer **Appendix 5**). The recommended triggers to initiate dredging are as follows:

- the throat[2] of the channel at The Entrance reduces to an estimated width of less than 15m measured at mid tide level;
- the flood tide sand shoals threaten to block[3] the ebb tide dominant channel along the northern/eastern side of The Entrance Area; and/or
- the flood tide sand shoals threaten to block the main channel east of the bridge.

While dredging campaigns are predominantly timed to prevent the closure of the estuary mouth, several other objectives are also considered.

[2] The throat is that section of the channel near the southern tip of the sand spit having minimum cross section dimensions.

[3] Some judgment would be required to assess when actual blockage could occur so as to allow adequate time to initiate dredging and avoid constraints such as peak recreational use of the waterway and ecological impacts, eg. Little Tern breeding and nesting.

Dredging and beach nourishment during peak tourism periods is generally avoided for both aesthetic and safety reasons. To ensure a more appealing appearance of The Entrance area during the summer holiday period, completion of dredging generally occurs prior to the commencement of the December school break.

Beach nourishment of North Entrance Beach is not undertaken during the spring-summer breeding times of the threatened species, the Little Tern (*Sterna albifrons*) (refer **Section 2.7**) which is known to breed on The Entrance sand spit.

Consideration has previously been given to the timing of dredging to benefit marine fauna passage between the ocean and the lakes following ocean spawning. However, advice from NSW Fisheries during the Tuggerah Lakes Restoration Project in the early 1990's indicated that no particular timing for the dredging is beneficial. Feedback from commercial fishers indicates a preference for dredging not to be undertaken during the prawning season which generally ends by March each year (refer **Table 5.2**).

For the above noted reasons, dredging is generally undertaken in the period from April to September.

A typical dredging campaign is approximately 3-4 months in duration with approximately 800 hours of dredging undertaken (as per Council's 2004 records). During each campaign operation times are:

six days a week (Mon-Sat);

between 6am and 6pm, Mon-Wed; and

between 6am and 2.30pm (and up to 6pm when necessary) from Thurs- Sat.

4. PROJECT JUSTIFICATION AND CONSIDERATION OF ALTERNATIVES

4.1 Alternatives to the Project Proposal

4.1.1 Alternatives to Dredging

Alternatives to the regular maintenance dredging of The Entrance Channel have previously been discussed in technical papers prepared by the NSW Public Works Department and Patterson Britton and Partners (refer PWD, 1988; PBP, 1994; PBP, 2004) and also by in The Tuggerah Lakes Estuary Management Study (Roberts and Dickinson, 2005). Options considered included:

- fixed jet pumping system with geotextile tubes stabilising the entrance channel;
- construction of entrance training walls and breakwaters;
- creating a second entrance to the lakes; and
- creating a connection to Lake Macquarie.

These options were considered unfeasible based on cost (high capital and maintenance costs) and/ or major environmental impacts.

4.1.2 Alternative Placement Options

To minimise costs, potential nourishment areas are limited to within the pumping distance of the dredge, i.e. approximately 800 m.

Placement on Town Beach

Town Beach is an informal beach area which forms transiently on the southern foreshore of The Entrance Channel. While nourishment of this area has been undertaken in the past, it is not an ideal location for beach nourishment for several reasons.

This is a highly dynamic area and is often occupied by the flood tide channel, which could be dredged to enhance the flood tide flows. In addition when the beach is present the flood tide channel is diverted across The Entrance Channel, causing additional scour along the estuary eastern beach. Council has also expressed safety concerns in relation to encouraging swimming within The Entrance Channel in this location.

Nourishment of Islands within the Estuary

Nourishment of the foreshores of islands within the estuary such as Yellawa Island and Terilbah Island using dredged material was considered unsuitable as placement would likely result in the smothering of seagrasses and intertidal habitat utilised by wading birds for feeding and nesting.

4.1.3 The Do-Nothing Option

The do-nothing alternative (i.e. to not undertake dredging and beach nourishment) would result in maintenance cost savings however it is considered an unacceptable option for the existing anthropogenic state of the estuary due to the following likely outcomes:

intermittent closing of The Entrance Channel;

reduction/prevention of tidal flushing of lake waters with the ocean and changes to circulation and mixing of the lake waters during low flow periods;

potential deterioration in water quality;

potential changes to the abundance and diversity of existing aquatic fauna and flora in Tuggerah Lakes due to decreased water quality and prevention of fauna movements between the lakes and ocean;

potential increased sedimentation of the estuary;

increased risk of flooding in the upper estuary;

increased safety risks to people and property as a result of increased flood risks;

adverse economic impacts associated with flood risks and changes in species abundance and diversity.

4.2 Ecologically Sustainable Development

Wyong Shire Council is committed to the principles of ecologically sustainable development (ESD). The proposal is consistent with these principles (set out in the *Protection of the Environment Administration Act 1991*), as discussed below.

Precautionary Principle

This principle states that “if there are threats of serious or irreversible damage, lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental damage”.

The possible short and long-term impacts on the environment have been assessed in relation to the proposal. Safeguards have been proposed to minimise the potential impacts identified during the assessment.

In the application of this principle, decisions should be guided by:

1) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and
2) an assessment of the risk-weighted consequences of various options.

The dredging and beach nourishment activities proposed have been undertaken in approximately yearly campaigns over the past 16 years. Detailed studies have been undertaken in the preparation

of this REF to determine the impacts from the dredging in The Entrance Channel and nourishment of adjacent beaches.

No material is removed from the active beach system which might otherwise result in the net loss of sand from the sand spit and sand shoals over time and resulting impacts to lake levels and a reduction in protection to the estuary from ocean storms. The effect of dredging and beach nourishment is reversible over time, hence the need for ongoing maintenance work.

Intergenerational and Intragenerational Equity

The principle states "the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations".

The regular dredging and beach nourishment activities proposed would have a positive impact on current and future generations for as long as the activities are carried out. These activities reduce risks associated with flooding and declining water quality, maintain the current hydraulic regime and associated lake ecology, and ensure the protection of the foreshore of the estuary eastern beach and North Entrance Beach against ongoing erosion.

Conservation of Biological Diversity and Ecological Integrity

The principle states that the "diversity of genes, species, populations and communities, as well as the ecosystems and habitats to which they belong, must be maintained and improved to ensure their survival".

Maintenance dredging would assist in the conservation of existing ecological assemblages within the estuary that have adapted to the current tidal regime and flow dynamics. Protection of dune vegetation and habitat behind North Entrance Beach is also possible through continuation of the maintenance dredging and beach nourishment practices.

Improved Valuation and Pricing of Environmental Resources

This principle states that "costs to the environment should be factored into the economic costs of a project". Namely that environmental factors should be included in the valuation of assets and services, such as:

> polluter pays, that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,
>
> the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,
>
> environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

Continuation of the existing dredging and beach nourishment activities has been selected as the preferred option to ensure ongoing amelioration of the flood risk, prevention of water quality degradation and protection of the dune systems from coastal erosion. Whilst this option is considered to be the most effective and has the least environmental impact, this environmental assessment along with the mitigative/ management measures outlined in this REF would result in an economic cost to Wyong Shire Council. Thus, the value of environmental resources has been recognised.

4.3 Justification for the Project

As the do-nothing option would potentially result in unacceptable flood risks and water quality impacts and associated ecological impacts, an option is required to prevent closure of The Entrance Channel.

As has previously been determined, maintenance dredging of The Entrance Channel is the only long term viable option that would prevent more frequent closure of The Entrance Channel, at a reasonable cost and with limited adverse social, economic or environmental impacts.

The continuation of the existing practices of annual maintenance dredging and beach nourishment would involve ongoing maintenance costs but would utilise available plant and equipment which could also be utilised elsewhere in the estuary. Additionally, the practices are flexible and allow for the selection of dredging and beach nourishment locations to achieve maximum benefit depending on antecedent conditions.

The dredging would facilitate:

- continual tidal exchange of lake waters with the ocean thereby reducing sediment loads, and pollutant and contaminant concentrations in the lake waters;
- preservation of the existing diversity and abundance of flora and fauna in the estuary which have adapted to the dredging regime;
- preservation of amenity at The Entrance; and
- reduction in peak flood levels and rapid drawdown of floodwaters in the estuary in comparison to a closed entrance.

Some small beds of seagrass (*Z. capricorni*) that have colonised since previous dredging campaigns would be removed during the dredging process. These areas are not considered significant relative to the overall abundance of *Z. capricorni* in the estuary. The removal of these areas is considered an acceptable consequence in the management of flood impacts and the overall water quality of the estuary. In addition, this option is seen as the most beneficial in terms of maintaining the overall health and abundance of the remaining seagrass beds in the estuary. The increased tidal range which would result from maintaining a permanently open entrance through the use of training walls or the like would likely result in a reduction in seagrass areas. Similarly, options that would allow permanent closure of The Entrance Channel could potentially result in the decline in seagrass density or abundance as a result of increased nutrient loadings, increased epiphyte fouling, and reduced salinity.

The preferred locations for beach nourishment (i.e. the estuary eastern beach, North Entrance Beach and The Entrance Beach) and the method of beach nourishment used (i.e. pumping of material via a pipeline) allows for the beneficial reuse of the proposed dredged material to protect the existing dunes and enhance beach amenity while retaining sand within The Entrance sand system. This option also minimises costs associated with transportation and access to nourishment areas.

If sand was to be placed in areas outside of the sand system (such as north of the null point on North Entrance Beach), the erosion problem along North Entrance Beach would most likely be exacerbated as a result of a reduction in supply of material. If nourishment of the preferred locations is not undertaken, continued erosion of the existing dune systems and foreshore vegetation, and eventually impacts to adjacent property may result.

5. ENVIRONMENTAL PLANNING FRAMEWORK

5.1 Commonwealth Approvals Process

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides an assessment and approvals system for actions that have significant impact on matters of national environmental significance, on the environment of Commonwealth land and actions carried out by the Commonwealth Government. Actions that have, or are likely to have, a significant impact on a matter of national environmental significance, on the environment of Commonwealth land and actions carried out by the Commonwealth Government require approval from the Australian Government Minister for the Environment, Heritage and the Arts under the Commonwealth EPBC Act.

The proposed dredging and beach nourishment works will not impact on Commonwealth land and will not be undertaken by the Commonwealth. Accordingly, the only potential for an approval to be required is in relation to the seven matters of national environmental significance. These are:

World Heritage properties;

National Heritage places;

wetlands of international importance (Ramsar wetlands);

listed threatened species and ecological communities;

listed migratory species;

Commonwealth marine areas; and

nuclear actions (including uranium mining).

As detailed in **Section 8.3.1**, the proposed works would not have a significant impact on matters of national environmental significance as listed in the EBPC Act and accordingly, a referral is not required to the Commonwealth Minister for the Environment, Heritage and the Arts.

5.2 NSW Planning and Approvals Process

The NSW environmental planning legislative framework provides for the classification of developments, and the assessment of impacts from developments and activities. This framework comprises:

Environmental Planning and Assessment Act 1979 (EP&A Act);

Environmental Planning and Assessment Regulation 2000 (EP&A Regulation);

Environmental Planning Instruments (EPIs) made under the EP&A Act (i.e. State Environmental Planning Policies (SEPPs), Regional Environmental Plans (REPs), and Local Environmental Plans (LEPs); and

other planning codes, policies, guidelines and strategies that relate to any proposed development of a particular site including Development Control Plans (DCPs) and Council codes and policies.

The EP&A Act provides the statutory basis for planning and environmental assessment in New South Wales. The Minister, statutory authorities and local councils are all responsible for implementing this Act.

EPI's prepared under the EP&A Act list the types of development which:

require development consent;

do not require development consent; and

are prohibited.

The Wyong LEP 1991 contains a variety of clauses that identify the requirement of consent for the proposed works. However, State environmental planning instruments such as State Environmental Planning Policies (SEPP's) generally prevail over Regional and Local Environmental Plans. The provisions of SEPP (Infrastructure) 2007 remove the consent requirements for the proposal under other EPI's, however the objectives of the LEP are still relevant to the proposal.

State Environmental Planning Policy (Infrastructure) 2007

Under SEPP (Infrastructure) 2007, the proposed works do not require consent. Excavation (i.e. dredging) carried out by, or on behalf of a public authority on any land is permitted without consent in order to alter tidal action for the purpose of flood mitigation under Clause 50 of the SEPP. Beach nourishment carried out by, or on behalf of a public authority on any land is permitted without consent under Clause 129 of the SEPP for the purpose of waterway or foreshore environmental management works.

State Environmental Planning Policy No 71 – Coastal Protection

The policy has been made under the *Environmental Planning and Assessment Act 1979* to ensure that development in the NSW coastal zone is appropriate and suitably located, to ensure that there is a consistent and strategic approach to coastal planning and management and to ensure there is a clear development assessment framework for the coastal zone.

5.3 Other Relevant State Legislation

Crown Lands Act 1989

A licence is required from the NSW Department of Lands (Lands) under Section 34 of the *Crown Lands Act 1989*. The licence applies to the dredging and beach nourishment activities carried out on Crown land, including submerged Crown land.

Council currently have a licence (Number LI 368371) covering the dredging of The Entrance Channel to the east of the road bridge, and nourishment of The Entrance Beach and North Entrance Beach. Clause 63 of the licence provides for the dredging and nourishment activities in accordance with the

previous REF (WSC, 2004) and the Tuggerah Lakes Estuary Management Plan (Dickinson et. al., 2006). As the proposed scope of work has increased to include dredging of unreserved Crown land to the west of the road bridge and nourishment of the estuary eastern beaches, it is expected that a modification or amendment to the licence is required.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) is administered by the NSW Department of Primary Industries (DPI) for the conservation, development and sharing of the States fisheries resources.

Part 7, Division 3 (dredging and reclamation) of the FM Act provides for the conservation of aquatic biodiversity and protection of fish habitat by managing dredging and reclamation works. Council's permit to dredge expired at the end of June 2009. Recent advice received from DPI indicates that a permit to dredge under Section 200 of the FM Act is not required where Council hold a permit to dredge the area from the Department of Lands.

Part 7A (Threatened Species Conservation) of the FM Act provides for the protection of threatened species, populations and ecological communities comprising fish and/or marine vegetation.

The potential impact of the proposal on threatened species and their habitats has been assessed in **Section 6.4**. The proposed works would not have a significant impact on any species, population or community listed under the FM Act, and therefore a Species Impact Statement and a licence for harm under Section 220ZW of the FM Act are not required.

In addition, direct harm (e.g. removal) and indirect harm (e.g. shading, changes to sedimentation/scour patterns) to marine vegetation (mangroves, seagrass and macroalgae) will require a permit to harm marine vegetation under Section 205 of the FM Act.

Protection of the Environment Operations Act, 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is the primary Act providing for the management of pollution and waste disposal in NSW. A licence is required prior to carrying out 'scheduled' activities as listed in Schedule 1 of the POEO Act, including the dredging of more than 30,000 m^3 of material per year.

An EPL is currently in effect (EPL 3200) for the extraction (dredging) of up to 100,000 m^3 of material. The EPL allows for application to land at specified locations and for discharge to waters within water quality limits regulated by monitoring of pH. As detailed in **Table 5.2** and **Section 6.2.1**, no modification to this EPL is required for the proposed dredging and beach nourishment works.

It should be noted that Council propose to establish a temporary haul-out area in Terilbah Reserve to allow for dredge maintenance activities. The temporary haul-out area would involve an amendment to the existing licence and will be considered by Council in a separate process to the REF.

Threatened Species Conservation Act

The NSW *Threatened Species Act 1995* (TSC Act) provides for the protection of threatened species, populations and ecological communities other than the fish, algae and aquatic plant species listed under the FM Act.

As discussed in Section **6.4**, no significant impacts to threatened species, populations or ecological communities listed under the TSC Act are expected from the proposed works. Therefore a Species Impact Statement and a licence for the harm under Section 91 of the TSC Act are not required.

5.4 Licences and Approvals

A summary of the licences and approvals that must be obtained before dredging and nourishment activities may be lawfully carried out are provided in **Table 5.1**.

Table 5.1 Licences and approvals required

Organisation Responsible	Approval/ Licence/ Compliance Required
DPI Fisheries	Permit for any harm to marine vegetation under Section 205 of FM Act.
DECC	Environmental Protection Licence. No renewal or variation to EPL 3200 is required for the proposed dredging and beach nourishment works.
Lands	Modification to the existing 34A Licence for the use of Crown land.

5.5 Other Relevant Plans

Achievement of an ecologically healthy estuary which caters for the needs of the community is a primary objective of the Tuggerah Lakes Estuary Management Plan (Dickinson *et. al*., 2006). Maintenance of the ocean entrance via dredging is consistent with this plan as it assists in the prevention of eutrophication of the estuary.

Flood risk to life and property has been prioritised as an important water management issue within the estuary (Roberts & Dickinson, 2005) and is addressed by the maintenance dredging of The Entrance Channel.

5.6 Consultation

5.6.1 Stakeholder Consultation

The following stakeholders were consulted on matters to be considered in preparing the REF and any permits, licenses or approvals that would be required:

NSW Department of Lands;

NSW Department of Environment and Climate Change;

NSW Department of Primary Industries (Fisheries);

NSW Maritime;

Hunter-Central Rivers Catchment Management Authority (HCR-CMA); and

Darkinjung Local Aboriginal Land Council (Darkinjung LALC).

Copies of formal correspondence received are attached in **Appendix 4**. Note that the consultation process also involved discussion of a proposed permanent haul-out area in Terilbah Reserve for the maintenance of the dredge. This aspect is not considered in this REF. A summary of responses relating to dredging and beach nourishment, and the section of the REF in which stakeholder comments/concerns are addressed, is shown in **Table 5.2**. No response was received from the HCR-CMA or Darkinjung LALC.

It should also be noted that Council consulted with DECC in February 2008 with regard to incorporating turbidity monitoring into the Environmental Protection Licence (EPL 3200) following a community complaint during the dredging operation. The response received from DECC in March 2009 is also included in **Table 5.2**.

Table 5.2 Comments Received from Stakeholders During the Consultation Process

Comments Received	Relevant Section of REF
NSW Department of Lands	
Lands responded with an email dated 15th May 2009	
Lands noted that "it is evident that there is some concern in the community and from government agencies over both the dredging program in general and the maintenance of the dredge on this reserve."	Noted. Alternative locations for dredge maintenance are being investigated.
The REF should ensure that alternative options are well explored and adequate justification for this proposal is provided.	Section 4.1
Some form of community & agency consultation by Council would be warranted.	Section 5.6
NSW Department of Environment and Climate Change	
DECC were consulted in February 2008 following a community complaint regarding turbidity during a dredging operation. Council requested that the Environmental Protection Licence (EPL 3200) be amended to "recognise the likelihood of turbidity associated with the dredging operation". DECC responded with a letter dated 17th March 2008:	
Council should ensure appropriate management strategies are employed to management turbidity and should carry out appropriate corrective actions when a plume is identified.	
"DECC does not consider it appropriate that the licence be varied with respect to turbidity".	
DECC responded with a letter dated 15th April 2009 and a phone call was made to Michael Howat of DECC on 27th April 2009:	
The Environmental Protection Licence (EPL 3200) currently held by Council is continuous and independent of any dredging permit required from DPI.	Noted
DECC considers that compliance with licence conditions provided under EPL 3200 and with Section 120 of the POEO Act (ie. no pollution of waters) sufficient for the preparation of the REF.	Section 5.4 Section and 7.1.2
DECC are primarily concerned with pH changes resulting from disturbance to acid sulfate soils rather than turbidity.	Appendix 1 Sections 2.4 and 7.1.2
NSW Maritime	
NSW Maritime responded with an email dated 23rd March 2009:	
NSW Maritime is to be notified prior to the commencement of any works that will require the relocation of navigations aids so that an appropriate Marine Notice may be promulgated.	The works will not require the relocation of any navigation aids.

Comments Received	**Relevant Section of REF**
The dredge is to display the required day shapes and lights when operating.	Section 7.1.9
Signage advising of the dredging hazard are to be displayed at the relevant boat ramps that access the dredge area.	Section 7.1.9
NSW Department of Primary Industries (Fisheries)	
DPI responded with a letter dated 27 March 2009 including a list of General Requirements detailed below.	
Substantiation of the need to remove seagrasses.	Section 4.3
Model or restate original modelling that requires sand silting The Entrance to be kept within the Entrance sand system and the fate and behaviour of The Entrance if sand is deposited north of the null point.	Appendix 5
Justification of the nourishment of The Entrance Beach as deposited sand moves back into The Entrance Channel.	Appendix 5
Management of Syngnathids if seagrasses are to be removed.	Appendix 2 Section 7.1.4
DPI were contacted via phone regarding Syngnathid management on 26 October 2009	
The density of seahorses up stream of the dredged footprint is quite significant (up to 4/m^2) in relation to the area to be dredged.	
Syngnathid management should be discussed in the REF in terms of the pros and cons of dredging/not dredging and the impacts on Syngnathid populations.	Sections 6.4 and 7.1.4
A permit under Section 37 of the FM Act is not required for the harming of marine fish (i.e. Syngnathids) where dredging is to be carried out in accordance with a permit issued under the FM Act	
DPI were contacted via email regarding approvals and responded with an email dated 30 October 2009	
Council's Crown lands licence covers dredging and therefore a permit to dredge under the Fisheries Management Act is not required from DPI	Appendix 4 Section 5.3
A permit to harm marine vegetation under Section 205 of the FM Act is required.	Appendix 4 Section 5.3
A permit for removal of Syngnathids is not required where Council hold a permit to carry out the works under the Fm Act (ie. permit to harm marine vegetation)	Appendix 4
GENERAL REQUIREMENTS from the letter dated 27th March 2009	

Comments Received	Relevant Section of REF
a topographic map of the locality should be provided	Figure 1
a recent aerial photograph should be provided if possible	Figure 2
Area which may be affected either directly or indirectly by the development or activity should be identified and shown on an appropriately scaled map (and aerial photographs)	Figures 1 and 2
All waterbodies and waterways within the proposed area of development are to be identified.	Section 2
Description of aquatic vegetation, snags, gravel beds and any other protected, threatened or dominant habitats should be presented. Area, density and species composition should be included and mapped. Identification of recognised recreational and commercial fishing grounds, aquaculture farms and/or other waterways users.	Appendix 2 Sections 2.6.2 and 2.7
Presented maps or plans.	Figures 1 and 2
Description of proposal and study area.	Sections 2 and 3
Details of the location of all component parts of the proposal, including any auxiliary infrastructure, timetable for construction of the proposal with details of various phases of construction.	Sections 1.2, 2 and 3
Size of the area affected.	Sections 1.2 and 3.1
Aspects of the management of the proposal, both during construction and after completion, which relate to impact minimisation e.g. Environment Management Plans.	Section 7
Plan of study area	Figures 1 and 2
Locations and types of landuses present.	Section 2.6
Land tenure details for all land parcels.	Section 2.6
Locations of streams and other waterbodies. For each freshwater body identified on the plan, the plan should include, either by annotation or by an accompanying table, hydrological and stream morphology information such as: flow characteristics, including any seasonal variations, bed substrate, and bed width. For each marine or estuarine area identified on the plan, the plan should include, either by annotation or by an accompanying table, hydrological and stream morphology information such as: tidal characteristics, bed substrate, and depth contours	Figure 1 Sections 1.2 and 2.2

Comments Received	Relevant Section of REF
DREDGING AND RECLAMATION ACTIVITIES	
Purpose of works	Sections 1, 3.1, 3.2 and 4.3
Type(s) of marine vegetation in the vicinity of the proposed works	Appendix 2
Distance of adjacent marine vegetation from the outer boundary of the proposed works	Section 2.7
Method of dredging to be used	Section 3.1
Duration of dredging works	Section 3.5
Time of dredging works	Section 3.5
Dimension of area to be dredged	Section 3.1
Depth of dredging activities	Section 3.1
Nature of sediment to be dredged, including Acid Sulfate Soil	Section 2.4 and Appendix 1
Method of marking area subject to works	Section 7.1.9
Environmental safeguards to be used during and after works	Section 7.1
Measures for minimising harm to fish habitat under the proposal	Section 7.1 and Appendix 2
Spoil type and source location for reclamation activities	
Method of disposal of dredge material	Section 3.2
Location and duration of spoil stockpiling, if planned	
Volume of material to be extracted or placed as fill	Section3.1
ACTIVITIES THAT DAMAGE MARINE VEGETATION	Sections 2.7.1 and 7.1.4
Type of marine vegetation to be harmed	Appendix 2
Amount of marine vegetation to be harmed, map distribution of marine vegetation	
Reasons for harming marine vegetation	
Methods of harming marine vegetation	
Construction details	
Duration of works/activities	
Measures for minimising harm to marine vegetation under the proposal	

Comments Received	Relevant Section of REF
Environmental measures to be employed, if necessary Method and location of transplanting activities or disposal of marine vegetation	
THREATENED SPECIES Threatened aquatic species assessment (Section 5c, EP&A Act 1979) Seven-Part Test	Sections 2.7 and 6.5 Appendix 6
INITIAL ASSESSMENT	
A list of threatened species, endangered populations and endangered ecological communities must be provided. In determining these species, consideration must be given to the habitat types present within the study area, recent records of threatened species in the locality and the known distributions of these species.	Sections 2.7 and 6.5 Appendix 5
In describing the locality in the vicinity of the proposal, discussion must be provided in regard to the previous land and water uses and the effect of these on the proposed site. Relevant historical events may include land clearing, agricultural activities, water abstraction/diversion, dredging, de-snagging, reclamation, siltation, commercial and recreational activities.	Sections 1.2 and 2.6
A description of habitat including such components as stream morphology, in-stream and riparian vegetation, water quality and flow characteristics, bed morphology, vegetation (both aquatic and adjacent terrestrial), water quality and tide/flow characteristics must be given. The condition of the habitat within the area must be described and discussed, including the presence and prevalence of introduced species. A description of the habitat requirements of threatened species likely to occur in the study area must be provided. In defining the proposal area, discussion must be provided in regard to possible indirect effects of the proposal on species/habitats in the area surrounding the subject site: for example, through altered hydrological regimes, soil erosion or pollution. The study area must extend downstream and/or upstream as far as is necessary to take all potential impacts into account.	Section 2 Appendix 5 Section 7.1.4
Please Note: Persons undertaking aquatic surveys may be required to hold or obtain appropriate permits or licences under relevant legislation. It is recommend that, prior to any field survey activities taking place, those persons proposing to undertake those activities give consideration to their obligation to obtain appropriate permits or licences which may be required in the specific context of the	No permits/licences were required for the purpose of this aquatic survey field investigation. Appendix 2

Comments Received	Relevant Section of REF
proposed survey activities.	
ASSESSMENT OF LIKELY IMPACT describe and discuss significant habitat areas within the study area; outline the habitat requirements of threatened species likely to occur in the study area; indicate the location, nature and extent of habitat removal or modification which may result from the proposed action; discuss the potential impact of the modification or removal of habitat; identify and discuss any potential for the proposal to introduce barriers to the movement of fish species; and describe and discuss any other potential impacts of the proposal on fish species or their habitat. For all species likely to have their lifecycle patterns disrupted by the proposal to the extent that individuals will cease to occupy any location within the subject site, the REF must describe and discuss other locally occurring populations of such species. The relative significance of this location for these species in the general locality must be discussed in terms of the extent, security and viability of remaining habitat in the locality	Sections 2.7 and 6.4 Appendix 2 Appendix 5
AMELIORATIVE MEASURES The REF must consider how the proposal has been or may be modified and managed to conserve fisheries habitat on the subject site and in the study area. In discussing alternatives to the proposal, and the measures proposed to mitigate any effects of the proposal, consideration must be given to developing long term management strategies to protect areas within the study area which are of particular importance for fish species. This may include proposals to restore or improve habitat. Any proposed pre-construction monitoring plans or on-going monitoring of the effectiveness of the mitigation measures must be outlined in detail, including the objectives of the monitoring program, method of monitoring, reporting framework, duration and frequency.	Section 6.4 Appendix 5 Section 7.1.4

5.6.2 Community Consultation

Consultation was undertaken through correspondence with the following interest groups:

The Entrance Community Precinct Committee;

The Entrance Beach Surf Club;

Dunleith Tourist Park;

Coast Care The Entrance North;

The Entrance North Progress Association;

The Entrance Boathouse.

The Entrance Hotel Fishing Club; and

Commercial Fishing Groups.

Comments received during the community consultation process relating to the dredging and beach nourishment, and the relevant sections where addressed in the REF are provided in **Table 5.3**.

Table 5.3 Comments Received During the Community Consultation Process

Comments Received	Relevant Section of REF
The Entrance Community Precinct Committee	
The committee responded with a letter and an engineer's report by Rod Slater on 16th April 2009.	
Proposed area of dredging does not appear to be based on detailed hydraulic study of the channel and the entry to the ocean.	Appendix 5
The proposed channel is directed towards a rock shelf which will result in very inefficient outflow and inflow, thus not achieving optimum tidal exchange.	Appendix 5

Comments Received	**Relevant Section of REF**
The proposed channel finished approximately 100 m short of the shoreline and again this will only achieve minimal tidal exchange.	Appendix 5
No mention is made of a programme to remove the sand plug to the ocean, even in the event of a major flood.	Appendix 5
Dunleith Tourist Park	
Dunleith Tourist Park responded with a phone call on 23rd March 2009, followed by a phone call and fax both received on 22nd April 2009.	
Concerned that the angle proposed for the main channel under the bridge is causing undercutting of a 50m section of foreshore in the vicinity of the southern caravan park boundary (ie. 30m along the caravan park boundary and 20m along Karagi Park foreshore).	Section 6.1.1
Indicated a preference that a beach is maintained along the townside seawall (ie. the flood dominant channel) as this area is a tourism asset and a “kids delight”.	Section 4.1.2
Provision of the preferred channel alignment that would in the opinion of Dunleith Caravan Park minimise erosion along the southern foreshore.	Noted
The Entrance North Progress Association	
The Progress Association responded with a phone call on 2nd April 2009 and an email dated 8th April 2009.	
Consider that the dredging of the Terilbah Channel causes erosion near Dunleith Caravan Park and at Yellawa Island.	Section 4.1.2
Consider that the trigger for dredging should be dependent on erosion of the ocean beaches rather than closing of the channel.	Appendix 5
Indicated that a Hazard Definition Report prepared by Australian Water and Coastal Studies and MHL in 1993 documented that dredging to the west of the bridge would likely cause undercutting of the bridge foundations.	Section 6.1.2
Concern regarding the typical placement and profiling of sand at nourishment areas and indicated that sufficient profiling to prevent placed sand washing away was only undertaken in 2008.	Noted
Suggestion that filters be placed onto the pipe outlet to remove bottles and broken glass which has previously been deposited on the beach front through nourishment activities.	Section 7.1.10
Indicated that approximately 10% of the dredged sand is black muddy material which has a distinct odour that can be detected as far north as the North Entrance Beach Surf Club.	Sections **2.4**, 6.9 and 7.1
Requested if dredge logs were available dating back to 1993.	Noted

Comments Received	**Relevant Section of REF**
Coast Care The North Entrance (T.E.N.)	
Coast Care T.E.N. replied via a phone call from The Entrance North Progress Association on 2nd April 2009	
Sand placed in nourishment areas should be revegetated.	Section 6.4.1
Commercial Fisher)	
Mr Clouton responded with a phone call on 25th March 2009:	
Dredging should not be undertaken during prawning season which generally ends by March each year but is likely to continue through to April and May in 2009.	Section 6.6

6. ASSESSMENT OF THE ENVIRONMENTAL IMPACTS & RISKS

6.1 Coastal and Estuarine Processes

6.1.1 Bank Erosion

Dredging of The Entrance Channel would prevent excessive build-up of sand across the mouth of the estuary thereby resulting in the maintenance of average conditions of The Entrance sand spit, The Entrance Channel and the flood tide shoals. No significant impact is expected to coastal processes as the dredged sand would be retained within The Entrance sand system.

No impact is expected to the general characteristics of The Entrance sand bar offshore of the mouth of the estuary or to either The Entrance Beach or North Entrance Beach as a result of the dredging. The mouth of the estuary would remain largely unnavigable.

The dredge footprint has been designed to minimise erosion impacts on adjacent foreshores within The Entrance Channel. Community concern has been raised over the angle of the main channel. It is assumed that the ebb tide flow within the main channel is causing the erosion which is evident along the southern corner of Dunleith Caravan Park and the Karagi Foreshore Park (ie. the estuary eastern beach). Observation of the tidal movements within the existing channel indicates that the build-up of sand at Town Beach is causing the floodtide flow (which naturally flows along the southern foreshore) to deflect across the sandy delta directly towards the area of erosion. Dredging of the flood dominant southern channel along the southern foreshore of The Entrance Channel in the vicinity of Town Beach to approximately 1 m in depth would minimise the erosion of the northern foreshore.

Concern has been expressed that dredging has the potential to cause erosion to Yellawa Island and Terilbah Island within and adjacent to the dredge footprint respectively. This issue is discussed in **Appendix 5** and is summarised below.

Terilbah Island

Terilbah Channel, adjacent to Terilbah Island, has been dredged approximately every five years since the commencement of maintenance dredging in 1993 with the last occasion of dredging undertaken in 2008. The extent of dredging (depth, width, distance upstream) has been aimed at simply re-establishing the natural channel cross-section and thereby has not altered the hydrodynamic and sediment transport behaviour within the channel beyond the natural tidal regime conditions.

There has been no evidence of erosion of the foreshores of Terilbah Island over this past 16 years of maintenance dredging. Providing future dredging within Terilbah Channel remains consistent with past dredging practices, erosion issues along Terilbah Island would not be anticipated. Visual monitoring of the Island foreshore by Council staff for any signs of erosion should continue.

Yellawa Island

Current practice is for dredging of the sump between the Central Coast Highway Bridge and the western side of Yellawa Island to take place every year, and for dredging of the northern channel immediately to the north of Yellawa Island to take place every two years. The purpose of the sump is to trap sand migrating upstream on the flood tide thereby mitigating the need for dredging upstream of the bridge.

Some concerns are understood to have been raised by the community regarding the possibility that dredging activities have caused erosion of Yellawa Island and that continued erosion of the Island may result in loss of the Canary Island date palm on the Island, which is of cultural significance. This palm is located on the western side of the Island adjacent to the sump.

It is understood that Council staff, in late 2008, inspected a photograph of Yellawa Island taken in 1934 which indicates there has been no significant erosion of the island over the 74 year period 1934-2008. In addition, it is understood Council staff undertook a comparison of vertical aerial photographs taken of the Island in December 2003, February 2007, May 2008 and August 2008, which showed no apparent evidence of erosion over this five year period.

Notwithstanding the findings of the photographic analysis undertaken by Council staff, dredging of the sump takes place very close to the Island and there is considered to be a risk of foreshore erosion by means of undercutting or regrading of the underwater dredge batters. While the concept of a sump is considered generally beneficial to management of sedimentary processes, that portion of the sump that lies in the flood tide 'shadow' zone behind Yellawa Island may not be capturing a significant proportion of the overall flood tide sediment transport approaching the bridge. As a precaution, that portion of the sump immediately to the west of Yellawa Island has therefore been excluded from the proposed dredged footprint for future dredging campaigns.

The infilling of this portion of the sump should be monitored by survey.

Monitoring of the shoreline of Yellawa Island by Council staff should also continue, by visual means, review of aerial photography and by survey if required.

6.1.2 Bridge Foundations

As noted in **Section 6.2**, the dredging proposed would be undertaken within the natural hydraulic limits of the system. The hydrodynamics and sediment transport behaviour would not change either directly or indirectly beyond that which could be achieved under natural conditions. As such, no scour to the bridge foundations is expected beyond that which may occur under natural conditions.

6.1.3 Dune System

The sediment within the proposed dredge footprint predominantly consists of marine sand which has been eroded from beaches within The Entrance Channel or reworked through the mouth of The Entrance Channel from the offshore shoal and adjacent beaches. Some finer alluvial sediment, interbedded within the sands is also present. Sediment with similar characteristics has been dredged from the footprint and used for beach nourishment over the past 16 years of maintenance dredging.

Apart from some turbidity within the surf zone during pumping of the material to each placement area, no significant incompatibility has been identified.

The potential presence of dead kelp and seagrasses in the dredged sand and the darker sands would result in the temporary discolouration of the beach profile within emplacement areas. This has previously been shown to be a temporary impact which is relatively quickly reduced through oxidation and bleaching of the sand and breakdown of the plant material.

Following pumping of dredged material into mounds the sand would be shaped by bulldozers consistent with a naturally accreted beach state (refer **Section 3.3**).

The beach nourishment activities aim to beneficially reuse the dredged material to rehabilitate the existing dune system and protect the dunes against erosion from currents and wave action, particularly during storm events. Consequently, the dune ecosystem would also receive some protection and the value of amenity and recreational value of the beaches would be maintained.

6.2 Hydrodynamics/Flooding

Dredging aims to re-establish the channels which may form within the system under the natural tidal regime such that under typical average tidal conditions, the entrance is open more often than it is closed. The dredging would not alter the hydrodynamics and sediment transport behaviour within the channel beyond naturally occurring conditions.

As a result of the channels and shoals being maintained in average condition, the average water levels in the lake would also be maintained.

Maintenance of an opening at The Entrance Channel by dredging would provide for more effective discharge of flood waters than might initially be expected in comparison to natural pre-flood conditions in which The Entrance Channel may be partially or fully closed. This would be expected to facilitate initial flood scour, though it is not likely to significantly impact peak flood levels in the lake (PBP, 2004).

6.2.1 Water Quality

Short term impacts to water quality would be expected from the continuation of the existing dredging and beach nourishment practices as discussed below.

Based on past experience with the dredging of The Entrance Channel, temporary and localised turbidity is likely within and adjacent to the proposed dredging footprint as a result of the suspension of muds and finer sands. Given the typically clean, sandy nature of the dredge material (refer **Section 2.4**), this sediment has been shown to settle rapidly following disturbance.

Turbidity in dredging projects is typically managed through the use of a turbidity curtain surrounding the dredge area. However, the high velocity currents experienced within The Entrance Channel prevent the practical implementation of such measures.

Dewatering of the material pumped sub-aerially onto beach nourishment areas may result in some turbidity of the waterways adjacent to the pipe outlet. Similarly, the installation of a turbidity curtain in the surf zone of the beaches on the open coast is not feasible. Turbidity adjacent to beach nourishment areas has not been a significant issue in previous campaigns and would not be expected to be a significant issue in the proposed activities due to the limited proportion of fines in the sediment.

Turbidity within The Entrance Channel and nearshore beach zone is also a natural consequence of catchment runoff into the lakes system.

A review of past modifications to Council's Environmental Protection Licence (EPL3200) (available at the *POEO Act* Public Register http://www.environment.nsw.gov.au/prpoeoapp/searchregister.aspx) shows that the requirement for monitoring of total suspended solids (TSS) and turbidity was removed from the EPL in 2003. This indicates that DECC did not consider turbidity to be a significant issue at the time.

Following a community complaint in February 2008, Council investigated the potential to modify the EPL to re-incorporate a turbidity trigger value and the requirement for monitoring turbidity. DECC's response indicated that no modification to the EPL would be approved and that Council should employ appropriate management strategies to manage any turbidity resulting from the activity. Council have since indicated that the complaint was received following a period of heavy rain where either turbidity levels in The Entrance Channel were likely to be relatively high, or a disturbance to recently deposited alluvial silts would have been likely.

From recent communications (refer **Table 5.2**) it appears that disturbance to ASS rather than turbidity is the primary concern of DECC in regards to water quality. In accordance with the current EPL, water quality monitoring is undertaken in the form of monitoring pH at the discharge point at each nourishment area. Monitoring is carried out from a sample of the discharged dredge slurry within 30 minutes of the dredge commencing operation each day. Council's dredge crew indicated that samples collected generally have a pH of 6.5 to 8.5. The EPL records indicate one recording of a pH of 8.6 which is indicative of alkaline, rather than acidic conditions and may have resulted from significant freshwater flows or other activities within the catchment.

Sediment quality investigations undertaken for this assessment (refer Appendix 1) indicated that sufficient acid neutralising capacity is available in the sediments to neutralise any acidity produced during the proposed activities. Consequently, no changes to soil or water pH either within The Entrance Channel or the adjacent beach nourishment areas are expected from the proposed works.

6.3 Fuel Storage and Handling

There is potential for contamination to land and water as a result of fuel and oil leaks and spills in association with both the dredge and land-based dozers used for re-shaping. Refer to **Section 7** for maintenance/ management measures to address this potential.

6.4 Ecology

Dredging of The Entrance Channel allows for the preservation of the existing biological assemblages that have adapted to average water levels in the lake. Impacts associated with elevated levels of nutrients and associated excessive growth of aquatic vegetation would be minimised with the maintenance of tidal flushing associated with the dredging.

Dredging and beach nourishment activities have the potential to adversely impact the ecology of the estuarine and marine environments as discussed below.

6.4.1 Flora

Seagrasses

The seagrass beds within and adjacent to the dredge footprint changed significantly between the DPI mapping undertaken in 2005/2006 and the field surveys undertaken by WorleyParsons in January and May 2009 for this assessment. The changes included both loss of previously mapped seagrass beds and growth of new seagrass beds.

Seagrass growth is dependent on depth, water clarity and sediment stability (McComb *et. al*., 1981) all of which may be affected by the dredging process. However the resulting changes may also be attributable to any, or a combination of the following:

damage/removal due to anchor drag or propeller wash;

increased turbidity or smothering due to boating activities; and

increased turbidity or smothering due to natural flooding.

The proposed works would require the removal of several, predominantly small, discontinuous beds of *Z. capricorni*. The majority of these seagrasses have recolonised the centre of the Terilbah Channel and the main channel to the west of the bridge in areas which have not been dredged for some years.

Seagrass beds adjacent to the dredge footprint, including fringing seagrass beds and four small beds of the slower growing *H. Ovalis* may experience minor and temporary impacts as a result of turbidity during dredging. However, due to the predominantly sandy nature of the dredge material turbidity impacts would not be expected to be widespread or long-lasting.

Some of the remaining seagrass beds within 50 m of the proposed dredge footprint may also be impacted by increases in channel velocity due to the restoration of tidal flows or from the instability of the rhizomes (plant roots) along the leading edge of any seagrass beds directly adjacent to the dredge batter slope. Due to the narrow nature of Terilbah Channel and the proximity of Yellawa Island to both the bridge and northern foreshore, impacts to seagrasses in these areas is unavoidable.

Dredging within the proposed dredge footprint and removal of seagrass areas is considered necessary to achieve the required depth profile to ensure sufficient tidal flushing and reduced flood

risk. The area of existing seagrass within the dredge footprint that would require removal is conservatively estimated to be less than 300 m^2. This area is very small in comparison to the 17.7 km^2 of seagrass meadow present within the estuary. In addition, the expected water quality benefits are considered to outweigh seagrass losses. As noted earlier, *Z. Capricorni* has been found to recolonise previously dredged areas.

Macroalgae

In reducing the nutrient loading of the lakes through improved tidal exchange, the probability of excessive macroalgae growth is much reduced.

No impacts are expected to the attached macroalgae in the estuary. Attached macroalgae adjacent to proposed beach nourishment areas would not be significantly impacted from the minor increases in turbidity.

Phytoplankton

Phytoplankton may be affected by anthropogenic activities that cause elevated levels of nutrients or sedimentation, or reduced dissolved oxygen, light penetration or tidal exchange. As far as is known, no occurrences of phytoplankton blooms have occurred in the Tuggerah Lakes Estuary (Scott, 1999). Due to the sandy nature of material to be dredged and the relatively small dredge footprint, the proposed dredging activities are not likely to cause phytoplankton blooms.

Saltmarsh

No direct removal of saltmarsh or placement of dredged material on saltmarsh areas is proposed.

Terrestrial Vegetation

The existing foreshore vegetation has adapted to the water level fluctuations and groundwater salinity levels maintained by the existing dredging practices. Dredging is not expected to affect foreshore vegetation.

The Canary Island Date Palm on Yellawa Island is an introduced species of landscape value. Due to the size of this tree, it has been present for some years and has therefore survived the previous dredging campaigns and flood flows which result in natural changes to the foreshore. There would be no direct impact to this palm as a result of the proposed dredging works and no indirect impacts are expected. However monitoring is proposed and management measures should be implemented if required (refer **Section 6.1.1**).

Placement of sand onto the eroded foredune is not expected to impact on terrestrial vegetation but would offer some protection to the vegetated dunes behind the placement areas. In time the foredune may be colonised by dune species such as Spinifex Spp.

6.4.2 Fauna

Marine and estuarine fauna

Potential adverse impacts to aquatic fauna may result from:

removal of seagrass which provides habitat for a diversity of fish, pipehorses and invertebrates;

turbidity increases (to the point where feeding is impaired);

suffocation or abrasion to mucous membranes (particularly of the fish) from suspended sediment particles in the water;

smothering of eggs or larvae from excessive siltation in the water; and

reduction of habitat and/or food availability.

Although some limited areas of seagrass, conservatively estimated to be less than 300 m^2 would be removed during the proposed dredging works, the Tuggerah Lakes have the third largest area of seagrass meadow in NSW. Therefore the removal of small areas of seagrass is not expected to significantly impact on the availability of habitat for species in the lakes.

Benthic fauna within The Entrance Channel are likely to have adapted to the constant flux of the shoaling sands within the channel. In addition, the depth of any fine sediment which resettles following disturbance by dredging is likely to be much less than 0.5 m thick. Burial to a depth of 0.5 m or more has been shown in previous studies as the depth from which benthic fauna are unlikely to recover (Maurer et al, 1980; 1981; 1982). Larger bottom-dwelling animals and small bottom-dwelling fish may be able to escape any areas of turbidity or sediment falling out of a turbid water column.

Impacts to species which are mobile in the water column are expected to the minor due to the relatively coarse nature of the sediment to be dredged, the temporary turbidity expected, and the ability of the animals to escape such impacts.

Species which inhabit the estuary for at least part of their life cycle are expected to benefit from the continuation of current dredging practices as it allows for:

the necessary lifecycle movements of some species between marine and estuarine environments;

maintenance of salinity levels necessary for marine and estuarine species to inhabit the estuary; and

improved water quality and flow-on habitat benefits, such as healthy seagrass meadows.

Nearshore Ecological Environment

The nearshore flora and fauna communities adjacent to North Entrance Beach placement area are likely to experience regular burial by mobile sands and high levels of turbidity as a result of wave energy during storm events. Similarly, the reef adjacent to The Entrance Beach would frequently be subject to increases in turbidity and disturbance from medium to high wave energy during storm events.

Marine and Wetland Birds

Some of the mobile sand shoals towards the mouth of The Entrance Channel would be dredged during the proposed works. Sufficient similar foraging habitat for wading birds in surrounding areas would remain.

The intertidal flats adjacent to Terilbah Island would not be impacted during the dredging of channels however some of the mobile sand shoals towards the mouth of The Entrance Channel would be removed. No significant impacts are expected to any marine bird species or to wading birds or their foraging habitats as a result of the proposed dredging works.

Renourishment activities on the estuary eastern beach and North Entrance Beach have the potential to impact on a known nesting site for the endangered species, the Little Tern, and potential breeding and nesting habitat for the Pied Oystercatcher. As discussed in **Appendix 6**, no impact to these species would occur when the control measures recommended in this document are implemented.

Other Fauna

Terrestrial fauna including terrestrial bird species, bats, quolls, flying-fox, and amphibians are unlikely to be impacted by the proposed works as no disturbance to their likely habitat, being Terilbah Island and the vegetated dunes adjacent to beach nourishment areas, is expected. The works would not affect any wildlife corridors for terrestrial species, other than to preserve the corridor offered by dune vegetation at North Entrance Beach.

6.5 Threatened Species Assessment

Threatened species, populations and ecological communities are scheduled under the NSW *Fisheries Management Act 1994* (FM Act) and the NSW *Threatened Species Conservation Act 1995* (TSC Act).

For all listed threatened species, populations of ecological communities likely to occur in the study area or likely to use the habitat provided by the area, consideration of direct and indirect impacts should be undertaken in accordance with Section 5A of the EP&A Act. This assessment of significance is intended to identify the need for:

a Species Impact Statement (SIS);

modifications to the proposal necessary to remove any identified impacts to threatened species; and

permits/ licences that may be required.

Details of this assessment are provided in **Appendix 6**. It was concluded that provided the mitigation measures detailed in this document are implemented, no significant impact would occur to any listed threatened species, populations or communities or their habitats as a result of the proposal. Therefore, no Species Impact Statements, or applications for licences for harm to threatened species are required.

Identified protected aquatic species as listed under the FM Act are not subject to the assessment of significance. Protected species are generally listed due to their susceptibility to be captured (for food, sport or live aquarium display) rather than for their rarity or vulnerability to other disturbances (TEL, 2002). The proposed works are not likely to increase the susceptibility of identified protected species being captured for food, sport or display.

6.6 Commercial and Recreational Fishing

Concern was expressed by one commercial fisher during the consultation process in regards to dredging during the prawning season. The season is generally over by March each year and is predominantly carried out during the summer holiday period in which dredging is avoided in order to minimise impacts during the tourist high season and to nesting habitat for the Little Tern.

Recreational fishing would be prohibited in the immediate vicinity of the dredge and at the discharge area on the open beach during operation. Numerous other locations within walking distance would remain unaffected. In addition, the dredging campaigns would be planned to avoid peak tourist seasons which would see an influx of recreational fishing use of The Entrance Channel.

Based on the above summary, it is considered that the proposed dredging and beach nourishment activities would have no adverse impact on recreational and commercial fishing.

6.7 Operational Noise

Ambient noise levels within The Entrance Channel and within the proposed dredging area are predominantly influenced by residential traffic movements in surrounding residential streets and by the main arterial road, The Central Coast Highway, which crosses from The Entrance to The Entrance North via a bridge spanning The Entrance Channel. Minor noise inputs from recreational users in the vicinity and by occasional boat traffic are also present.

Background noise levels at The Entrance Beach and North Entrance Beach are influenced by the surf zone, recreational users of the foreshore, and by adjacent residential areas.

Minor operational noise impacts are expected from the use of the dredge and associated workboat, the refuelling of the dredge, and with bulldozing of the beach nourishment areas. Operational noise would have most impact on the nearest residential receivers (which would vary as the dredge and bulldozers would not be located in the same location over the period of works). These include residences at Dunleith Street, the western end of Hargraves Street, and at the southern end of Hutton Road. Any impacts would be temporary over the approximate three month period of each yearly dredging campaign. The noise is expected to have little impact on the local community and no noise complaints have been recorded for the dredging, refuelling and beach nourishment activities undertaken over the past 16 years.

6.8 Heritage

A search of the National Heritage Database (http://www.environment.gov.au/cgi-bin/ahdb/search.pl.) and a search of the EPBC Protected Matters database indicated that there are no world heritage properties, national heritage places or heritage items in the vicinity that would be impacted by the proposed dredging and beach nourishment areas.

There are 10 heritage items listed in Schedule 1 of the Wyong Local Environmental Plan 1991 for The Entrance and North Entrance area in general, including The Entrance Beach Surf Club building on Marine Parade. This structure would potentially benefit from beach renourishment at The Entrance Beach.

The proposed activities would not impact on any recorded Aboriginal sites. The dredging is proposed in areas of recently deposited submerged marine sands and would be unlikely to disturb any potential archaeological sites that have Aboriginal heritage significance. The renourishment activities are proposed along pre-eroded beach profiles which are unlikely to contain unrecorded artefacts.

6.9 Air Quality

At North Entrance Beach, emissions of hydrogen sulfide are likely to occur, as have occurred in the past, from the disturbance of sediment which contains layers of decaying organic matter. As a result, odours may be detected at nearby receptors from time to time. However this is not considered a significant issue in comparison to the benefits offered by the proposed works.

Plant and equipment may emit smoke/fumes which could adversely affect air quality in the localised area of operation. Appropriate maintenance of plant and equipment would be undertaken to address this potential issue.

6.10 Amenity

Minor impacts to amenity are expected in The Entrance Channel and adjacent nourishment areas as a result of the following:

- presence of the dredge, pipelines and buoys;
- presence of the discharge pipeline outlet, fencing, signage and bulldozers;
- mounded discharged sand within the beach nourishment areas;
- slight turbidity of waters surrounding the dredge and in the surf zone adjacent to the discharge pipeline outlet (refer **Section 6.2.1**); and
- temporary discolouration of sand within the beach nourishment areas due to placement of sands containing organic matter and anoxic sands which are generally a darker grey than beach sands.

These impacts would be temporary in nature and are necessary for works that enhance the long-term visual amenity and recreational value of The Entrance Channel and surrounding beaches.

6.11 Access and Safety

Public safety may be an issue during dredging (increased water depths) and the placement of sand in beach nourishment areas (stockpiled sand). However, the sides of the dredge area would be sloped to prevent bank collapse and to provide a gradual transition in existing water depths. Sand pumped to the beach would initially find its own stable angle of repose and the public would be temporarily excluded from areas of emplaced sand until work has been undertaken to regrade these areas to a natural stable slope as per the methodology detailed in **Section 3.3**.

There is also a potential public safety risk associated with the location of the discharge pipeline across the rock platform to the north of The Entrance Beach when beach nourishment of this area is taking place. Whilst the discharge pipeline is generally chained to the rock platform to prevent displacement, it is susceptible to breakage during strong flood tides and during large swells posing a safety risk to any persons in the vicinity of the rock platform.

It is expected that normal recreational activities would be possible during the dredging and beach nourishment activities in areas outside of the immediate influence of the dredge and discharge pipeline.

No removal or relocation of existing navigation aids within The Entrance Channel is required for the proposed dredging works.

To some effect, the proposed works may improve public safety through the removal of risks associated with:

- the instability of eroded foredunes;
- navigational hazards to boating within the channels; and
- high velocities experienced within channels adjacent to the Karagi Foreshore Park as have previously been experienced prior to channel re-alignment.

6.12 Waste and Disposal

The use of the proposed dredge material for beach nourishment is considered a beneficial reuse of a natural resource and therefore no impacts would be associated with the disposal of this material.

Anthropogenic waste materials such as plastic bottles, glass, fishing line, tyres, beds and machinery may occasionally be removed from the dredge footprint or from nourishment areas during the dredging and beach nourishment. This would be disposed of at an appropriately licensed waste management facility.

7. ENVIRONMENTAL CONTROL MEASURES

7.1 Summary of Control Measures

A Dredging Environmental Management Plan (EMP) or a Plan of Management for The Entrance Channel and beach nourishment areas would be developed for the proposed works which would incorporate the following proposed management and mitigation measures.

7.1.1 Erosion

Dredging of Town Beach on an “as needs” basis to minimise the deflection of the floodtide flow onto the northern foreshore.

Visual monitoring of the shoreline of Terilbah Island.

Dredging of the portion of the sump in the flood tide shadow zone on the western side of Yellawa Island should not be undertaken.

Visual monitoring of the shoreline of Yellawa Island and monitoring of the infilling of the sump by survey. Monitoring of the shoreline of by review of aerial photography and survey if required.

Shaping of placed sand by dozer into a cross-shore and alongshore profile consistent with a natural accreted beach state determined through land survey or photogrammetric data of the naturally accreted beach state. In the absence of such information, the profile should aim to:

- match the crest level of the emplaced material with the existing dune crest level;
- achieve a stable seaward gradient of the foredune of not more than 1 in 5 (1 vertical : 5 horizontal); and
- achieve a beach berm gradient of 1 in 20 to 1 in 30.

Establishing cross beach survey transects for beach nourishment areas and undertaking pre- and post- dredging and beach nourishment surveys to determine desired cross-shore and alongshore profiles under beach-full conditions, the effectiveness of the works, the movement of the placed material and the timeframe in which the material provides sufficient protection.

Carrying out regular photogrammetric analysis as undertaken for the Coastline Management Plan (WSC, 2009).

Maintenance of a dredge log to record source, placement area and volumes of dredge material being placed.

7.1.2 Water Quality

Monitoring of the pH of the discharged dredge slurry within 30 minutes of the dredge commencing operation each day in accordance with EPL3200. Monitoring would be recorded and reported in accordance with the EPL.

Regular visual monitoring of turbidity within the dredge area and at the discharge location within each beach nourishment area by the dredge crew.

The dredge master would undertake all reasonable efforts to minimise turbidity during dredging and during discharge at each beach nourishment area.

Should the dredge master determine that any turbidity observed is likely due to the dredging or beach nourishment activities, the dredge master would implement all reasonable and feasible contingency measures to minimise prolonged visible turbidity plumes.

7.1.3 Fuel Storage and Handling

Regular inspection of plant and equipment to minimise the risk of oil and fuel leaks.

Display of Material Safety Data Sheets (MSDS) onboard the dredge and dozers and with stores of each substance used in the works (ie. fuel, lubricants etc).

Carrying out of all re-fuelling and associated activities in accordance with Council's Dredge Procedure's Manual (Procedure Manual OS and R – 010) which covers fuel bunker transfer operations including communications, berthing of vessels, hoses and connections, delivery, occupational health and safety, accidental fuel spillage and emergency response.

Completion of the following actions, in order, by the dredge crew in the event of an accidental fuel spillage: Control, Contain, Notify the Supervisor, and Clean Up the spill.

Notification of the NSW Fire Brigade (call 000) and relevant Government agencies (NSW DECC EPA Group) by the Supervisor to enable removal/ treatment in a focussed and well coordinated manner.

Fitting of the dredge with appropriate environmental controls such as absorbent pads and booms and pumping equipment.

Management of any spillages in accordance with the relevant Material Safety Data information for the material being handled.

7.1.4 Ecology

Avoidance of harm to all areas of saltmarsh and to seagrasses outside of the immediate dredge footprint necessary to achieve improved tidal exchange.

Application of a permit to harm marine vegetation under Section 205 of the *Fisheries Management Act 1994*.

Dredging of those areas to the west of the bridge during the ebb-tide, where possible.

Temporary cessation of dredging in the event that Green Turtles are sighted within the vicinity of the dredge area to minimise impacts from turbidity.

Continued monitoring by Council of the arrival, breeding and nesting of Little Terns at The Entrance sand spit. Beach nourishment works in these areas would aim to be completed prior to the arrival of the migratory species. Access to nests would be fenced off and no beach nourishment works would be undertaken in the immediate vicinity of any nests.

Implementing a pre-dredge survey for each area in which beach nourishment is to take place or be otherwise impacted by the pipeline or presence of plant and equipment, prior to the commencement of works. Any Pied Oystercatcher nesting sites identified should be fenced off for protection from physical damage.

Identification and removal of any Bitou Bush and noxious weeds within the potential beach nourishment areas prior to the placement of dredged material.

7.1.5 Noise

Restriction of working hours to the times specified in **Section 3.5**, ie. between 6am and 6pm Monday to Wednesday and between 6am and 2.30pm (and up to 6pm when necessary) from Thursday to Saturday.

Selection of appropriate plant and equipment and fitting of plant and equipment with noise control devices where necessary.

7.1.6 Heritage

If during the proposed works any item of potential non-indigenous heritage significance is found, works would stop, and the NSW Heritage Council would be contacted in accordance with the *Heritage Act 1977*.

Similarly, if any item of potential indigenous heritage significance is found, works would stop, and DECC and the Local Aboriginal Land Council would be contacted, in accordance with the *National Parks and Wildlife Act 1974*.

7.1.7 Air Quality

Regularly maintaining all plant and equipment used during the dredging and beach nourishment works in keeping with best practice principles and the EPL. Maintenance would be in accordance with manufacturer's specifications in order to minimise the emission of smoke, fumes and other air pollutants into the atmosphere.

Suspending the used of any plant/ equipment found to be emitting visible smoke/ fumes for longer than periods designated by their operations manuals. Suspension of use and undertaking of maintenance (if necessary) until acceptable levels are achieved.

Maintaining all service/inspection log books.

7.1.8 Amenity

Completing works prior to the summer holiday period in which the areas receive the highest usage by community and visitors.

Restricting working hours to the times specified in **Section 3.5**, ie. between 6am and 6pm Monday to Wednesday and between 6am and 2.30pm (and up to 6pm when necessary) from Thursday to Saturday.

Mounding of placed sand to allow oxidation and bleaching of discoloured sands.

Operating a telephone complaints line in accordance with EPL3200 during operating hours to receive any complaints from members of the public relating to the works.

Notifying the public regarding the complaints telephone hotline number.

Recording of any complaints, any action taken and any responses/follow-up contact provided to the complainant.

Turbidity impacts would be managed in accordance with the measures detailed in **Section 7.1.2**.

All plant, equipment and waste would be removed following the operation with the exception of safety signage adjacent to the dredged channels within the estuary.

7.1.9 Access and Safety

Navigational hazards posed by the dredge and pipeline would be managed as per NSW Maritime requirements. That is, the dredge is to be fitted with the required appropriate signage and night lights during operation. The dredge is currently fitted with “obstruction signage” and floats are placed regularly along the discharge pipeline to mark the navigational hazard.

Signage is also to be displayed at boat ramps that access the dredge area (ie. Picnic Point Boat Ramp and The Entrance North Boat Ramp) displaying the dredging hazard.

Permanent signage has been erected along the foreshores of the dredge footprint warning of the danger associated with the dredged channel.

During the beach nourishment activities, the outlet of the discharge pipeline would be fenced off and signage erected as noted in **Section 3.4.1**.

Restricting public access to nourished areas through the use of signage and fencing until the material has been reshaped into a profile consistent with the naturally accreted beach state (refer **Section 7.1.1**).

During placement on The Entrance Beach, the discharge pipeline would be chained to the rock platform and signage would be erected along the foreshore of the rock platform indicating the risk of breakage of the pipeline during flood tides and large swells.

All efforts would be made to nourish The Entrance Beach only during periods of reduced swell height.

The dredge is to be manned and operated by two personnel. One person is also required to continually monitor the pipe outlet at the beach nourishments area during operational hours.

7.1.10 Waste

Collection, temporary storage and appropriate management of all waste material retrieved from The Entrance Channel and generated during the works.

Monitoring of the beach nourishment areas during placement of dredged material and during shaping of material with bulldozers. Any visible rubbish such as bottles or broken glass would be removed from the dredged material within the beach nourishment areas.

Waste would be managed in accordance with the philosophy of the NSW *Waste Avoidance and Resource Recovery Act 2001* under a Waste Minimisation Hierarchy as follows:

avoidance of the production of waste, where possible;

treated, as required and reused onsite;

recycled, either within the site or offsite; and

where other alternatives are not possible, waste shall be disposed of at appropriately licensed waste management facilities.

8. SUMMARY OF IMPACTS

8.1 Clause 228 Factors

Clause 228 of the EP&A Regulation 2000 provides a list of factors that must be considered in determining the likely impacts of an activity on the natural and built environment and therefore the necessity for an EIS.

Following review of Clause 228 Factors in the section below, the proposed works are not considered to result in any significant detrimental environmental impacts. Therefore it is concluded that an Environmental Impact Statement (EIS) is not required and an REF is considered adequate.

8.2 Consideration of Clause 228 Factors

a. Any Environmental Impact on a Community?

Minor short term impacts to the community may occur as a result of:

reduced access to areas of the beach fronts and waterways; and

noise, odour, and visual impacts due to turbidity and the presence of plant and equipment.

Long term beneficial impacts to the community would be expected as a result of the works. Benefits are discussed in detail throughout this environmental assessment and include reduced flood risks, improved amenity, improved recreational value, improved water quality and estuarine environment, and protection of dunes, dune vegetation and property.

b. Any Transformation of a Locality?

The physical environment of the locality is continually transforming as a result of coastal erosion, flooding and the migration of sand shoals through The Entrance Channel. The proposal would result in the positive transformation of The Entrance Channel and eroded beach profiles by enhancing ebb tide flows, which would encourage a more permanent entrance, and by renourishing the beach profiles in eroded areas. By maintaining the dredged sand within The Entrance sand system, no long-term adverse transformation to the locality is expected.

c. Any Environmental Impact on the Ecosystems of the Locality?

The proposed dredging would require the removal of small areas of the seagrass *Zostera capricorni*, predominantly from areas that have recolonised since previous dredging campaigns. Seagrass in the estuary provides important habitat for estuarine fish and bird species.

The area of seagrass requiring removal over the five year period is limited and is not considered significant to the large seagrass beds located elsewhere in the estuary. Long term beneficial impacts would be expected to any remaining seagrass within The Entrance Channel and in the estuary in

general as a result of maintaining tidal exchange and improvements to water quality. Flow-on beneficial impacts to species using this habitat would be expected from the dredging.

The proposed beach nourishment activity would have no significant adverse impact on marine of terrestrial ecosystems but would offer protection to terrestrial ecosystems against further erosion of the dune system.

d. Any Reduction of the Aesthetic, Recreational, Scientific or Other Environmental Quality or Value of a Locality?

Short term minor impacts to the aesthetics, recreational value and environmental quality of The Entrance area may result from the proposed works. Potential impacts may result from noise, odour, access restrictions to the channel and foreshore areas, turbidity, and the presence of plant and equipment.

Overall, the quality and values of the locality are expected to outweigh any potential impacts from the works.

e. Any Effect on a Locality, Place or Building Having Aesthetic, Anthropological, Archaeological, Architectural, Cultural, Historical, Scientific or Social Significance or Other Special Value for Present or Future Generations?

The proposal would have a beneficial impact on the locality as discussed in **Sub-clause d**. A positive impact would also be expected due to the indirect protection of property and building in the vicinity of North Entrance Beach which are subject to risk from coastal erosion.

f. Any Impact on the Habitat of Protected Fauna (Within the Meaning of the *National Parks And Wildlife Act 1974*)?

Protected fauna within the meaning of the *National Parks and Wildlife Act 1974* (NPWS Act) essentially entails all native and migratory fauna to Australia. This subclause therefore applies to all habitat within the vicinity of the study area for native and migratory fauna.

Short term impacts to estuarine and marine habitat in the immediate vicinity of the proposed works are expected from localised increases in turbidity. Short term impacts to terrestrial species including native and migratory birds are expected from noise and the presence of people, plant and equipment. The removal of small areas of seagrass habitat is also required.

Provided the mitigation measures detailed in **Section 7.1** of this document are implemented, the proposal is not likely to adversely impact on protected fauna or the habitat of protected fauna within the meaning of the *National Parks and Wildlife Act 1974*.

Protected fauna are likely to experience long-term improvements to their habitat as a result of the proposed works. Benefits are associated with improved water quality, maintenance of the existing tidal regime, and protection of the dune system.

g. Any Endangering of Any Species of Animal, Plant or Other Form of Life Whether Living on Land, In Water or In the Air?

Small impacts to individuals of flora and fauna species may occur as a result of the proposed works. In particular, areas of seagrass would require removal. These impacts are not expected to endanger any species of animal, plant or other form of life but would likely result in long-term beneficial impacts to flora and fauna species and any other form of life which inhabit or otherwise utilise the estuary and surrounds.

h. Any Long Term Effects on the Environment?

Long term beneficial impacts relating to the health of the estuary are expected as a result of maintaining the flow regime to which estuarine ecosystems have adapted. Benefits are likely to include improved water quality, habitat health and an increase in fish stocks as a result of maintaining a more open entrance.

The proposal also minimises long term effects to the environment that may be cause by continued erosion of the beach front at both The Entrance Beach and in particular, North Entrance Beach.

i. Any Degradation of the Quality of the Environment?

A primary aim of the proposal is to minimise the long term degradation of the quality of the environment that might otherwise occur as a result of degrading water quality and erosion. Short term degradation to the quality of the environment may be expected in relation to water quality, air quality and amenity impacts due to noise, discoloured sands and the presence of plant and equipment. These short term impacts would be controlled through the implementation of mitigation measures detailed in **Section 7.1** of this document.

j. Any Risk to the Safety of the Environment?

There would be no risk to the safety of the environment provided the controls and mitigation measures detailed in **Section 7.1** of this document are implemented.

k. Any Reduction in the Range of Beneficial Uses of the Environment?

The proposal would increase the beneficial uses of the environment by improving the amenity and recreational value of the estuary and beach nourishment areas, and by improving fish stocks which are fished both commercially and recreationally.

l. Any Pollution of the Environment?

The dredging works have the potential to pollute the environment through increased turbidity caused by the dredging process, and through increased turbidity in the surf zone as a result of the dewatering of material placed within beach nourishment areas. Pollution from leaks and spills of fuel and lubricants from plant is also a possibility. These impacts would be managed through the implementation of control measures outlined in **Section 7.1** of this document.

The use of plant and equipment necessary to carry out the works would also emit greenhouse gases however this is not expected to have a significant impact on the environment.

m. Any Environmental Problems Associated with the Disposal of Waste?

Any waste removed from the estuary during dredging or otherwise generated during the proposed works would be handled accordingly. There are not expected to be any environmental issues associated with the disposal of any waste.

n. Any Increased Demands on Resources (Natural or Otherwise) that are or are Likely to Become in Short Supply?

No increase in demands on resources that are or are likely to become in short supply is likely. The beneficial reuse of dredged material in beach nourishment prevents the sourcing of clean material that would otherwise be required for use in beach nourishment.

o. Any Cumulative Environmental Effect with Other Existing or Likely Future Activities?

No cumulative environmental effect with other existing or likely future activities is expected.

8.3 *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Factors (Commonwealth Legislation)

Matters of National Environmental Significance must be considered as a requirement of the EPBC Act. A search was undertaken of the online EPBC Protected Matters Search Tool (http://www.environment.gov.au/erin/ert/epbc/index.html) on 3rd June 2009. The results are reported below.

No matters of National Environmental Significance would be triggered by the proposed works where the management and mitigations measures provided in this document are implemented. Therefore the proposal does not require referral under the EPBC Act.

8.3.1 Consideration of Commonwealth EPBC Act (1999) Factors

a. Any Environmental Impact on a World Heritage Property?

There would be no impact on any World Heritage property.

b. Any Environmental Impact on a National Heritage Place?

There would be no impact on any National Heritage place.

c. Any Environmental Impact on Ramsar Wetlands of International Importance?

The estuary is not listed as a Ramsar wetland of international importance and the proposed works would have no direct or indirect impact to the nearest Ramsar wetlands, being the Hunter Estuary Wetlands approximately 50 km from the proposed site.

d. Any Environmental Impact on Commonwealth Listed Threatened Species and Ecological Communities?

Of the protected species listed in **Section 2.7.2**, the majority would not be directly impacted by the proposed works and no adverse impacts to habitat critical to these species are likely. Access to the estuary for many of these species would be attained through continued dredging practices. Species with potential to be impacted during the proposed works include syngnathids which are known to inhabit the seagrasses of the channel and any wading birds which may utilise the intertidal habitats or dunes surrounding The Entrance Channel for foraging, breeding and nesting. Any potential impacts to these species are not expected to be significant and would be managed in accordance with the mitigation measures detailed herein.

As such, there would be no adverse impact on Commonwealth listed Threatened Species or Ecological Communities.

e. Any Environmental Impact on Commonwealth Listed Migratory Species?

Thirty four (34) migratory species are listed as likely to be present or have habitat present within the proposed area of works. The majority of these species may visit the site on occasion and due to the limited scale and duration of the works and the provision of large areas of similar habitat elsewhere in the estuary, these species and their habitat are unlikely to be impacted.

Provided the measures detailed in this document are implemented, no impact to the foraging, breeding and nesting habitat is expected for the listed migratory wetland bird species which frequent the intertidal areas of The Entrance Channel and in the case of the Little Tern, The Entrance sand spit.

f. Does Any Part of the Project Involve a Nuclear Action?

This project does not involve a nuclear action.

g. Any Environmental Impact on the Commonwealth Marine environment?

The Commonwealth Marine environment is located 3 nautical miles offshore of the beach nourishment locations on the open coast. As such, there would be no adverse impact on the Commonwealth Marine environment.

h. Any Impact on Commonwealth Land?

There would be no impact on Commonwealth land.

9. AMENDMENTS

The dredging and beach nourishment practices and mitigation measures recommended in this REF may be reviewed and amended in light of the following:

completion of Wyong Shire Council's Coastline Management Plan (CMP);

completion of future studies carried out under Wyong Shire Council's Estuary Management Plan (EMP) ; and

impacts from climate change such as sea level rise, higher flood peaks or other changes to the hydrological regime of the estuary.

10. REFERENCES

Acid Sulfate Soils Management Advisory Committee (ASSMAC) (1998) Acid Sulfate Soil Manual (ASSM).

ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand, October 2000.

Commonwealth of Australia (2009a) A Directory of Important Wetlands in Australia. Tuggerah Lake – NSW141. Department of Environment, Water, Heritage and the Arts. Available at: http://www.environment.gov.au/cgi-bin/wetlands/report.pl

Commonwealth of Australia (2009b) National Assessment Guidelines for Dredging.

Department of Land and Water Conservation (DLWC) (1997) NSW Acid Sulfate Soil Risk maps. Edition two.

Department of Planning (DoP) (2007) Primefacts No. 629 – Seagrasses.

Dickinson, T.G., Roberts, D.E., Geary, M., McPherson, R., Dye, A., Muston, R. (2006) Tuggerah Lakes Estuary Management Plan. Prepared for Wyong Shire Council and Department of Natural Resources. BIO-ANALYSIS Pty Ltd: Marine, Estuarine and Freshwater Ecology, Narara.

McComb, A. J. (1981) The Biology of Australian Seagrasses. In Pate, J.s. and McComb, A. J. (Eds) The Biology of Australian Plants. university of Western Australian Press. pp 258-293.

NEPC (1999) National Environment Protection (Assessment of Site Contamination Measure). Schedule B (7a) Guidelines on Health-Based Investigation Levels.

NSW National Parks and Wildlife Service (1995) Wyrrabalong National Park Plan of Management.

NSW Department of Environment and Climate Change (DECC) (2008) Atlas of NSW Wildlife. Available online at: www.wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas.html.

Patterson Britton and Partners (PBP) (1992) The Tuggerah Lakes Restoration Project. Status Report as at 30 June 1992. Report prepared for Wyong Shire Council.

Patterson Britton and Partners (PBP) (1994) Tuggerah Lakes, Entrance training Walls: Technical Discussion. Report prepared for Wyong Shire Council.

Public Works Department (1988) Tuggerah Lakes Entrance Improvements. Entrance Restraining Wall Concept Design Report. Report prepared for Wyong Shire Council.

Roberts, D.E. (2001) Tuggerah Lakes Estuary Process Study. Wyong Shire Council, Wyong.

Roberts, D.E. and Dickinson, T.G. (2005) Tuggerah Lakes Estuary Management Study. Prepared for Wyong Shire Council and Department of Infrastructure, Planning and Natural Resources. BIO-ANALYSIS: Marine, Estuarine and Freshwater Ecology, Narara.

Ryan, D. A., Heap, A. D., Radke, L., and Heggie, D. T., (2003) Conceptual models of Australia's estuaries and coastal waterways: applications for coastal resource management. Geoscience Australia, Record 2003/09, 136 pp.

Scott, A. (1999) Ecological History of the Tuggerah Lakes. Final report. Produced by CSIRO Land and Water and Sainty & Associates for Wyong Shire Council. Technical Report 18/99, June 1999.

Sutas, A. R. (1996) Treatment of acid sulphate soils on Tuggerah Lakes foreshores. Proceedings of the 2ns National Conference on acid sulphate soil, pp 215-220.

The Ecology Lab (TEL) (2002) Port Hacking Dredging and Spoil Disposal. Aquatic Ecology, Conservation & Fisheries: Supplementary Information. Prepared for Patterson Britton and Partners.

Williams, R.J., West, G., Morrison, D., and Creese, R.G. (2006) Estuarine Resources of New South Wales. Prepared for the Comprehensive Coastal Assessment (DoP) by the NSW Department of Primary Industries, Port Stephens.

WorleyParsons (2008) Technical Advice on Dredging Related Matters – Tuggerah Lakes Entrance. Prepared by for Wyong Shire Council, April 2008.

Wyong Shire Council (1991) Wyong Local Environmental Plan

Wyong Shire Council (2004) Review of Environmental Factors – Entrance Channel Dredging and Beach Nourishment. Report prepared for Wyong Shire Council, May 2004.

Appendix 1 Sediment Investigation

WorleyParsons
resources & energy

EcoNomics

WYONG SHIRE COUNCIL

The Entrance Channel Maintenance Dredging Project

Sediment Sampling and Testing Investigation

301015-00962

–

10 June 2009

when experience counts

10 June 2009

Level 12, 141 Walker Street
North Sydney
NSW 2060
Australia

Disclaimer

PROJECT 301015-00962/01 - THE ENTRANCE CHANNEL MAINTENANCE DREDGING PROJECT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Internal Review	O Murray	A Watters	G Britton	19-May-09		
0	Draft issued for Client	O Murray	G Britton	G Britton	10-Jun-09		

CONTENTS

1. INTRODUCTION 4
2. METHODOLOGY....5
2.1 General 5
2.2 Sample Locations 5
2.3 Sample Collection....5
2.4 Analytical Work 6
2.4.1 Physical Analysis 6
2.4.2 Acid Sulfate Soils Analysis....6
2.4.3 Chemical Analysis....7
3. FINDINGS OF THE INVESTIGATION....8
3.1 Physical Testing of Sediment 8
3.2 Acid Sulfate Soil Testing....10
3.3 Chemical Testing of Sediments....12
3.3.1 Field and Laboratory Quality Assurance/Quality Control....14
4. SUMMARY AND IMPLICATIONS FOR REUSE OF THE SEDIMENT 15
5. REFERENCES 16

ATTACHMENT 1 CORE LOGS
ATTACHMENT 2 RESULTS OF THE PHYSICAL ANALYSIS
ATTACHMENT 3 RESULTS OF ACID SULFATE SOIL ANALYSIS
ATTACHMENT 4 RESULTS OF CHEMICAL ANALYSIS
ATTACHMENT 5 FIELD AND LABORATORY QA/QC

1. INTRODUCTION

Wyong Shire Council (Council) has carried out regular maintenance dredging of The Entrance Channel, Tuggerah Lakes since 1993. The dredging is integral in managing tidal exchange in the estuary and the subsequent water quality and flood risk.

Dredging is undertaken approximately yearly with the dredged material used to renourish nearby beaches such as The Entrance Beach, North Entrance Beach and the estuary eastern beach located along the north eastern foreshore of The Entrance Channel, in the vicinity of Karagi Foreshore Reserve.

An environmental assessment, by way of a Review of Environmental Factors (REF), is required in order for Council to renew their permit to dredge and to obtain other relevant permits and approvals for the dredging and beach nourishment activities. The REF must address the suitability of the proposed dredge material for reuse in beach nourishment.

This report documents the sediment sampling and testing undertaken with the view to verifying the suitability of the potential dredge material for reuse in beach nourishment. This report contains the following:

- a description of the sampling program;
- tabulation of all laboratory results and a copy of the original laboratory sheets;
- statistical analysis of the results for each chemical analyte to calculate the mean and standard deviation, and the 95% upper confidence limit of the mean (95% UCL). The 95% UCL will be used for comparison to the guideline levels;
- assessment of acid sulfate soil potential;
- assessment of physical properties of the sediment; and
- reporting of all QA/QC.

2. METHODOLOGY

2.1 General

The sampling and analysis was undertaken in accordance with the Sampling and Analysis Plan (SAP) prepared by WorleyParsons (2009) for the exercise.

2.2 Sample Locations

Samples were retrieved from ten locations (refer **Figure 1**) spaced approximately 200 – 250 m apart in an effort to gain a broad understanding of the suitability of sediments likely to be dredged from different section of The Entrance channel in the next five years. Sample locations were aimed at areas of reduced depth in order to ensure maximum sample recovery.

Sampling locations where determined with consideration of the following guidelines:

- the Acid Sulfate Soils Manual guidelines prepared by the NSW Acid Sulfate Soils Management Advisory Committee (ASSMAC) (1998); and
- the Contaminated Site Sampling Design Guidelines prepared by the NSW Environment Protection Authority (1995).

Due to depth limitations for sampling, Cores S9 and S10 were moved to the edge of the batter slope on the north side of the main channel. The new locations are adjacent to the proposed dredge footprint and sediment at depth in these cores is likely to provide a good indicator of the sediment characteristics which would occur in the adjacent sections of the channel.

2.3 Sample Collection

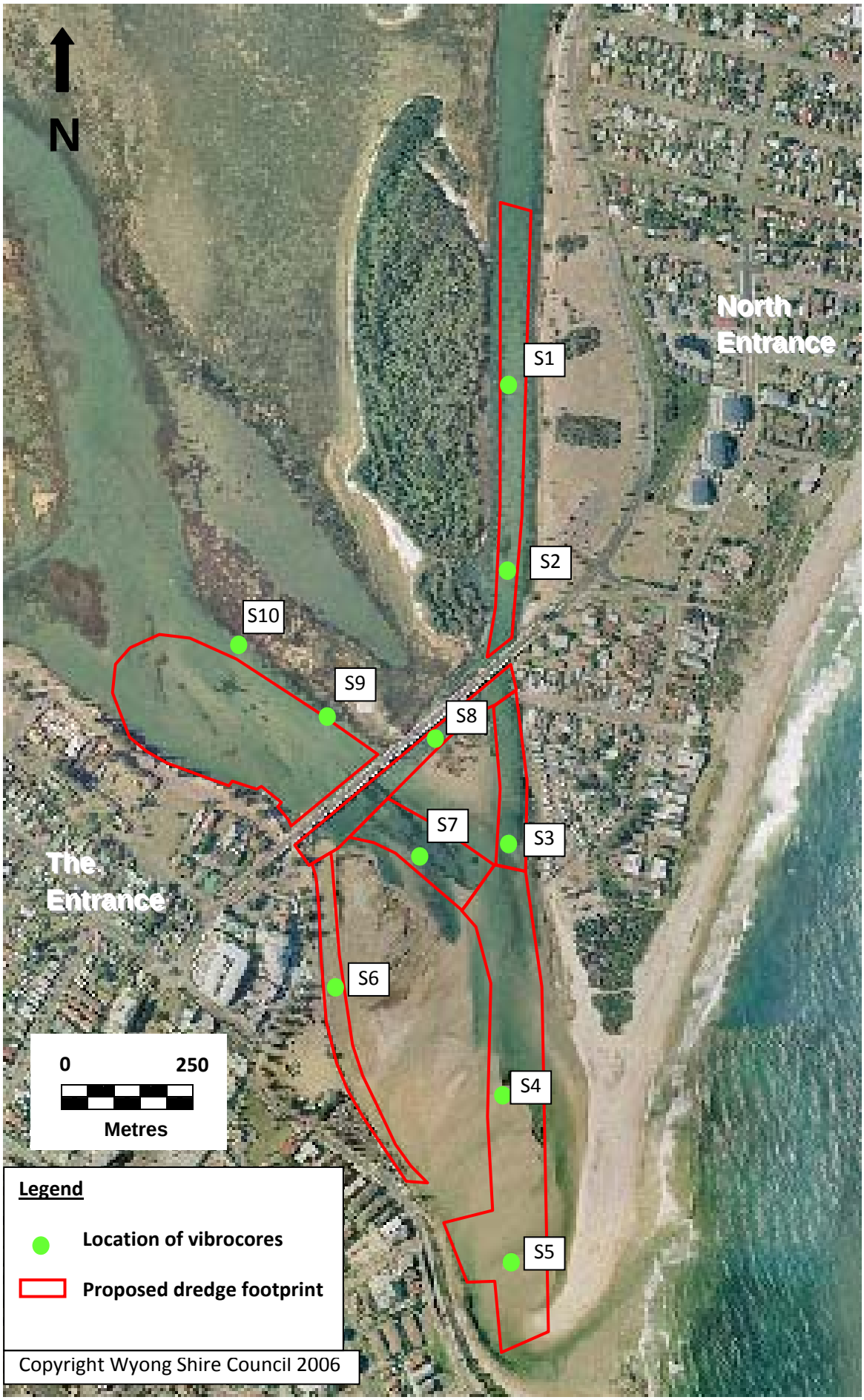
Vibrocoring was undertaken to obtain sediment samples at depth within the sediment profile. The vibrocoring was undertaken by Adrian Frankel of Vibrosed Analytical on Tuesday 21/04/2009.

At each location, a vibrating head was attached to an aluminium tube approximately 80 mm in diameter and used to drive the core into the sediment to a level about 0.5 m beyond the depth of proposed dredging (i.e. to approximately 2.5 m below normal lake water level). The head of each core was capped prior to removal to ensure maximum recovery of sediment.

The water depth and recovery depth of each core are recorded in the core logs provided in **Attachment 1**. Note that depths of sediment (ie. subsample depths) in this report refer to depth below existing bed level.

Subsampling and sample handling was carried out by an experienced WorleyParsons Environmental Scientist on 22nd May 2009. Each vibrocore was split in half using a circular saw then logged and photographed. Subsamples were then collected from suitable sections of each vibrocore for laboratory analysis.

FIGURE 1



Vibrocore Sampling Locations

Typically, two composite subsamples were collected at depth within each core with the exception of S2 and S4 (one subsample from each due to the length of core retrieved). In total, 18 subsamples and one split duplicate[1] were collected. All samples collected from each core were collected from within the dredge design depth.

Samples for chemical analysis were transferred to sterile glass jars (2 × 250mL and 2 x 150 mL). Samples for physical analysis were transferred to plastic zip lock bags. Samples for acid sulphate soil testing were transferred to freezer bags and excess air was removed prior to placement into plastic zip lock bags. This was undertaken to reduce the potential for oxidation of any sulphides on route to the laboratory. All jars/bags were filled with zero headspace. The lid of each sample container was tightly screwed on to avoid loss of sample and the jars/bags labelled with a unique identification number.

All sampling equipment was decontaminated between each sampling event. Decontamination procedures included rinsing the equipment to remove visible sediment, followed by a Decon 90 rinse.

Field logs were completed during sampling, noting the sediment characteristics such as colour and texture found within the strata in each core (refer **Attachment 1**).

Samples for chemical analysis were packed in ice in an esky immediately after sampling to maintain the temperature below 4°C. Samples for chemical analysis were transported in an esky in ice to the NATA registered analytical laboratory while the samples for physical analysis were transported to the nominated laboratory at room temperature. All samples were transported under WorleyParsons Chain of Custody procedures.

2.4 Analytical Work

WorleyParsons engaged ALS Environmental to undertake the physical analysis and geochemical analysis of the samples.

2.4.1 Physical Analysis

Physical analysis was undertaken on 11 subsamples (approximately one from each core) to assist in the physical characterisation of the sediment for the purpose of beach nourishment on The Entrance Beach, North Entrance Beach and the estuary eastern beach. Physical testing comprised analysis for the mud, sand and gravel content as well as particle size grading to 63µm.

2.4.2 Acid Sulfate Soils Analysis

The preliminary assessment involved laboratory screen testing of 18 samples to identify the presence and severity of actual acid sulfate soils and the likely presence of potential acid sulfate soil. The

[1] Split duplicate – at one location the sample is homogenised and split into two containers to assess variation associated with subsample handling as part of QA/QC measures.

screening test records pH measurements before and after oxidation with 30% hydrogen peroxide and the recording of the severity of the reaction.

Detailed laboratory analysis using the Chromium Reducible Sulfur suite was carried out on five selected samples where the screening test indicated that acid sulfate soils may be present.

Both stages of testing were carried out in accordance with the Acid Sulfate Soils Manual (ASSMAC, 1998) guidelines and the Acid Sulfate Soils Laboratory Methods Guidelines (Ahern et al., 2004).

2.4.3 Chemical Analysis

Chemical analysis included the following:

- a suite of heavy metals (As, Cd, Co, Cr, Cu, Ni, Pb, Se, Zn) on each sample collected, including the split duplicate;
- total organic carbon (TOC) on 20% of samples; and
- organochlorine pesticides (OC Pesticides) on 20% of samples.

3. FINDINGS OF THE INVESTIGATION

3.1 Physical Testing of Sediment

Physical analysis was undertaken on approximately 50% of subsamples to assist in the physical characterisation of the sediment for reuse as beach nourishment material. The full laboratory results of this analysis are included in **Attachment 2**. A summary of the mud, sand and gravel content analysis is provided in **Table 3.1** below with core logs from the sub-sampling provided in **Attachment 1**.

Table 3.1 Summary of Sediment Texture Results

Material	Mud (<63µm)	Sand (>63 µm and <2mm)	Gravel (>2mm)	Particle Size Analysis Description
S1 0.5-1.0M	5	95	<1	Med to coarse sand
S2 0-0.7M	9	90	1	Fine to med sand
S3 0-0.4M	18	80	2	Fine to coarse sand and silt
S4 0.4-0.9M	5	95	<1	Med to coarse sand
S5 0.4-0.9M	2	97	1	Predominantly coarse sand
S5 1.0-1.3M	4	95	1	Med to coarse sand
S6 0.1-0.6MA	4	94	2	Med to coarse sand
S7 0.1-0..6M	3	96	1	Med to coarse sand
S8 0.8-1.3M	10	89	1	Fine to med sand
S9 0-0.6M	8	91	1	Fine to med sand
S10 1.0-1.5M	6	87	7	Med to coarse sand

The results of the analysis show that the material recovered in the sandy shoals towards the mouth of the entrance channel (ie. Cores S4-S7 and surface sediments of Core S8) are typical of clean marine sands worked through the mouth of the entrance channel. These sediments comprise interbedded medium to coarse grained yellow/light grey sand with <5% mud as depicted in **Plate 1**. Medium to coarse dark grey sand containing decomposing organic matter was recovered at depths below 0.95 m from Core S5 taken in the lee of the entrance sand spit.

Analysis of sediment recovered from the existing channels (ie. Cores S1-S3 and sediments at depth in Core S8) indicate that these sediments comprise interbedded fine to coarse grained grey/brown sand and silty sand with ≤10% mud as shown in **Plate 2**. Similarly, sediment at depth within Cores S9 and S10 comprise medium to coarse grey sand with less than 10% mud and is likely to be representative of the adjacent sediment within deeper sections of the channel to the west of the bridge. Some gravel which is likely to comprise coarse shell fragments may be present in these sediments as indicated by Core S10 (1.0 – 1.5 m) (7% gravel).

The exception to physical sediment characteristics of the existing channels is Core S3 (refer **Plate 3**) which comprised fine to coarse grained grey silty sand with 18% mud overlying grey/brown sand at depths of 0.4 m.

Plate 1 Interbedded yellow and grey sands typical of the sediments retrieved from the entrance sand shoals (ie. Cores S4 – S7 and S8 (surface sediments only))

Plate 2 Interbedded fine to coarse grained grey/brown sand and silty sand typical of the sediments retrieved from existing channel areas (ie. Cores S1, S2, S8 (at depth) and S9 – S10)

Plate 3 Fine to coarse grained grey silty sand overlying grey/brown sand found in Core S3

3.2 Acid Sulfate Soil Testing

Laboratory results for ASS testing are provided in **Attachment 3** and are summarised in **Table 3.2**. The laboratory screening test indicated that pH_f prior to oxidation ranged from 6.9 to 8.9 and therefore no actual acid sulfate soils ($pH_f \leq 4$) where identified. Samples showed slight to moderate reactions during oxidation with 30% hydrogen peroxide. Following oxidation, pH_{fox} ranged from 5.2 to 6.4 with approximately 83% of the 18 samples showing a significant pH change (change >2 pH units).

The laboratory screening test was used to select five representative samples which were subjected to the more rigid Chromium Reducible Sulfur suite. The net acidity of each sample was determined from the results of the Chromium Reducible Sulfur testing using the acid base accounting equation:

Net acidity = potential sulfidic acidity + existing acidity– acid neutralising capacity

The results indicate that there is no existing acidity (ie. actual and retained acidity) in the sediment. Therefore, the net acidity of these samples is calculated using the equation:

Net acidity = potential sulfidic acidity– acid neutralising capacity

The potential sulfidic acidity of each sample was determined using the Chromium Reducible Sulfur test which is a direct measure of reduced inorganic sulfur and therefore allows distinction between inorganic sulfur such as pyrite and sulfur from organic sources. The Chromium Reducible Sulfur test (S_{CR}) is appropriate for use in dredging studies as there is a high likelihood of encountering organic material in the sediment.

All samples reported a potential sulfidic acidity greater than the “action criteria” specified in the Acid Sulfate Soils Manual guidelines (ASSMAC, 1998). Generally, where action criteria are exceeded, an acid sulfate soil management plan is required for the disturbance of the sediments, unless mitigating factors such as sufficient acid neutralising capacity are established.

The acid neutralising capacity (ANC) of a sediment is the ability of the sediment to neutralise any acid that may be produced on oxidation and maintain the pH above 5.5. Organic matter, calcium carbonates (ie. shell) and magnesium carbonates are common naturally occurring neutralising agents. The effectiveness of these agents varies depending on particle size, coatings on the agent and kinetic factors which affect the rate at which they dissolve and become available. To account for these limitations, the acid neutralising capacity is divided by a minimum fineness factor of 1.5.

All five samples had a negative net acidity result indicating that sufficient acid neutralising capacity is available in the sediment to neutralise any acid that may result from the removal, handling and placement of the dredged sediments. As such, no acid sulfate soil management plan is required.

Table 3.2 Summary of Acid Sulfate Soil Results

Sample ID	Field pH Screen				Chromium Suite				Acid Base Account
					Potential Acidity	Actual Acidity		Acid Neutralising Capacity	
					S_{CR}	ph $_{KCL}$	s-TAA	s-ANC_{BT}	Net acidity
	pH_F	pH_{FOX}	pH change	Reaction	% S	pH Unit	% pyrite S	% pyrite S	% S
S1 0-0.5M	8.1	6.2	1.9	Slight	-	-	-	-	-
S1 0.5-1.0M	8.7	5.8	2.9	Slight	0.07	9.5	<0.02	2.45	-1.56
S2 0-0.7M	8.4	5.9	2.5	Slight	-	-	-	-	-
S3 0-0.4M	8.7	5.9	2.8	Mod	0.29	9.1	<0.02	2.45	-1.34
S3 0.7-1.2M	8.8	5.8	3	Mod	-	-	-	-	-
S4 0.4-0.9M	8.6	6.1	2.5	Slight	-	-	-	-	-
S5 0.4-0.9M	8.4	6	2.4	Slight	-	-	-	-	-
S5 1.0-1.3M	8.5	6	2.5	Slight	0.06	9.6	<0.02	2.92	-1.89
S6 0.1-0.6MA	8.4	6.2	2.2	Slight	-	-	-	-	-
S6 0.7-0.95M	7.8	6.2	1.6	Slight	-	-	-	-	-
S7 0.1-0.6M	8.3	6	2.3	Slight	0.03	9.9	<0.02	3.24	-2.13
S7 0.6-1.0M	8.3	6.4	1.9	Slight	-	-	-	-	-
S8 0.2-0.6M	8.7	6.2	2.5	Slight	-	-	-	-	-
S8 0.8-1.3M	8.6	6.1	2.5	Mod	0.28	9.4	<0.02	1.7	-0.85
S9 0-0.6M	8.8	6.3	2.5	Slight	-	-	-	-	-
S9 1-1.5M	8.9	6.3	2.6	Slight	-	-	-	-	-
S10 0-0.5M	8.7	5.2	**3.5**	Slight	-	-	-	-	-
S10 1.0-1.5M	8.7	6.3	2.4	Slight	-	-	-	-	-

Notes:
Retained Acidity not required because pH KCl > 4.5
Net acidity = SCR - (ANCBT/Fineness Factor (ie. 1.5))

3.3 Chemical Testing of Sediments

The full laboratory results of the chemical analysis of the sediment samples are provided in **Attachment 4**.

Statistical analysis of the laboratory results for each contaminant has been undertaken to calculate the mean, standard deviation and the 95% upper confidence limit of the mean[2] *(*95% UCL*)*. In accordance with the 2009 National Assessment Guidelines for Dredging (NAGD), the US EPA's ProUcl Ver. 4.0 Statistical software was used to calculate the 95% UCL of the mean for each contaminant. Where data was not normally distributed (Shapiro-Wilks test with a 5% significance) the Standard Bootstrap Method was used to calculate the 95% UCL of the mean. Where data sets were found to be normally distributed or the data set did not contain enough discrete values to use the Standard Bootstrap Method, the Student-t Method was used to calculate the 95% UCL of the mean.

Results of the chemical analysis were compared to the NAGD. These guidelines provide Screening Levels (SL) based on the biological-effects-based Interim Sediment Quality Guidelines (ISQG) – Low provided in the ANZECC/ARMCANZ Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000). The Screening Levels are equivalent to the ISQG-Low values updated (in draft) by Simpson et al. (2008). Where contaminant concentrations are below Screening Levels, adverse impacts to marine organisms are considered unlikely. The NAGD Screening Levels are significantly more stringent than the human use Health Investigation Levels provided in the National Environment Protection (Assessment of Site Contamination Measure) Measure 1999 (NEPC Guidelines).

As indicated in the summary of the results provided in **Table 3.3** below, no contaminants have a 95% UCL of the mean above the NAGD SL. Concentrations of antimony, cadmium, silver, and OC pesticides were below laboratory detection levels.

[2] Confidence level is the probability, expressed as a percentage, that a statistical statement is correct. For example, if the 95% UCL is stated for a mean contaminant concentration, it implies that there is a 95% probability that the mean contaminant concentration within the sampling area will not exceed the value determined by this method.

Table 3.3 Contaminant Concentrations

Contaminant	Results				NAGD	NEPC
					SL	HILS[3]
	No.	SD	Mean	95% UCL		
Metals & Metalloids						
Antimony	18	0	<0.5	--	2	--
Arsenic	18	1.2	4.0	4.4	20	100
Cadmium	18	0	<0.1	--	1.5	--
Chromium	18	1.1	1.9	2.3	80	(III) 12%
Copper	18	1.2	1.1	1.5	65	1000
Lead	18	1.4	1.5	2.0	50	300
Mercury	18	0.01	0.01	0.01	0.15	15
Nickel	18	0.59	0.83	0.93	21	600
Silver	18	0	<0.1	--	1	--
Zinc	18	2.9	3.2	4.3	200	7000
Manganese	18	8.9	17.1	20.7	--	1500
Cobalt	18	0.33	0.4	0.54	65	100
Vanadium	18	1.9	2.7	3.4	--	--
Selenium	18	0.07	0.1	0.13	--	--
Organics						
Pesticides	4	0	<0.5	--	0.32-280 µg/kg	10-200

Notes:
1. *units are in mg/kg dry weight unless otherwise stated*
2. *95% upper confidence limit of the mean level. eg if the 95% UCL=4.3 mg/kg there is a 95% probability that the mean level of the contaminant will not exceed 4.3 mg/kg.*
3. *Screening Levels (SL) as per the National Assessment Guidelines for Dredging (Commonwealth of Australia, 2009).*
4. ** 95% confidence limit of the mean level calculated using the recommendations of the National Assessment Guidelines for Dredging (2009). If data is considered normally distributed by the Shapiro-Wilks test to 95% confidence then Student-t method was used. If data is not normally distributed then Standard Boot Strap method was used. When data is not normally distributed but there are not enough discrete values to use Boot Strap Method the Student-t Method was used (Current investigation).*

[3] NEPC (1999) HILS Category A - Standard' residential with garden/accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake; no poultry): this category includes children's day-care centres, kindergartens, pre-schools and primary schools, ie. the lowest HILS values.

3.3.1 Field and Laboratory Quality Assurance/Quality Control

A replicate sample was collected for field quality assurance. The relative percent difference (RPD) for metals were calculated for the replicate field sample (refer **Attachment 5**).

The NAGD (2009) recommends that field replicates should agree within an RPD of +/-50%. All contaminants which reported results above the limit of reporting had RPD's within this range.

Laboratory quality assurance consisted of the analysis of matrix spikes, blanks and duplicate samples. The results of this quality assurance can be found within the laboratory reports in **Attachment 5**. Recovery of one matrix spike sample for an OC Pesticide was slightly less than the recommended data quality objectives. This result is likely due to the inherent heterogeneity of sediment and the collection of composite samples from 0.5 m depth increments.

Overall, the field and laboratory quality assurance was considered satisfactory.

4. SUMMARY AND IMPLICATIONS FOR REUSE OF THE SEDIMENT

A sediment sampling and testing program has been undertaken to provide current chemical and physical sediment data for the potential beach nourishment material from The Entrance. Chemical and physical testing of samples from ten cores within the Entrance was undertaken. The main findings of the investigation are summarised below.

The sediments vary in physical composition. The sandy shoals prograding northwest from the mouth of the entrance comprise light coloured clean marine sands with little mud content. The remaining sediments are interbedded grey sands and silty sands with a slightly higher mud content likely to be influenced by the deposition of alluvial sediments during high flow events. The sands range from fine to coarse in texture and would be suitable for reuse on the adjacent beaches. The interbedded grey sands and silty sands may cause renourished areas to appear grey rather than yellow however this impact would be temporary and sand would be expected to "bleach" over time.

The 95% UCL of the mean concentration of all contaminants analysed was below the NAGD (2009) SL and the concentrations of antimony, cadmium, silver, OC pesticides were below laboratory detection. Currently, there are no guidelines for the beneficial reuse of sediment. However, comparison of the geochemical properties of the sediment with the health-based soil investigation levels (NEPC, 1999) and the more stringent NAGD (Commonwealth of Australia, 2009) Screening Levels indicate that no adverse impacts could be expected to humans or marine organism as a result of reuse of the sediment in beach nourishment.

Organic matter, primarily consisting of decaying seagrass and seaweed was observed within two of the cores. This material is likely to cause some discolouration of the emplaced sand in comparison to that of the existing beach profile however the discolouration would fade over time through UV bleaching.

Slight to strong emissions of H_2S where detected within several cores and may temporarily impact on nearby receptors from time to time.

Acid sulfate soil results indicate that there is sufficient acid neutralising capacity within the sediments to neutralise any potential acid sulfate soils that will be disturbed and that no acid sulfate soil management plan is required.

In conclusion, the material is considered suitable for reuse in beach nourishment. Mitigation measures involving temporary mounding and reworking to allow the material to bleach are recommended. This generally occurs as a matter of course in any case during the beach reshaping process by dozers.

5. REFERENCES

ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand, October 2000.

Commonwealth of Australia (2009) National Assessment Guidelines for Dredging.

Environmental Australia (2002) National Ocean Disposal Guidelines for Dredged Material.

NEPC (1999) National Environment Protection (Assessment of Site Contamination Measure). Schedule B (7a) Guidelines on Health-Based Investigation Levels.

Simpson, SL, Batley, GE and Chariton, AA. (2008) Revision of the ANZECC/ARMCANZ sediment quality guidelines. Draft, CSIRO Land and Water Report No. 8/07, August 2008. Prepared for the Commonwealth Department of the Environment, Heritage, Water and the Arts.

US EPA (2007) ProUCL Version 4.00.02 User Guide

US EPA (2007a) ProUCL Version 4.0 Technical Guide

WorleyParsons (2009) The Entrance Channel Maintenance Dredging Project: Sampling and Analysis Plan. Prepared for by WorleyParsons for Wyong Shire Council, March 2009.

Attachment 1 Core Logs

Field Logs –Area E Vibrocores

Sample Location and *Depth (m)	Description		
Core S1	Retrieved 21/04/2009	Water depth 1.5 m at 13:39	Sub sampled 22/04/2009 at 11:00
0- 0.2	Medium to course grained grey sand. Layer of mix shell at 0.1 to 0.15m		
0.2- 0.62	Fine grained silty grey sand		
0.62- 0.65	Mud layer		
0.65- 1.0	Med grained grey silty sand terminating in mud. H_2S odour in last 0.2m of core.		
Core S2	Retrieved 21/04/2009	Water depth 1.9 m at 14:27	Sub sampled 22/04/2009 at 12:00
0 – 0.1	Fine grained grey brown silty sand		
0.1- 0.3	Medium grained grey brown silty sand with mottled yellow sand at 0.16- 0.2m and mottles of dark grey silty sand at 0.18m & 0.3m		
0.3- 0.7m	Fine to medium grained grey silty sand. Fine lens of mud at 0.43- 0.46m		
Core S3	Retrieved 21/04/2009	Water depth 0.63 m at 12.23	Sub sampled 22/04/2009 at 12:30
0 – 0.36	Interbedded fine-medium grained grey silty sand and dark grey mud and silty clay. Strong H_2S odour		
0.36- 0.92	Medium to coarse grained light grey/brown silty sand with fine shell fragments.		
0.92-1.3	Interbedded brown sandy mud and muddy sand. Large shell fragment at 1.02m		
Core S4	Retrieved 21/04/2009	Water depth 0.4 m at 11:18	Sub sampled 22/04/2009 at 13:00
0- 0.58	Medium to course yellow sand with mottles of fine to med grained grey silty sand		
0.58- 0.7	Fine grained dark grey silty sand		
0.7- 1.0m	Medium to course grained yellow sand		
Core S5	Retrieved 21/04/2009	Water depth 0.3 mat 10:40	Sub sampled 22/04/2009 at 13:30
0-0.95	Coarse yellow sand		
0.95-1.33	Coarse dark grey silty sand with thin layer of rotting organic matter and weed at 1.12- 1.17m		
Core S6	Retrieved 21/04/2009	Water depth 0.22 m at 11:39	Sub sampled 22/04/2009 at 14:00
0- 0.7	Course interbedded yellow sand and grey silty sand		
0.7- 0.95	Fine to medium grained grey silty sand, large shell fragments at 0.67m		
Core S7	Retrieved 21/04/2009	Water depth 0.53 m at 12:03	Sub sampled 22/04/2009 at 14:30
0- 0.6	Medium to course grained, interbedded yellow brown and dark gray sand. Slight H_2S odour		
0.6- 0.72	Yellow brown fine grained silty sand		
0.72- 1.0	Grey fine grained silty sand		
Core S8	Retrieved 21/04/2009	Water depth 0.45 m at 15:05	Sub sampled 22/04/2009 at 15:00
0- 0.6	Fine to med grained grey brown silty sand. Dark silty sand lens with H_2S odour at 0.4- 0.43m		
0.6- 0.7	Medium to course grained yellow to light grey silty sand		
0.7- 0.8	Medium to course grained yellow to grey silty sand		
0.8- 1.13	Dark grey sandy mud. H_2S odour		
1.3- 1.75	Grey muddy sand with shell fragments		
Core S9	Retrieved 21/04/2009	Water depth 0.45 m at 15:30	Sub sampled 22/04/2009 at 15:45
0- 0.25	Fine dark grey silty sand		
0.25- 0.37	Dark grey firm sandy mud. H_2S odour		
0.37- 0.74	Grey sand/ soft mud. Large Shells present. H_2S odour		
0.74-1.57	Grey fine to medium grained silty sand interbedded with grey course grained silty sand. Thin lens of organic matter with sulfidic smell at 1.32m		

Core S10	Retrieved 21/04/2009	Water depth 0.65 m at 15:53	Sub sampled 22/04/2009 at 16:10
0- 0.8	Grey sandy/muddy sand. Fine shell		
0.8- 1.37	Brown/grey fine to medium grained silty sand with frequent shell		
1.37- 1.9	Grey medium grained sand. Shell fragments common		

Notes: * no correction for compaction

Attachment 2 Results of the Physical Analysis

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **ES0905883**	Page	: 1 of 5
Client	: **WORLEYPARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: OM	Issue Date	: 06-MAY-2009
Site	: THE ENTRANCE CHANNEL		
		No. of samples received	: 12
Quote number	: EN/034/08	No. of samples analysed	: 12

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dianne Blane		Newcastle

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: S1 0.5-1.0M	S2 0-0.7M	S3 0-0.4M	S4 0.4-0.9M	S5 0.4-0.9M
				Client sampling date / time: 22-APR-2009 11:30	22-APR-2009 12:00	22-APR-2009 12:30	22-APR-2009 13:00	22-APR-2009 13:30
				ES0905883-001	ES0905883-002	ES0905883-003	ES0905883-004	ES0905883-005
EA150: Particle Sizing								
-63µm	----	1	%	**5**	**9**	**18**	**5**	**2**
+63µm	----	1	%	**95**	**91**	**82**	**95**	**98**
+150µm	----	1	%	**93**	**90**	**80**	**94**	**98**
+300µm	----	1	%	**61**	**51**	**45**	**61**	**90**
+425µm	----	1	%	**36**	**20**	**28**	**31**	**70**
+600µm	----	1	%	**16**	**7**	**15**	**12**	**45**
+1180µm	----	1	%	**1**	**2**	**4**	<1	**9**
+2.36mm	----	1	%	<1	**1**	**2**	<1	**1**
+4.75mm	----	1	%	<1	<1	**2**	<1	<1
+9.5mm	----	1	%	<1	<1	**1**	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Sand (>63 µm)	----	1	%	**95**	**90**	**80**	**95**	**97**
Gravel (>2mm)	----	1	%	<1	**1**	**2**	<1	**1**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: S5 1.0-1.3M	S6 0.1-0.6MA	S6 0.1-0.6MB	S7 0.1-0..6M	S8 0.8-1.3M
				Client sampling date / time: 22-APR-2009 13:30	22-APR-2009 14:00	22-APR-2009 14:00	22-APR-2009 14:45	22-APR-2009 15:10
				ES0905883-006	ES0905883-007	ES0905883-008	ES0905883-009	ES0905883-010
EA150: Particle Sizing								
-63µm	----	1	%	**4**	**4**	**1**	**3**	**10**
+63µm	----	1	%	**96**	**96**	**99**	**97**	**90**
+150µm	----	1	%	**96**	**96**	**99**	**97**	**88**
+300µm	----	1	%	**78**	**68**	**66**	**67**	**51**
+425µm	----	1	%	**57**	**57**	**55**	**49**	**23**
+600µm	----	1	%	**34**	**44**	**42**	**30**	**10**
+1180µm	----	1	%	**7**	**12**	**13**	**3**	**2**
+2.36mm	----	1	%	**1**	**2**	**2**	**1**	**1**
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Sand (>63 µm)	----	1	%	**95**	**94**	**97**	**96**	**89**
Gravel (>2mm)	----	1	%	**1**	**2**	**2**	**1**	**1**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	S9 0-0.6M	S10 1.0-1.5M	----	----	----
				Client sampling date / time	22-APR-2009 15:45	22-APR-2009 16:10	----	----	----
					ES0905883-011	ES0905883-012	----	----	----
EA150: Particle Sizing									
-63µm	----	1	%		**8**	**6**	----	----	----
+63µm	----	1	%		**92**	**94**	----	----	----
+150µm	----	1	%		**88**	**93**	----	----	----
+300µm	----	1	%		**34**	**70**	----	----	----
+425µm	----	1	%		**15**	**44**	----	----	----
+600µm	----	1	%		**7**	**24**	----	----	----
+1180µm	----	1	%		**2**	**10**	----	----	----
+2.36mm	----	1	%		**1**	**7**	----	----	----
+4.75mm	----	1	%		<1	**5**	----	----	----
+9.5mm	----	1	%		<1	**2**	----	----	----
+19.0mm	----	1	%		<1	<1	----	----	----
+37.5mm	----	1	%		<1	<1	----	----	----
+75.0mm	----	1	%		<1	<1	----	----	----
EA150: Soil Classification based on Particle Size									
Sand (>63 µm)	----	1	%		**91**	**87**	----	----	----
Gravel (>2mm)	----	1	%		**1**	**7**	----	----	----
Cobbles (>6cm)	----	1	%		<1	<1	----	----	----

Certificate of Analysis

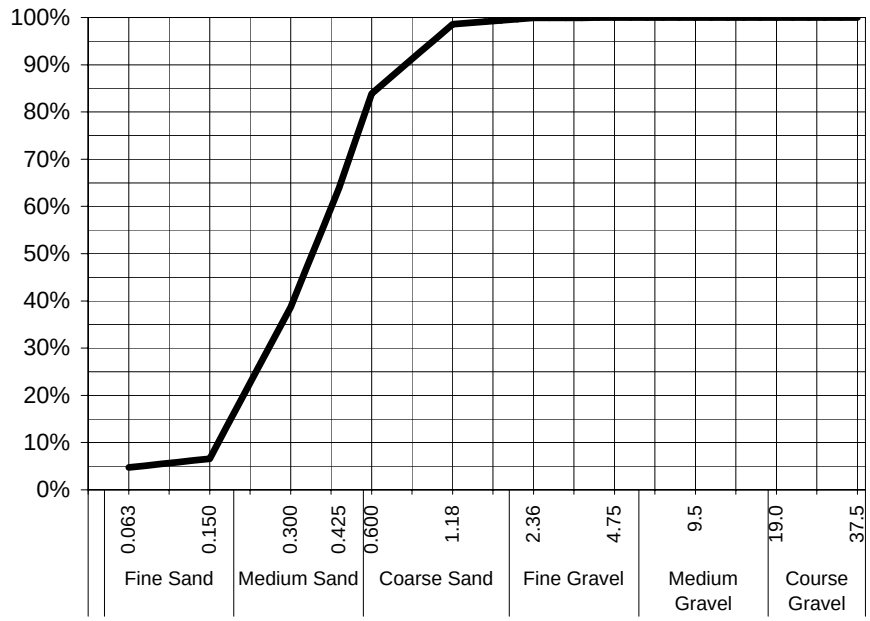
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-001 / PSD
PROJECT:	7291	**SAMPLE ID:**	S1 0.5-1.0M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	100%
1.18	99%
0.600	84%
0.425	64%
0.300	39%
0.150	7%
0.063	5%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

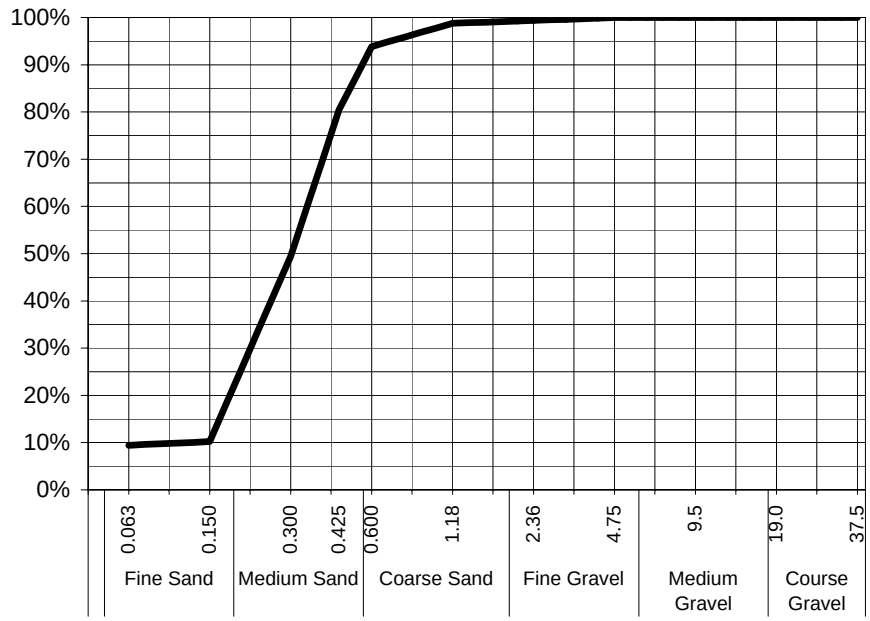
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-002 / PSD
PROJECT:	7291	**SAMPLE ID:**	S2 0-0.7M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	99%
1.18	99%
0.600	94%
0.425	80%
0.300	49%
0.150	10%
0.063	9%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

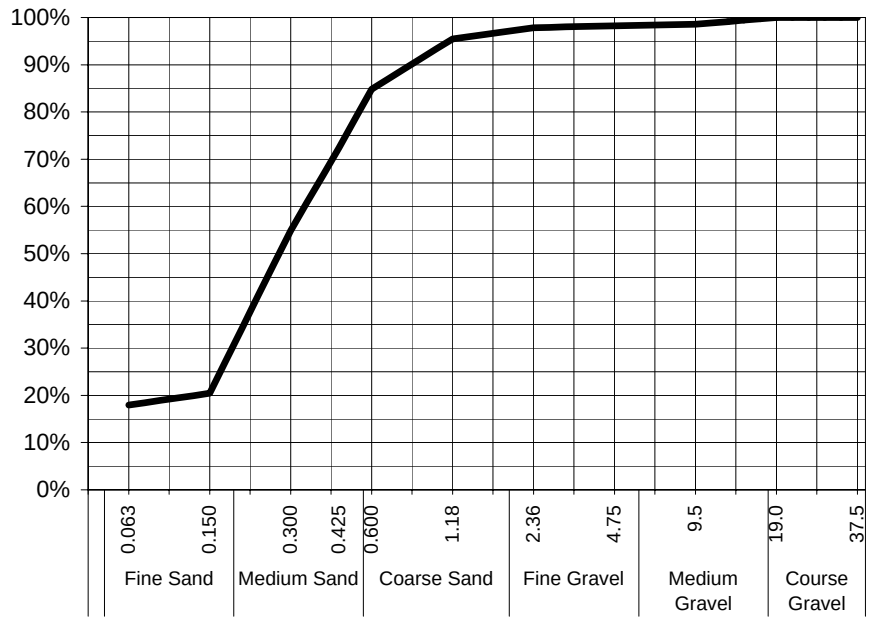
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-003 / PSD
PROJECT:	7291	**SAMPLE ID:**	S3 0-0.4M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	99%
4.75	98%
2.36	98%
1.18	95%
0.600	85%
0.425	72%
0.300	55%
0.150	20%
0.063	18%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand & silt

Test Method: AS1289.3.6.1

NATA Accreditation: 825 Site: Newcastle
This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

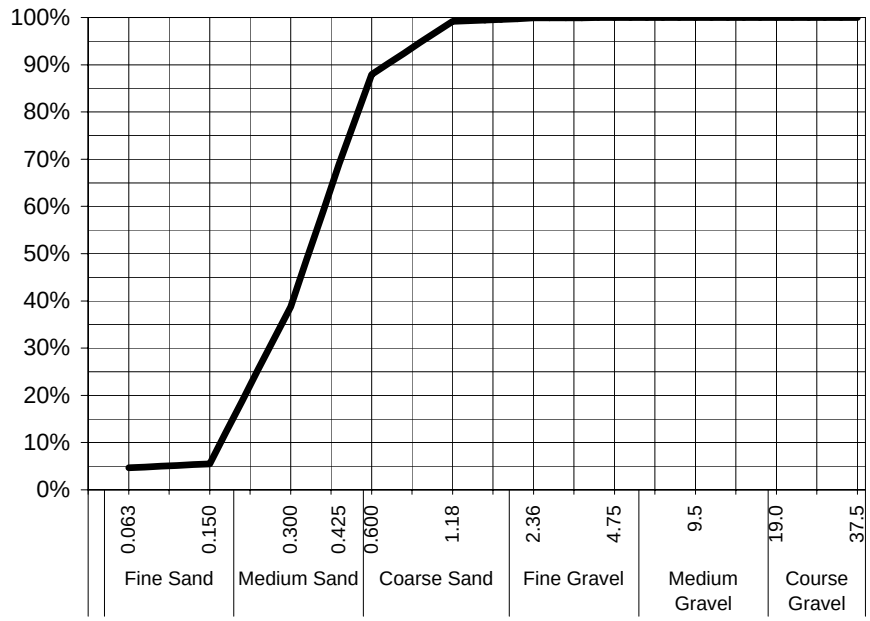
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-004 / PSD
PROJECT:	7291	**SAMPLE ID:**	S4 0.4-0.9M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	100%
1.18	99%
0.600	88%
0.425	69%
0.300	39%
0.150	5%
0.063	5%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

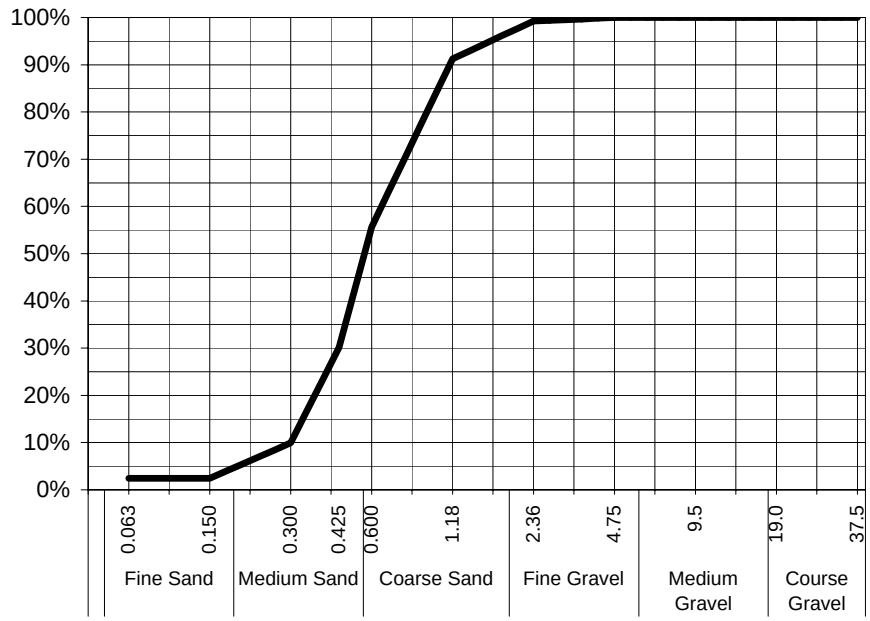
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-005 / PSD
PROJECT:	7291	**SAMPLE ID:**	S5 0.4-0.9M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	99%
1.18	91%
0.600	56%
0.425	30%
0.300	10%
0.150	2%
0.063	2%

Samples analysed as received.

Sample Comments:		**Analysed:**	29-Apr-09
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	Sand		
Test Method:	AS1289.3.6.1		

NATA Accreditation: 825 Site: Newcastle
This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

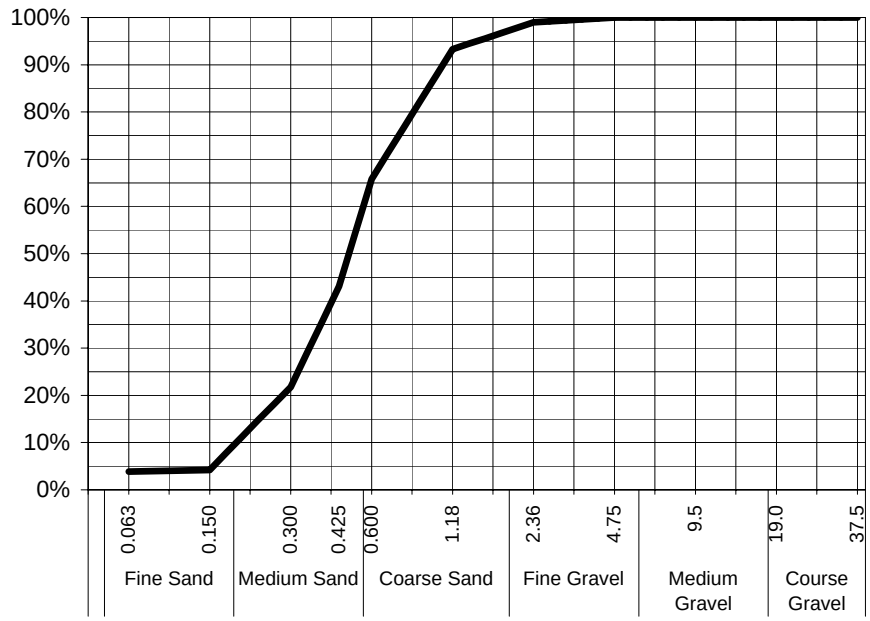
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-006 / PSD
PROJECT:	7291	**SAMPLE ID:**	S5 1.0-1.3M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	99%
1.18	93%
0.600	66%
0.425	43%
0.300	22%
0.150	4%
0.063	4%

Samples analysed as received.

Sample Comments:		**Analysed:**	29-Apr-09
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	Sand		
Test Method:	AS1289.3.6.1		

NATA Accreditation: 825 Site: Newcastle
This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

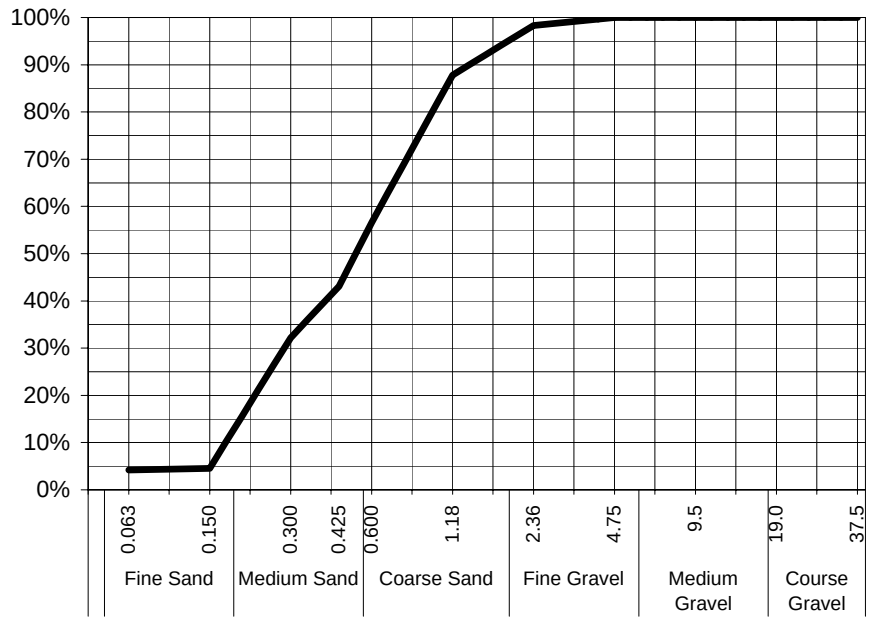
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-007 / PSD
PROJECT:	7291	**SAMPLE ID:**	S6 0.1-0.6MA

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	98%
1.18	88%
0.600	57%
0.425	43%
0.300	32%
0.150	5%
0.063	4%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

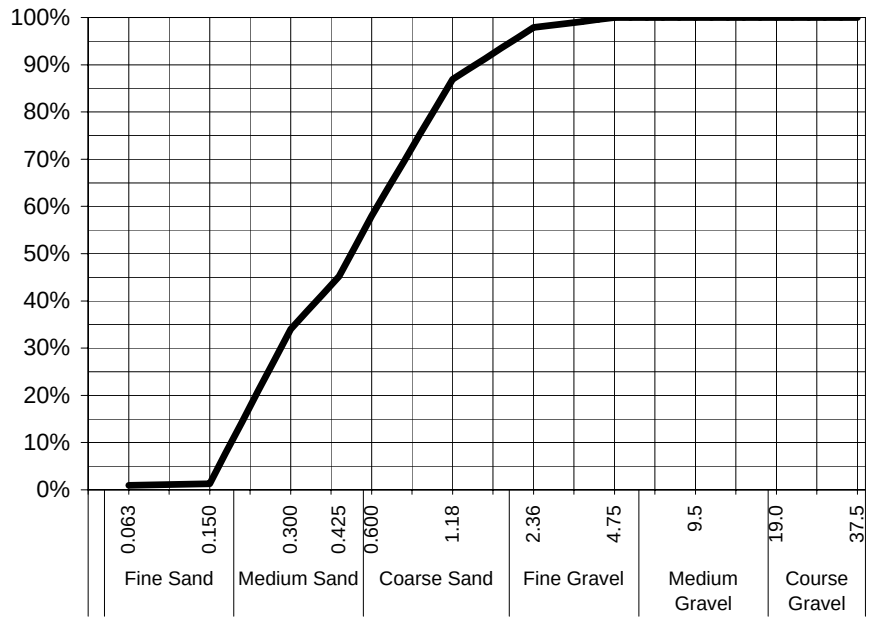
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-008 / PSD
PROJECT:	7291	**SAMPLE ID:**	S6 0.1-0.6MB

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	98%
1.18	87%
0.600	58%
0.425	45%
0.300	34%
0.150	1%
0.063	1%

Samples analysed as received.

Sample Comments:		**Analysed:**	29-Apr-09
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	Sand		
Test Method:	AS1289.3.6.1		

NATA Accreditation: 825 Site: Newcastle
This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

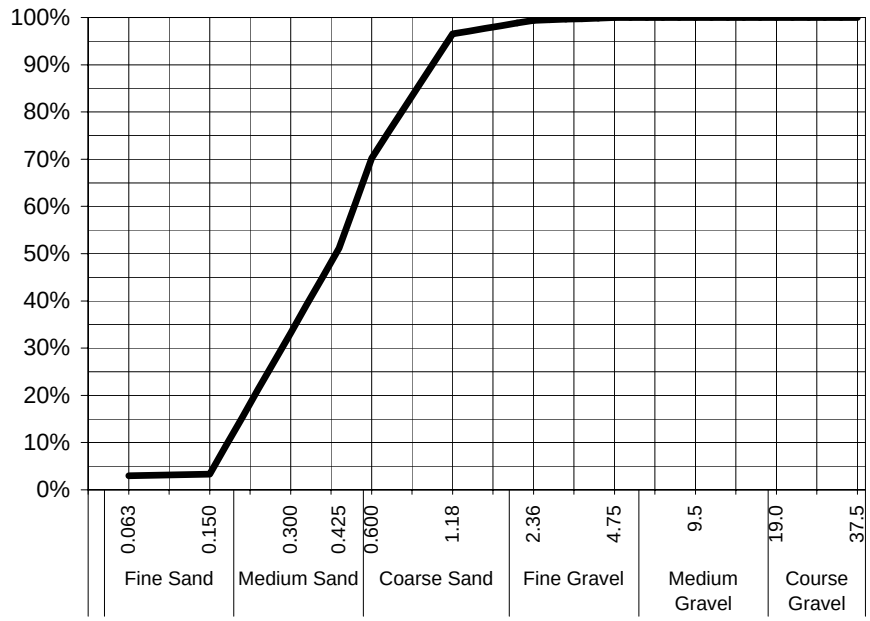
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-009 / PSD
PROJECT:	7291	**SAMPLE ID:**	S7 0.1-0..6M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	99%
1.18	97%
0.600	70%
0.425	51%
0.300	33%
0.150	3%
0.063	3%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

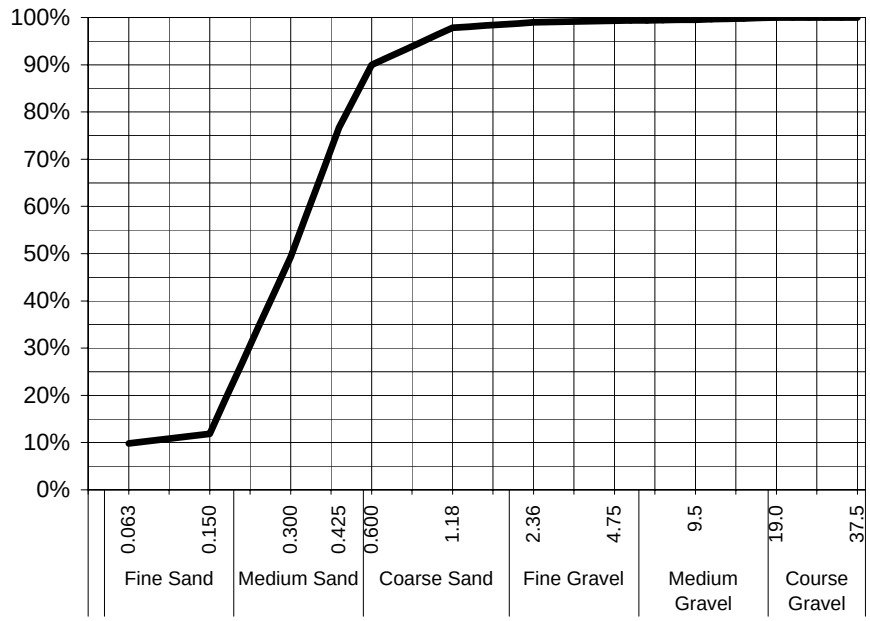
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-010 / PSD
PROJECT:	7291	**SAMPLE ID:**	S8 0.8-1.3M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	99%
2.36	99%
1.18	98%
0.600	90%
0.425	77%
0.300	49%
0.150	12%
0.063	10%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

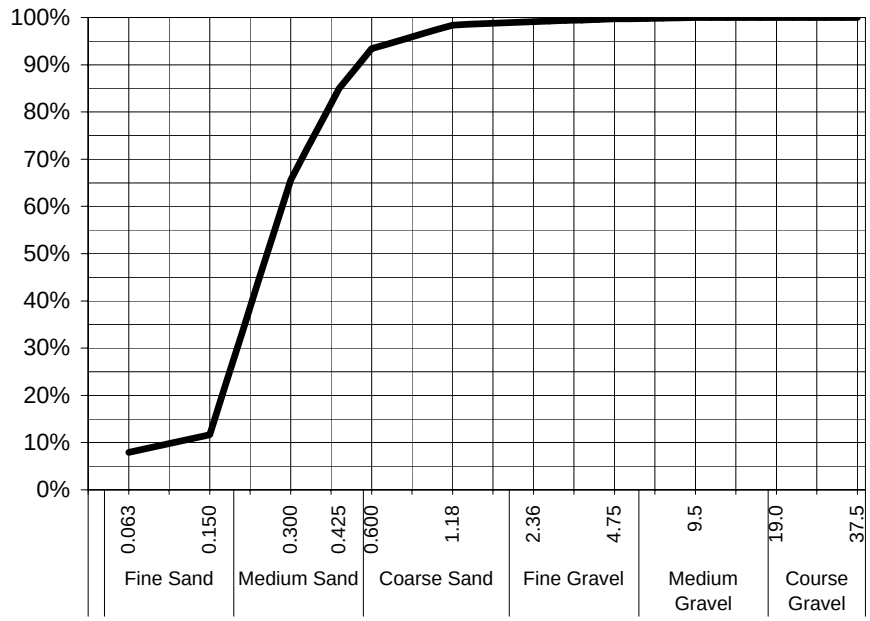
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-011 / PSD
PROJECT:	7291	**SAMPLE ID:**	S9 0-0.6M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	99%
1.18	98%
0.600	93%
0.425	85%
0.300	66%
0.150	12%
0.063	8%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

Dianne Blane
Senior Analyst
Authorised Signatory

Certificate of Analysis

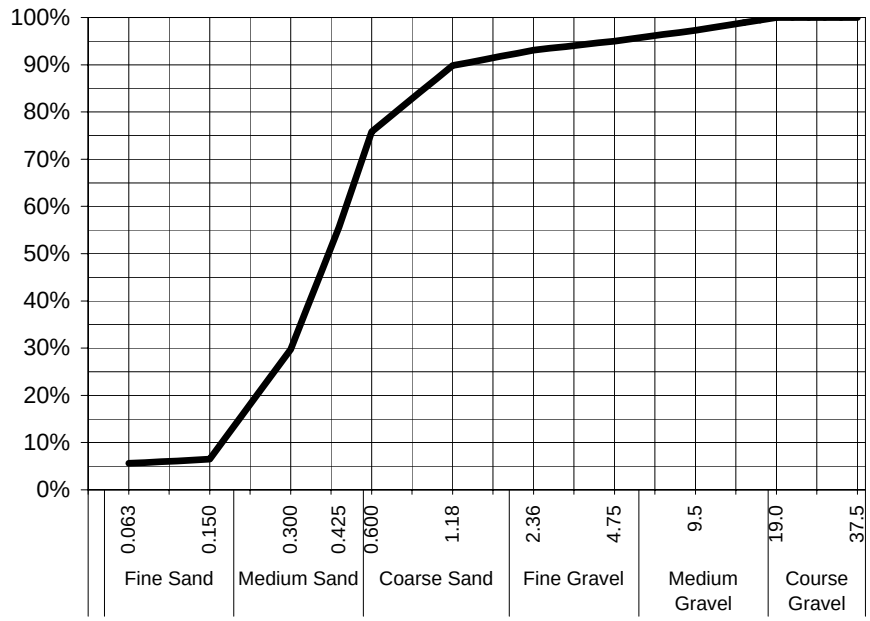
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Orla Murray	**DATE REPORTED:**	6-May-2009
COMPANY:	Worleyparsons - Infrastructure MWE	**DATE RECEIVED:**	23-Apr-2009
ADDRESS:	Level 10/141 Walker Street North Sydney, NSW, Australia 2060	**REPORT NO:**	ES0905883-012 / PSD
PROJECT:	7291	**SAMPLE ID:**	S10 1.0-1.5M

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	97%
4.75	95%
2.36	93%
1.18	90%
0.600	76%
0.425	56%
0.300	30%
0.150	6%
0.063	6%

Samples analysed as received.

Sample Comments:

Analysed: 29-Apr-09

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

Dianne Blane
Senior Analyst
Authorised Signatory

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **ES0905883**	Page	: 1 of 5
Client	: **WORLEYPARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: THE ENTRANCE CHANNEL		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: OM	Issue Date	: 06-MAY-2009
Order number	: ----		
		No. of samples received	: 12
Quote number	: EN/034/08	No. of samples analysed	: 12

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dianne Blane		Newcastle

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

		----						No Limit

- **No Laboratory Duplicate (DUP) Results are required to be reported.**

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (SCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **ES0905883**	Page	: 1 of 5
Client	: WORLEYPARSONS - INFRASTRUCTURE MWE	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: THE ENTRANCE CHANNEL		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: OM	Issue Date	: 06-MAY-2009
Order number	: ----		
		No. of samples received	: 12
Quote number	: EN/034/08	No. of samples analysed	: 12

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA150: Particle Sizing								
Snap Lock Bag								
S1 0.5-1.0M,	S2 0-0.7M,	**22-APR-2009**	**---**	---	----	**29-APR-2009**	19-OCT-2009	✓
S3 0-0.4M,	S4 0.4-0.9M,							
S5 0.4-0.9M,	S5 1.0-1.3M,							
S6 0.1-0.6MA,	S6 0.1-0.6MB,							
S7 0.1-0..6M,	S8 0.8-1.3M,							
S9 0-0.6M,	S10 1.0-1.5M							
EA150: Soil Classification based on Particle Size								
Snap Lock Bag								
S1 0.5-1.0M,	S2 0-0.7M,	**22-APR-2009**	**---**	---	----	**29-APR-2009**	19-OCT-2009	✓
S3 0-0.4M,	S4 0.4-0.9M,							
S5 0.4-0.9M,	S5 1.0-1.3M,							
S6 0.1-0.6MA,	S6 0.1-0.6MB,							
S7 0.1-0..6M,	S8 0.8-1.3M,							
S9 0-0.6M,	S10 1.0-1.5M							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix:

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Particle Size Analysis (Sieving)	EA150	SOIL	Particle Size Analysis by Sieving according to AS1289.3.6.1 - 1995

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW 846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**
- **For all matrices, no Matrix Spike outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- **No Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Attachment 3 Results of Acid Sulfate Soil Analysis

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **ES0905888**	Page	: 1 of 6
Client	: **WORLEYPARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: OM	Issue Date	: 05-MAY-2009
Site	: THE ENTRANCE CHANNEL		
		No. of samples received	: 19
Quote number	: EN/034/08	No. of samples analysed	: 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Analysis conducted by ALS Brisbane, NATA Site No. 818.**
- **pH FOX Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Vigorous; 4 - Very Vigorous**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: S1 0-0.5M	S1 0.5-1.0M	S2 0-0.7M	S3 0-0.4M	S3 0.7-1.2M
				Client sampling date / time: 22-APR-2009 11:30	22-APR-2009 11:30	22-APR-2009 12:00	22-APR-2009 12:30	22-APR-2009 12:30
				ES0905888-001	ES0905888-002	ES0905888-003	ES0905888-004	ES0905888-005
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**8.1**	**8.7**	**8.4**	**8.7**	**8.8**
pH (Fox)	----	0.1	pH Unit	**6.2**	**5.8**	**5.9**	**5.9**	**5.8**
Reaction Rate	----	1	-	**1**	**1**	**1**	**2**	**2**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: S4 0.4-0.9M	S5 0.4-0.9M	S5 1.0-1.3M	S6 0.1-0.6MA	S6 0.1-0.6MB
				Client sampling date / time: 22-APR-2009 13:00	22-APR-2009 13:30	22-APR-2009 13:30	22-APR-2009 14:00	22-APR-2009 14:00
				ES0905888-006	ES0905888-007	ES0905888-008	ES0905888-009	ES0905888-010
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**8.6**	**8.4**	**8.5**	**8.4**	**6.9**
pH (Fox)	----	0.1	pH Unit	**6.1**	**6.0**	**6.0**	**6.2**	**6.2**
Reaction Rate	----	1	-	**1**	**1**	**1**	**1**	**1**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	S6 0.7-0.95M	S7 0.1-0.6M	S7 0.6-1.0M	S8 0.2-0.6M	S8 0.8-1.3M
				Client sampling date / time	22-APR-2009 14:00	22-APR-2009 14:45	22-APR-2009 14:45	22-APR-2009 15:10	22-APR-2009 15:10
					ES0905888-011	ES0905888-012	ES0905888-013	ES0905888-014	ES0905888-015
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		**7.8**	**8.3**	**8.3**	**8.7**	**8.6**
pH (Fox)	----	0.1	pH Unit		**6.2**	**6.0**	**6.4**	**6.2**	**6.1**
Reaction Rate	----	1	-		**1**	**1**	**1**	**1**	**2**

Analytical Results

Sub-Matrix: SOIL			Client sample ID	S9 0-0.6M	S9 1-1.5M	S10 0-0.5M	S10 1.0-1.5M	----
			Client sampling date / time	22-APR-2009 15:45	22-APR-2009 15:45	22-APR-2009 16:10	22-APR-2009 16:10	----
Compound	CAS Number	LOR	Unit	ES0905888-016	ES0905888-017	ES0905888-018	ES0905888-019	----
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	**8.8**	**8.9**	**8.7**	**8.7**	----
pH (Fox)	----	0.1	pH Unit	**6.3**	**6.3**	**5.2**	**6.3**	----
Reaction Rate	----	1	-	**1**	**1**	**1**	**1**	----

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **ES0905888**	Page	: 1 of 5
Client	: **WORLEYPARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: THE ENTRANCE CHANNEL		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: OM	Issue Date	: 05-MAY-2009
Order number	: ----		
		No. of samples received	: 19
Quote number	: EN/034/08	No. of samples analysed	: 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA037: Ass Field Screening Analysis (QC Lot: 968037)									
ES0905888-001	S1 0-0.5M	EA037: pH (F)	----	0.1	pH Unit	8.1	8.2	1.2	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	6.2	6.3	1.6	0% - 20%
ES0905888-011	S6 0.7-0.95M	EA037: pH (F)	----	0.1	pH Unit	7.8	8.0	2.5	0% - 20%
		EA037: pH (Fox)	----	0.1	pH Unit	6.2	6.3	1.6	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

- **No Method Blank (MB) or Laboratory Control Spike (SCS) Results are required to be reported.**

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **ES0905888**	Page	: 1 of 5
Client	: WORLEYPARSONS - INFRASTRUCTURE MWE	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: THE ENTRANCE CHANNEL		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: OM	Issue Date	: 05-MAY-2009
Order number	: ----		
		No. of samples received	: 19
Quote number	: EN/034/08	No. of samples analysed	: 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA037: Ass Field Screening Analysis								
Snap Lock Bag - frozen								
S1 0-0.5M,	S1 0.5-1.0M,	**22-APR-2009**	**23-APR-2009**	19-OCT-2009	✓	**05-MAY-2009**	19-OCT-2009	✓
S2 0-0.7M,	S3 0-0.4M,							
S3 0.7-1.2M,	S4 0.4-0.9M,							
S5 0.4-0.9M,	S5 1.0-1.3M,							
S6 0.1-0.6MA,	S6 0.1-0.6MB,							
S6 0.7-0.95M,	S7 0.1-0.6M,							
S7 0.6-1.0M,	S8 0.2-0.6M,							
S8 0.8-1.3M,	S9 0-0.6M,							
S9 1-1.5M,	S10 0-0.5M,							
S10 1.0-1.5M								

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
ASS Field Screening Analysis	EA037	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
ASS Field Screening Analysis	* EA037	SOIL	Acid Sulfate Soils Laboratory Methods Guidelines, version 2.1 June 2004. As received samples are tested for pH field and pH fox and assessed for a reaction rating.

Preparation Methods	Method	Matrix	Method Descriptions
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW 846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**
- **For all matrices, no Matrix Spike outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- **No Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB0907368**	Page	: 1 of 3
Client	: **WORLEYPARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Brisbane
Contact	: MS ORLA MURRAY	Contact	: Tim Kilmister
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: orla.murray@worleyparsons.com	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 07-MAY-2009
Sampler	: O.Murray	Issue Date	: 14-MAY-2009
Site	: The Entrance channel		
		No. of samples received	: 5
Quote number	: EN/034/09	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.**
- **Retained Acidity not required because pH KCl greater than or equal to 4.5**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: S7 0.1-0.6M Client sampling date / time: 22-APR-2009 11:15 EB0907368-001	Client sample ID: S5 1.0-1.3M Client sampling date / time: 22-APR-2009 13:30 EB0907368-002	Client sample ID: S8 0.8-1.3M Client sampling date / time: 22-APR-2009 15:10 EB0907368-003	Client sample ID: S3 0-0.4M Client sampling date / time: 22-APR-2009 12:30 EB0907368-004	Client sample ID: S1 0.5-1.0M Client sampling date / time: 22-APR-2009 11:30 EB0907368-005
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	**9.9**	**9.6**	**9.4**	**9.1**	**9.5**
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.02	% S	**0.03**	**0.06**	**0.28**	**0.29**	**0.07**
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	**18**	**38**	**174**	**184**	**45**
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	**10.1**	**9.13**	**5.30**	**7.66**	**7.66**
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	**2020**	**1820**	**1060**	**1530**	**1530**
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	**3.24**	**2.92**	**1.70**	**2.45**	**2.45**
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB0907368**	Page	: 1 of 5
Client	: **WORLEYPARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Brisbane
Contact	: MS ORLA MURRAY	Contact	: Tim Kilmister
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: orla.murray@worleyparsons.com	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: The Entrance channel		
C-O-C number	: ----	Date Samples Received	: 07-MAY-2009
Sampler	: O.Murray	Issue Date	: 14-MAY-2009
Order number	: ----		
		No. of samples received	: 5
Quote number	: EN/034/09	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA033-A: Actual Acidity (QC Lot: 974079)									
EB0907368-001	S7 0.1-0.6M	EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	0.0	No Limit
		EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	0.0	No Limit
		EA033: pH KCl (23A)	----	0.1	pH Unit	9.9	9.9	0.0	0% - 20%
EA033-B: Potential Acidity (QC Lot: 974079)									
EB0907368-001	S7 0.1-0.6M	EA033: Chromium Reducible Sulfur (22B)	----	0.02	% S	0.03	0.04	44.4	No Limit
		EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	18	28	44.4	No Limit
EA033-C: Acid Neutralising Capacity (QC Lot: 974079)									
EB0907368-001	S7 0.1-0.6M	EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	10.1	10.2	1.0	0% - 20%
		EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	3.24	3.27	1.0	0% - 20%
		EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	2020	2040	1.0	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA033-A: Actual Acidity (QCLot: 974079)								
EA033: Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	----	----	----	----
EA033: sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	----	----	----	----
EA033-B: Potential Acidity (QCLot: 974079)								
EA033: Chromium Reducible Sulfur (22B)	----	0.02	% S	<0.02	----	----	----	----
EA033: acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	<10	----	----	----	----
EA033-C: Acid Neutralising Capacity (QCLot: 974079)								
EA033: Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	<0.01	----	----	----	----
EA033: acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	<10	----	----	----	----
EA033: sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	<0.01	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

- **No Matrix Spike (MS) Results are required to be reported.**

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EB0907368**	Page	: 1 of 5
Client	: WORLEYPARSONS - INFRASTRUCTURE MWE	Laboratory	: Environmental Division Brisbane
Contact	: MS ORLA MURRAY	Contact	: Tim Kilmister
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: orla.murray@worleyparsons.com	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: The Entrance channel		
C-O-C number	: ----	Date Samples Received	: 07-MAY-2009
Sampler	: O.Murray	Issue Date	: 14-MAY-2009
Order number	: ----		
		No. of samples received	: 5
Quote number	: EN/034/09	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA033-A: Actual Acidity							
80* dried soil S7 0.1-0.6M, S5 1.0-1.3M, S8 0.8-1.3M, S3 0-0.4M, S1 0.5-1.0M	**22-APR-2009**	**11-MAY-2009**	22-APR-2010	✓	**14-MAY-2009**	09-AUG-2009	✓
EA033-B: Potential Acidity							
80* dried soil S7 0.1-0.6M, S5 1.0-1.3M, S8 0.8-1.3M, S3 0-0.4M, S1 0.5-1.0M	**22-APR-2009**	**11-MAY-2009**	22-APR-2010	✓	**14-MAY-2009**	09-AUG-2009	✓
EA033-C: Acid Neutralising Capacity							
80* dried soil S7 0.1-0.6M, S5 1.0-1.3M, S8 0.8-1.3M, S3 0-0.4M, S1 0.5-1.0M	**22-APR-2009**	**11-MAY-2009**	22-APR-2010	✓	**14-MAY-2009**	09-AUG-2009	✓
EA033-D: Retained Acidity							
80* dried soil S7 0.1-0.6M, S5 1.0-1.3M, S8 0.8-1.3M, S3 0-0.4M, S1 0.5-1.0M	**22-APR-2009**	**11-MAY-2009**	22-APR-2010	✓	**14-MAY-2009**	09-AUG-2009	✓
EA033-E: Acid Base Accounting							
80* dried soil S7 0.1-0.6M, S5 1.0-1.3M, S8 0.8-1.3M, S3 0-0.4M, S1 0.5-1.0M	**22-APR-2009**	**11-MAY-2009**	22-APR-2010	✓	**14-MAY-2009**	09-AUG-2009	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Chromium Suite for Acid Sulphate Soils	EA033	1	5	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Chromium Suite for Acid Sulphate Soils	EA033	1	5	**20.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Chromium Suite for Acid Sulphate Soils	EA033	SOIL	Ahern et al 2004. This method covers the determination of Chromium Reducible Sulfur (SCR); pHKCl; titratable actual acidity (TAA); acid neutralising capacity by back titration (ANC); and net acid soluble sulfur (SNAS) which incorporates peroxide sulfur. It applies to soils and sediments (including sands) derived from coastal regions. Liming Rate is based on results for samples as submitted and incorporates a minimum safety factor of 1.5.

Preparation Methods	Method	Matrix	Method Descriptions
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW 846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**
- **For all matrices, no Matrix Spike outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- **No Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Attachment 4 Results of Chemical Analysis

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **ES0905879**	Page	: 1 of 10
Client	: **WORLEYPARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: MURRAY	Issue Date	: 06-MAY-2009
Site	: THE ENTRANCE CHANNEL		
		No. of samples received	: 19
Quote number	: EN/034/08	No. of samples analysed	: 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alex Rossi	Organic Chemist	Organics
Celine Conceicao	Spectroscopist	Inorganics
Hoa Nguyen	Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	LOR	Unit	Client sample ID: S1 0-0.5M Client sampling date / time: 22-APR-2009 11:30 ES0905879-001	Client sample ID: S1 0.5-1.0M Client sampling date / time: 22-APR-2009 11:30 ES0905879-002	Client sample ID: S2 0-0.7M Client sampling date / time: 22-APR-2009 12:00 ES0905879-003	Client sample ID: S3 0-0.4M Client sampling date / time: 22-APR-2009 12:30 ES0905879-004	Client sample ID: S3 0.7-1.2M Client sampling date / time: 22-APR-2009 12:30 ES0905879-005
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**630**	**950**	**550**	**1420**	**1030**
Iron	7439-89-6	50	mg/kg	**1220**	**1610**	**690**	**2730**	**2030**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**2.70**	**2.61**	**1.85**	**3.55**	**4.35**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**1.6**	**1.9**	<1.0	**3.5**	**2.0**
Copper	7440-50-8	1.0	mg/kg	<1.0	<1.0	**4.7**	**1.9**	<1.0
Cobalt	7440-48-4	0.5	mg/kg	<0.5	<0.5	<0.5	**0.6**	<0.5
Lead	7439-92-1	1.0	mg/kg	**1.4**	**1.5**	**1.1**	**3.6**	**1.8**
Manganese	7439-96-5	10	mg/kg	**14**	**15**	<10	**27**	**11**
Nickel	7440-02-0	1.0	mg/kg	<1.0	<1.0	<1.0	**1.4**	**1.1**
Selenium	7782-49-2	0.1	mg/kg	**0.1**	<0.1	<0.1	**0.2**	**0.2**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	<2.0	**2.3**	<2.0	**4.8**	**3.5**
Zinc	7440-66-6	1.0	mg/kg	**2.5**	**3.0**	**1.7**	**7.7**	**3.1**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	**0.01**	<0.01
EP004: Organic Matter								
^ Total Organic Carbon	----	0.5	%	<0.5	----	----	**1.0**	----
EP131A: Organochlorine Pesticides								
Aldrin	309-00-2	0.50	µg/kg	<0.50	----	----	<0.50	----
alpha-BHC	319-84-6	0.50	µg/kg	<0.50	----	----	<0.50	----
beta-BHC	319-85-7	0.50	µg/kg	<0.50	----	----	<0.50	----
delta-BHC	319-86-8	0.50	µg/kg	<0.50	----	----	<0.50	----
4.4`-DDD	72-54-8	0.50	µg/kg	<0.50	----	----	<0.50	----
4.4`-DDE	72-55-9	0.50	µg/kg	<0.50	----	----	<0.50	----
4.4`-DDT	50-29-3	0.50	µg/kg	<0.50	----	----	<0.50	----
Dieldrin	60-57-1	0.50	µg/kg	<0.50	----	----	<0.50	----
alpha-Endosulfan	959-98-8	0.50	µg/kg	<0.50	----	----	<0.50	----
beta-Endosulfan	33213-65-9	0.50	µg/kg	<0.50	----	----	<0.50	----
Endosulfan sulfate	1031-07-8	0.50	µg/kg	<0.50	----	----	<0.50	----
Endrin	72-20-8	0.50	µg/kg	<0.50	----	----	<0.50	----
Endrin aldehyde	7421-93-4	0.50	µg/kg	<0.50	----	----	<0.50	----
Endrin ketone	53494-70-5	0.50	µg/kg	<0.50	----	----	<0.50	----
Heptachlor	76-44-8	0.50	µg/kg	<0.50	----	----	<0.50	----
Heptachlor epoxide	1024-57-3	0.50	µg/kg	<0.50	----	----	<0.50	----
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	<0.50	----	----	<0.50	----

Analytical Results

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	LOR	Unit	Client sample ID: S1 0-0.5M Client sampling date / time: 22-APR-2009 11:30 ES0905879-001	S1 0.5-1.0M 22-APR-2009 11:30 ES0905879-002	S2 0-0.7M 22-APR-2009 12:00 ES0905879-003	S3 0-0.4M 22-APR-2009 12:30 ES0905879-004	S3 0.7-1.2M 22-APR-2009 12:30 ES0905879-005
EP131A: Organochlorine Pesticides - Continued								
gamma-BHC	58-89-9	0.50	µg/kg	<0.50	----	----	<0.50	----
Methoxychlor	72-43-5	0.50	µg/kg	<0.50	----	----	<0.50	----
cis-Chlordane	5103-71-9	0.50	µg/kg	<0.50	----	----	<0.50	----
trans-Chlordane	5103-74-2	0.50	µg/kg	<0.50	----	----	<0.50	----
EP131S: OC Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	**59.0**	----	----	**57.3**	----

Analytical Results

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	LOR	Unit	Client sample ID: S4 0.4-0.9M	S5 0.4-0.9M	S5 1.0-1.3M	S6 0.1-0.6M	S6 0.1-0.6M
				Client sampling date / time: 22-APR-2009 13:00	22-APR-2009 13:30	22-APR-2009 13:30	22-APR-2009 14:00	22-APR-2009 14:00
				ES0905879-006	ES0905879-007	ES0905879-008	ES0905879-009	ES0905879-010
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**370**	**180**	**280**	**250**	**300**
Iron	7439-89-6	50	mg/kg	**1530**	**850**	**1270**	**1110**	**1460**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**6.36**	**3.67**	**4.90**	**4.72**	**6.52**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**1.8**	<1.0	<1.0	**1.2**	**1.3**
Copper	7440-50-8	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0
Cobalt	7440-48-4	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Lead	7439-92-1	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0
Manganese	7439-96-5	10	mg/kg	**22**	<10	**11**	**13**	**12**
Nickel	7440-02-0	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium	7782-49-2	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	**2.2**	<2.0	<2.0	<2.0	**2.3**
Zinc	7440-66-6	1.0	mg/kg	**1.8**	<1.0	**1.7**	**1.1**	**1.4**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP004: Organic Matter								
^ Total Organic Carbon	----	0.5	%	----	----	<0.5	----	----
EP131A: Organochlorine Pesticides								
Aldrin	309-00-2	0.50	µg/kg	----	----	<0.50	----	----
alpha-BHC	319-84-6	0.50	µg/kg	----	----	<0.50	----	----
beta-BHC	319-85-7	0.50	µg/kg	----	----	<0.50	----	----
delta-BHC	319-86-8	0.50	µg/kg	----	----	<0.50	----	----
4.4`-DDD	72-54-8	0.50	µg/kg	----	----	<0.50	----	----
4.4`-DDE	72-55-9	0.50	µg/kg	----	----	<0.50	----	----
4.4`-DDT	50-29-3	0.50	µg/kg	----	----	<0.50	----	----
Dieldrin	60-57-1	0.50	µg/kg	----	----	<0.50	----	----
alpha-Endosulfan	959-98-8	0.50	µg/kg	----	----	<0.50	----	----
beta-Endosulfan	33213-65-9	0.50	µg/kg	----	----	<0.50	----	----
Endosulfan sulfate	1031-07-8	0.50	µg/kg	----	----	<0.50	----	----
Endrin	72-20-8	0.50	µg/kg	----	----	<0.50	----	----
Endrin aldehyde	7421-93-4	0.50	µg/kg	----	----	<0.50	----	----
Endrin ketone	53494-70-5	0.50	µg/kg	----	----	<0.50	----	----
Heptachlor	76-44-8	0.50	µg/kg	----	----	<0.50	----	----
Heptachlor epoxide	1024-57-3	0.50	µg/kg	----	----	<0.50	----	----
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	----	----	<0.50	----	----

Analytical Results

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	LOR	Unit	Client sample ID: S4 0.4-0.9M	S5 0.4-0.9M	S5 1.0-1.3M	S6 0.1-0.6M	S6 0.1-0.6M
				Client sampling date / time: 22-APR-2009 13:00	22-APR-2009 13:30	22-APR-2009 13:30	22-APR-2009 14:00	22-APR-2009 14:00
				ES0905879-006	ES0905879-007	ES0905879-008	ES0905879-009	ES0905879-010
EP131A: Organochlorine Pesticides - Continued								
gamma-BHC	58-89-9	0.50	µg/kg	----	----	<0.50	----	----
Methoxychlor	72-43-5	0.50	µg/kg	----	----	<0.50	----	----
cis-Chlordane	5103-71-9	0.50	µg/kg	----	----	<0.50	----	----
trans-Chlordane	5103-74-2	0.50	µg/kg	----	----	<0.50	----	----
EP131S: OC Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	----	----	**49.2**	----	----

Analytical Results

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	LOR	Unit	Client sample ID: S6 0.7-0.95M	S7 0.1-0.6M	S7 0.6-1.0M	S8 0.2-0.6M	S8 0.8-1.3M
				Client sampling date / time: 22-APR-2009 14:00	22-APR-2009 14:45	22-APR-2009 14:45	22-APR-2009 15:10	22-APR-2009 15:10
				ES0905879-011	ES0905879-012	ES0905879-013	ES0905879-014	ES0905879-015
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**330**	**260**	**390**	**310**	**2220**
Iron	7439-89-6	50	mg/kg	**1390**	**1070**	**1540**	**1120**	**4420**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**5.61**	**4.40**	**5.32**	**4.01**	**3.71**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**1.6**	**1.0**	**2.1**	**1.6**	**4.0**
Copper	7440-50-8	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	**3.0**
Cobalt	7440-48-4	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	**1.2**
Lead	7439-92-1	1.0	mg/kg	<1.0	<1.0	**1.0**	<1.0	**5.7**
Manganese	7439-96-5	10	mg/kg	**16**	**11**	**23**	**14**	**30**
Nickel	7440-02-0	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	**2.1**
Selenium	7782-49-2	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	**0.1**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg	**2.3**	<2.0	**2.8**	<2.0	**6.9**
Zinc	7440-66-6	1.0	mg/kg	**1.6**	**1.3**	**2.0**	**1.4**	**11.3**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	**0.04**

Analytical Results

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	LOR	Unit	Client sample ID: S9 0-0.6M	S9 1-1.5M	S10 0-0.5M	S10 1.0-1.5M	----
				Client sampling date / time: 22-APR-2009 15:45	22-APR-2009 15:45	22-APR-2009 16:10	22-APR-2009 16:10	----
				ES0905879-016	ES0905879-017	ES0905879-018	ES0905879-019	----
EG005-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**2180**	**760**	**1020**	**1150**	----
Iron	7439-89-6	50	mg/kg	**4570**	**1730**	**1910**	**1860**	----
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	----
Arsenic	7440-38-2	1.00	mg/kg	**4.61**	**3.36**	**2.30**	**3.09**	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Chromium	7440-47-3	1.0	mg/kg	**4.4**	**2.4**	**1.7**	**2.0**	----
Copper	7440-50-8	1.0	mg/kg	**2.1**	<1.0	**1.2**	<1.0	----
Cobalt	7440-48-4	0.5	mg/kg	**1.3**	<0.5	**0.6**	**0.6**	----
Lead	7439-92-1	1.0	mg/kg	**3.4**	<1.0	**1.8**	**1.1**	----
Manganese	7439-96-5	10	mg/kg	**40**	**22**	**14**	**14**	----
Nickel	7440-02-0	1.0	mg/kg	**2.4**	<1.0	**1.0**	**1.0**	----
Selenium	7782-49-2	0.1	mg/kg	**0.2**	**0.2**	**0.1**	**0.2**	----
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Vanadium	7440-62-2	2.0	mg/kg	**7.2**	**3.0**	**2.7**	**3.5**	----
Zinc	7440-66-6	1.0	mg/kg	**8.2**	**1.9**	**4.4**	**2.5**	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	**0.02**	<0.01	<0.01	<0.01	----
EP004: Organic Matter								
^ Total Organic Carbon	----	0.5	%	----	----	<0.5	----	----
EP131A: Organochlorine Pesticides								
Aldrin	309-00-2	0.50	µg/kg	----	----	<0.50	----	----
alpha-BHC	319-84-6	0.50	µg/kg	----	----	<0.50	----	----
beta-BHC	319-85-7	0.50	µg/kg	----	----	<0.50	----	----
delta-BHC	319-86-8	0.50	µg/kg	----	----	<0.50	----	----
4.4`-DDD	72-54-8	0.50	µg/kg	----	----	<0.50	----	----
4.4`-DDE	72-55-9	0.50	µg/kg	----	----	<0.50	----	----
4.4`-DDT	50-29-3	0.50	µg/kg	----	----	<0.50	----	----
Dieldrin	60-57-1	0.50	µg/kg	----	----	<0.50	----	----
alpha-Endosulfan	959-98-8	0.50	µg/kg	----	----	<0.50	----	----
beta-Endosulfan	33213-65-9	0.50	µg/kg	----	----	<0.50	----	----
Endosulfan sulfate	1031-07-8	0.50	µg/kg	----	----	<0.50	----	----
Endrin	72-20-8	0.50	µg/kg	----	----	<0.50	----	----
Endrin aldehyde	7421-93-4	0.50	µg/kg	----	----	<0.50	----	----
Endrin ketone	53494-70-5	0.50	µg/kg	----	----	<0.50	----	----
Heptachlor	76-44-8	0.50	µg/kg	----	----	<0.50	----	----
Heptachlor epoxide	1024-57-3	0.50	µg/kg	----	----	<0.50	----	----
Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	----	----	<0.50	----	----

Analytical Results

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	LOR	Unit	Client sample ID: S9 0-0.6M	S9 1-1.5M	S10 0-0.5M	S10 1.0-1.5M	----
				Client sampling date / time: 22-APR-2009 15:45	22-APR-2009 15:45	22-APR-2009 16:10	22-APR-2009 16:10	----
				ES0905879-016	ES0905879-017	ES0905879-018	ES0905879-019	----
EP131A: Organochlorine Pesticides - Continued								
gamma-BHC	58-89-9	0.50	µg/kg	----	----	<0.50	----	----
Methoxychlor	72-43-5	0.50	µg/kg	----	----	<0.50	----	----
cis-Chlordane	5103-71-9	0.50	µg/kg	----	----	<0.50	----	----
trans-Chlordane	5103-74-2	0.50	µg/kg	----	----	<0.50	----	----
EP131S: OC Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	----	----	**54.4**	----	----

Surrogate Control Limits

Sub-Matrix: **SEDIMENT**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP131S: OC Pesticide Surrogate			
Dibromo-DDE	21655-73-2	10	136

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **ES0905879**	Page	: 1 of 7
Client	: **WORLEYPARSONS - INFRASTRUCTURE MWE**	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: THE ENTRANCE CHANNEL		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: MURRAY	Issue Date	: 06-MAY-2009
Order number	: ----		
		No. of samples received	: 19
Quote number	: EN/034/08	No. of samples analysed	: 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alex Rossi	Organic Chemist	Organics
Celine Conceicao	Spectroscopist	Inorganics
Hoa Nguyen	Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG005-SD: Total Metals in Sediments by ICP-AES (QC Lot: 964339)									
ES0905879-001	S1 0-0.5M	EG005-SD: Aluminium	7429-90-5	50	mg/kg	630	610	3.7	0% - 50%
		EG005-SD: Iron	7439-89-6	50	mg/kg	1220	1230	0.0	0% - 20%
ES0905879-011	S6 0.7-0.95M	EG005-SD: Aluminium	7429-90-5	50	mg/kg	330	280	17.8	No Limit
		EG005-SD: Iron	7439-89-6	50	mg/kg	1390	1250	10.4	0% - 20%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 964338)									
ES0905879-001	S1 0-0.5M	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Selenium	7782-49-2	0.1	mg/kg	0.1	<0.1	0.0	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Cobalt	7440-48-4	0.5	mg/kg	<0.5	<0.5	0.0	No Limit
		EG020-SD: Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	0.0	No Limit
		EG020-SD: Chromium	7440-47-3	1.0	mg/kg	1.6	1.6	0.0	No Limit
		EG020-SD: Copper	7440-50-8	1.0	mg/kg	<1.0	<1.0	0.0	No Limit
		EG020-SD: Lead	7439-92-1	1.0	mg/kg	1.4	1.3	0.0	No Limit
		EG020-SD: Nickel	7440-02-0	1.0	mg/kg	<1.0	<1.0	0.0	No Limit
		EG020-SD: Zinc	7440-66-6	1.0	mg/kg	2.5	2.2	15.9	No Limit
		EG020-SD: Arsenic	7440-38-2	1.00	mg/kg	2.70	2.76	2.4	No Limit
		EG020-SD: Manganese	7439-96-5	10	mg/kg	14	14	0.0	No Limit
		EG020-SD: Vanadium	7440-62-2	2.0	mg/kg	<2.0	<2.0	0.0	No Limit
ES0905879-011	S6 0.7-0.95M	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Selenium	7782-49-2	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020-SD: Cobalt	7440-48-4	0.5	mg/kg	<0.5	<0.5	0.0	No Limit
		EG020-SD: Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	0.0	No Limit
		EG020-SD: Chromium	7440-47-3	1.0	mg/kg	1.6	1.5	0.0	No Limit
		EG020-SD: Copper	7440-50-8	1.0	mg/kg	<1.0	<1.0	0.0	No Limit
		EG020-SD: Lead	7439-92-1	1.0	mg/kg	<1.0	<1.0	0.0	No Limit
		EG020-SD: Nickel	7440-02-0	1.0	mg/kg	<1.0	<1.0	0.0	No Limit
		EG020-SD: Zinc	7440-66-6	1.0	mg/kg	1.6	1.7	6.7	No Limit
		EG020-SD: Arsenic	7440-38-2	1.00	mg/kg	5.61	4.89	13.7	No Limit
		EG020-SD: Manganese	7439-96-5	10	mg/kg	16	14	12.3	No Limit
		EG020-SD: Vanadium	7440-62-2	2.0	mg/kg	2.3	<2.0	14.2	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 964337)									
ES0905879-001	S1 0-0.5M	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.0	No Limit
ES0905879-011	S6 0.7-0.95M	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.0	No Limit
EP004: Organic Matter (QC Lot: 958764)									

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP004: Organic Matter (QC Lot: 958764) - continued									
ES0905849-002	Anonymous	EP004: Total Organic Carbon	----	0.1	%	3.9	3.9	0.0	0% - 20%
EP131A: Organochlorine Pesticides (QC Lot: 958365)									
EB0906384-001	Anonymous	EP131A: Aldrin	309-00-2	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: alpha-BHC	319-84-6	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: beta-BHC	319-85-7	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: delta-BHC	319-86-8	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: 4.4`-DDD	72-54-8	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: 4.4`-DDE	72-55-9	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: 4.4`-DDT	50-29-3	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Dieldrin	60-57-1	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: alpha-Endosulfan	959-98-8	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: beta-Endosulfan	33213-65-9	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Endosulfan sulfate	1031-07-8	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Endrin	72-20-8	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Endrin aldehyde	7421-93-4	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Endrin ketone	53494-70-5	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Heptachlor	76-44-8	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Heptachlor epoxide	1024-57-3	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Hexachlorobenzene (HCB)	118-74-1	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: gamma-BHC	58-89-9	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: Methoxychlor	72-43-5	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: cis-Chlordane	5103-71-9	0.50	µg/kg	<0.50	<0.50	0.0	No Limit
		EP131A: trans-Chlordane	5103-74-2	0.50	µg/kg	<0.50	<0.50	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG005-SD: Total Metals in Sediments by ICP-AES (QCLot: 964339)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 964338)								
EG020-SD: Antimony	7440-36-0	0.50	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1.0	mg/kg	----	13.1 mg/kg	106	70	130
		1.00	mg/kg	<1.00	----	----	----	----
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	2.76 mg/kg	102	70	130
EG020-SD: Chromium	7440-47-3	1.0	mg/kg	<1.0	60.9 mg/kg	100	70	130
EG020-SD: Copper	7440-50-8	1.0	mg/kg	<1.0	54.7 mg/kg	103	70	130
EG020-SD: Cobalt	7440-48-4	10	mg/kg	----	24.5 mg/kg	109	70	130
		10.0	mg/kg	<10.0	----	----	----	----
EG020-SD: Lead	7439-92-1	1.0	mg/kg	<1.0	54.8 mg/kg	106	70	130
EG020-SD: Manganese	7439-96-5	10	mg/kg	<10	136 mg/kg	97.9	70	130
EG020-SD: Nickel	7440-02-0	1.0	mg/kg	<1.0	55.2 mg/kg	104	70	130
EG020-SD: Selenium	7782-49-2	0.1	mg/kg	<0.1	----	----	----	----
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	5.6 mg/kg	104	70	130
EG020-SD: Vanadium	7440-62-2	2	mg/kg	----	34 mg/kg	95.8	70	130
		2.0	mg/kg	<2.0	----	----	----	----
EG020-SD: Zinc	7440-66-6	1.0	mg/kg	<1.0	104 mg/kg	97.1	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 964337)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	0.09 mg/kg	111	74.2	126
EP004: Organic Matter (QCLot: 958764)								
EP004: Total Organic Carbon	----	0.5	%	<0.5	----	----	----	----
EP131A: Organochlorine Pesticides (QCLot: 958365)								
EP131A: Aldrin	309-00-2	0.5	µg/kg	----	5 µg/kg	70.8	31.7	140
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: alpha-BHC	319-84-6	0.5	µg/kg	----	5 µg/kg	67.6	24.5	150
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: beta-BHC	319-85-7	0.5	µg/kg	----	5 µg/kg	80.6	36.9	139
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: delta-BHC	319-86-8	0.5	µg/kg	----	5 µg/kg	87.7	38.2	137
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: 4.4`-DDD	72-54-8	0.5	µg/kg	----	5 µg/kg	73.1	42.5	141
		0.50	µg/kg	<0.50	----	----	----	----

Sub-Matrix: **SOIL**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP131A: Organochlorine Pesticides (QCLot: 958365) - continued								
EP131A: 4.4`-DDE	72-55-9	0.5	µg/kg	----	5 µg/kg	74.0	34.8	140
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: 4.4`-DDT	50-29-3	0.5	µg/kg	----	5 µg/kg	82.6	38	143
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Dieldrin	60-57-1	0.5	µg/kg	----	5 µg/kg	74.5	43.2	134
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: alpha-Endosulfan	959-98-8	0.5	µg/kg	----	5 µg/kg	76.4	23.7	139
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: beta-Endosulfan	33213-65-9	0.5	µg/kg	----	5 µg/kg	52.3	35.8	138
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Endosulfan sulfate	1031-07-8	0.5	µg/kg	----	5 µg/kg	77.1	7.45	158
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Endrin	72-20-8	0.5	µg/kg	----	5 µg/kg	91.2	21.6	162
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Endrin aldehyde	7421-93-4	0.5	µg/kg	----	5 µg/kg	79.0	19.3	131
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Endrin ketone	53494-70-5	0.5	µg/kg	----	5 µg/kg	57.3	17.9	141
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Heptachlor	76-44-8	0.5	µg/kg	----	5 µg/kg	81.9	31	153
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Heptachlor epoxide	1024-57-3	0.5	µg/kg	----	5 µg/kg	64.8	34.3	138
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Hexachlorobenzene (HCB)	118-74-1	0.5	µg/kg	----	5 µg/kg	83.2	18.6	146
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: gamma-BHC	58-89-9	0.5	µg/kg	----	5 µg/kg	81.1	30.7	145
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: Methoxychlor	72-43-5	0.5	µg/kg	----	5 µg/kg	77.6	15	157
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: cis-Chlordane	5103-71-9	0.5	µg/kg	----	5 µg/kg	62.7	22.3	145
		0.50	µg/kg	<0.50	----	----	----	----
EP131A: trans-Chlordane	5103-74-2	0.5	µg/kg	----	5 µg/kg	56.3	42.4	139
		0.50	µg/kg	<0.50	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 964338)							
ES0905879-001	S1 0-0.5M	EG020-SD: Arsenic	7440-38-2	50 mg/kg	103	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	102	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	102	70	130
		EG020-SD: Copper	7440-50-8	250 mg/kg	96.8	70	130
		EG020-SD: Lead	7439-92-1	250 mg/kg	99.6	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	103	70	130
		EG020-SD: Zinc	7440-66-6	250 mg/kg	89.2	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 964337)							
ES0905879-001	S1 0-0.5M	EG035T-LL: Mercury	7439-97-6	0.50 mg/kg	97.1	70	130
EP131A: Organochlorine Pesticides (QCLot: 958365)							
EB0906384-001	Anonymous	EP131A: Aldrin	309-00-2	5 µg/kg	52.4	31.7	140
		EP131A: alpha-BHC	319-84-6	5 µg/kg	33.1	24.5	150
		EP131A: beta-BHC	319-85-7	5 µg/kg	37.5	36.9	139
		EP131A: delta-BHC	319-86-8	5 µg/kg	44.8	38.2	137
		EP131A: 4.4`-DDD	72-54-8	5 µg/kg	56.5	42.5	141
		EP131A: 4.4`-DDE	72-55-9	5 µg/kg	46.9	34.8	140
		EP131A: 4.4`-DDT	50-29-3	5 µg/kg	54.2	38	143
		EP131A: Dieldrin	60-57-1	5 µg/kg	52.4	43.2	134
		EP131A: alpha-Endosulfan	959-98-8	5 µg/kg	52.0	23.7	139
		EP131A: beta-Endosulfan	33213-65-9	5 µg/kg	49.2	35.8	138
		EP131A: Endosulfan sulfate	1031-07-8	5 µg/kg	67.2	7.45	158
		EP131A: Endrin	72-20-8	5 µg/kg	67.6	21.6	162
		EP131A: Endrin aldehyde	7421-93-4	5 µg/kg	62.4	19.3	131
		EP131A: Endrin ketone	53494-70-5	5 µg/kg	52.0	17.9	141
		EP131A: Heptachlor	76-44-8	5 µg/kg	38.4	31	153
		EP131A: Heptachlor epoxide	1024-57-3	5 µg/kg	44.7	34.3	138
		EP131A: Hexachlorobenzene (HCB)	118-74-1	5 µg/kg	40.5	18.6	146
		EP131A: gamma-BHC	58-89-9	5 µg/kg	74.4	30.7	145
		EP131A: Methoxychlor	72-43-5	5 µg/kg	50.1	15	157
		EP131A: cis-Chlordane	5103-71-9	5 µg/kg	40.3	22.3	145
		EP131A: trans-Chlordane	5103-74-2	5 µg/kg	# 35.1	42.4	139

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **ES0905879**	Page	: 1 of 6
Client	: WORLEYPARSONS - INFRASTRUCTURE MWE	Laboratory	: Environmental Division Sydney
Contact	: MS ORLA MURRAY	Contact	: Charlie Pierce
Address	: Level 10/141 Walker Street NORTH SYDNEY NSW, AUSTRALIA 2060	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: orla.murray@worleyparsons.com	E-mail	: charlie.pierce@alsenviro.com
Telephone	: 8907 2131	Telephone	: +61-2-8784 8555
Facsimile	: ----	Facsimile	: +61-2-8784 8500
Project	: 7291	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: THE ENTRANCE CHANNEL		
C-O-C number	: ----	Date Samples Received	: 23-APR-2009
Sampler	: MURRAY	Issue Date	: 06-MAY-2009
Order number	: ----		
		No. of samples received	: 19
Quote number	: EN/034/08	No. of samples analysed	: 19

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non -volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG005-SD: Total Metals in Sediments by ICP-AES								
Soil Glass Jar - Unpreserved								
S1 0-0.5M,	S1 0.5-1.0M,	**22-APR-2009**	**30-APR-2009**	19-OCT-2009	✓	**30-APR-2009**	19-OCT-2009	✓
S2 0-0.7M,	S3 0-0.4M,							
S3 0.7-1.2M,	S4 0.4-0.9M,							
S5 0.4-0.9M,	S5 1.0-1.3M,							
S6 0.1-0.6M,	S6 0.1-0.6M,							
S6 0.7-0.95M,	S7 0.1-0.6M,							
S7 0.6-1.0M,	S8 0.2-0.6M,							
S8 0.8-1.3M,	S9 0-0.6M,							
S9 1-1.5M,	S10 0-0.5M,							
S10 1.0-1.5M								
EG020-SD: Total Metals in Sediments by ICPMS								
Soil Glass Jar - Unpreserved								
S1 0-0.5M,	S1 0.5-1.0M,	**22-APR-2009**	**30-APR-2009**	19-OCT-2009	✓	**30-APR-2009**	19-OCT-2009	✓
S2 0-0.7M,	S3 0-0.4M,							
S3 0.7-1.2M,	S4 0.4-0.9M,							
S5 0.4-0.9M,	S5 1.0-1.3M,							
S6 0.1-0.6M,	S6 0.1-0.6M,							
S6 0.7-0.95M,	S7 0.1-0.6M,							
S7 0.6-1.0M,	S8 0.2-0.6M,							
S8 0.8-1.3M,	S9 0-0.6M,							
S9 1-1.5M,	S10 0-0.5M,							
S10 1.0-1.5M								

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035T: Total Recoverable Mercury by FIMS								
Soil Glass Jar - Unpreserved								
S1 0-0.5M,	S1 0.5-1.0M,	**22-APR-2009**	**30-APR-2009**	19-OCT-2009	✓	**01-MAY-2009**	20-MAY-2009	✓
S2 0-0.7M,	S3 0-0.4M,							
S3 0.7-1.2M,	S4 0.4-0.9M,							
S5 0.4-0.9M,	S5 1.0-1.3M,							
S6 0.1-0.6M,	S6 0.1-0.6M,							
S6 0.7-0.95M,	S7 0.1-0.6M,							
S7 0.6-1.0M,	S8 0.2-0.6M,							
S8 0.8-1.3M,	S9 0-0.6M,							
S9 1-1.5M,	S10 0-0.5M,							
S10 1.0-1.5M								
EP004: Organic Matter								
Soil Glass Jar - Unpreserved								
S1 0-0.5M,	S3 0-0.4M,	**22-APR-2009**	**----**	----	----	**24-APR-2009**	29-APR-2009	✓
S5 1.0-1.3M,	S10 0-0.5M							
EP131A: Organochlorine Pesticides								
Soil Glass Jar - Unpreserved								
S1 0-0.5M,	S3 0-0.4M,	**22-APR-2009**	**24-APR-2009**	06-MAY-2009	✓	**29-APR-2009**	03-JUN-2009	✓
S5 1.0-1.3M,	S10 0-0.5M							

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Moisture Content	EA055-103	2	4	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Organic Matter	EP004	1	7	**14.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Organochlorine Pesticides (Ultra-trace)	EP131A	1	5	**20.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Fe and Al in Sediments by ICPAES	EG005-SD	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS (Low Level)	EG035T-LL	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals in Sediments by ICPMS	EG020-SD	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Organic Matter	EP004	1	7	**14.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Organochlorine Pesticides (Ultra-trace)	EP131A	1	5	**20.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS (Low Level)	EG035T-LL	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals in Sediments by ICPMS	EG020-SD	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Organic Matter	EP004	1	7	**14.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Organochlorine Pesticides (Ultra-trace)	EP131A	1	5	**20.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Fe and Al in Sediments by ICPAES	EG005-SD	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS (Low Level)	EG035T-LL	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals in Sediments by ICPMS	EG020-SD	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Organochlorine Pesticides (Ultra-trace)	EP131A	1	5	**20.0**	**5.0**	✓	ALS QCS3 requirement
Total Mercury by FIMS (Low Level)	EG035T-LL	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Total Metals in Sediments by ICPMS	EG020-SD	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Moisture Content	EA055-103	SOIL	A gravimetric procedure based on weight loss over a 12 hour drying period at 103-105 degrees C. This method is compliant with NEPM (1999) Schedule B(3) (Method 102)
Total Fe and Al in Sediments by ICPAES	EG005-SD	SOIL	(APHA 21st ed., 3120; USEPA SW 846 - 6010) (ICPAES) Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (1999) Schedule B(3). LORs per NODG
Total Metals in Sediments by ICPMS	EG020-SD	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector. Analyte list and LORs per NODG.
Total Mercury by FIMS (Low Level)	EG035T-LL	SOIL	AS 3550, APHA 21st ed., 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3)
Organic Matter	EP004	SOIL	AS1289.4.1.1 - 1997., Dichromate oxidation method after Walkley and Black. This method is compliant with NEPM (1999) Schedule B(3) (Method 105)
Organochlorine Pesticides (Ultra-trace)	EP131A	SOIL	USEPA Method 3640 (GPC cleanup),3620 (Florisil), 8081/8082 (GC/uECD/uECD) This technique is compliant with NEPM (1999) Schedule B(3) (Method 504)

Preparation Methods	Method	Matrix	Method Descriptions
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	USEPA 200.2 Mod. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (1999) Schedule B(3) (Method 202)
Tumbler Extraction of Solids/ Sample Cleanup	ORG17A-UTP	SOIL	In-house, Mechanical agitation (tumbler). 20g of sample, Na2SO4 and surrogate are extracted with 150mL 1:1 DCM/Acetone by end over end tumble. Samples are extracted, concentrated (by KD) and exchanged into an appropriate solvent for GPC and florisil cleanup as required.

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW 846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EP131A: Organochlorine Pesticides	EB0906384-001	Anonymous	**trans-Chlordane**	5103-74-2	35.1 %	42.4-139%	**Recovery less than lower data quality objective**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

- **No Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

Attachment 5 Field and Laboratory QA/QC

Relative Percent Difference Analysis of Split Duplicates

	Arsenic	Cadmium	Chromium	Copper	Cobalt	Lead	Manganese	Nickel	Selenium	Silver	Vanadium	Zinc	Mercury
Screening Level	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
SL	**20**	**1.5**	**80**	**65**	**--**	**50**	**--**	**21**	**--**	**1**		**200**	**0.15**
S6 0.1-0.6MA	4.72	<0.1	1.2	<1.0	<0.5	<1.0	13	<1.0	<0.1	<0.1	<2	1.1	<0.01
S6 0.1-0.6MB	6.52	<0.1	1.3	<1.0	<0.5	<1.0	12	<1.0	<0.1	<0.1	2.3	1.4	<0.01
Mean B5	5.62	-	1.25	-	-	-	12.5	-	-	-	-	1.25	-
% RPD	-32	-	-8	-	-	-	8	-	-	-	-	-24	-

Notes

1) Screening Levels as per the National Assessment Guidelines for Dredging (Commonwealth of Australia, 2009).

2) Split duplicate samples (that is, splits of a single mixed sample) should be within a Relative Percent Difference (RPD) n RPD of ±35% (NODGDM, 2002).

Appendix 2 Seagrass Field Report

WorleyParsons
resources & energy

EcoNomics

WYONG SHIRE COUNCIL

The Entrance Channel Maintenance Dredging Project

Seagrass Field Report

301015-00962

–

12-Nov-09

when experience counts

10 June 2009
Infrastructure

141 Walker St
North Sydney
NSW 2060
Australia

Disclaimer

PROJECT 301015-00962

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
B	Issued for internal review	N Hannaford	O Murray	G Britton	21-May-09	N/A	
0	Issued for Client	N Hannaford	G Britton	G Britton	25-May-09		
1	Issued for Client	N Hannaford	O Murray	O Murray	30-Oct-09		11-Nov-09

CONTENTS

1. INTRODUCTION 1

1.1 Background and Aims 1

1.2 Existing Mapping Information 1

2. STUDY METHOD 2

2.1 Study site 2

2.2 Seagrass Identification and Verification 2

2.3 Syngnathid Surveys 2

3. RESULTS 3

3.1 Meteorological Conditions on 20 January 2009 3

3.1.1 Tidal conditions 3

3.2 Meteorological Conditions on 16 April 2009 3

3.2.1 Tidal conditions 3

3.3 Site A: Seagrass Identification, Mapping/Verification 4

3.4 Site B: Seagrass Identification, Mapping/Verification 4

3.5 Site C: Seagrass Identification, Mapping/Verification 5

3.6 Site D Seagrass Identification Mapping/Verification 5

3.7 Site E Seagrass Identification Mapping/Verification 6

3.8 Syngnathid Survey 6

4. CONCLUSIONS 7

Figure 1: The Entrance Seagrass Habitat, based on 2001/02 imagery & spot checked in 2005 (DPI). 9

Figure 2: Harvey Hydrographic Services Survey (15-17 December 2008). Base aerial photo Copyright Wyong Shire Council 2006. 10

Figure 3: Study sites A-C (20 January 2009) and D-E (16 April 2009). Source Google Maps, 2009 (modified). 11

Figure 4: Site A Survey. Source Google Maps, 2009 (modified). 12

Figure 5: Site B Survey via spot check validation of previous DPI seagrass mapping data. Source Google Maps, 2009 (modified). 13

Figure 6: Site C Spot check validation of previous DPI seagrass mapping data. Source Google Maps, 2009 (modified). 14

Figure 7: Site D spot check validation of previous DPI seagrass mapping data. Source Google Maps, 2009 (modified). 15

Figure 8: Site E spot check validation of previous DPI seagrass mapping data. Source Google Maps, 2009 (modified). 16

LIST OF SITE PHOTOS

Photo 1 *Z. capricorni* covered with high density of epiphytes in Area A. 18

Photo 2 *Z. capricorni* bed in Area A. 18

Photo 3 Site A macroalgae bed on shoal drop off. 19

Photo 4 Site A macroalgae bed on shoal drop off. 19

Photo 5 Site B - *Z. capricorni* with moderate epiphyte fouling. 20

Photo 6: Narrow *Zostera* bed on the southern shore of Site D. 21

Photo 7 Halophila bed on southern shore of Site D. 22

Photo 8 *Z. capricorni* bed in centre of Site D. 22

Photo 9 Narrow *Z. capricorni* bed in the southern shore of Site E. 23

Photo 10 Pipehorse found adjacent to *Z. capricorni* bed on northern shore Yellawa Island, Site A. ...23

1. INTRODUCTION

1.1 Background and Aims

The Entrance Channel and adjacent areas within Tuggerah Lakes contain a variety of biota, some of which is considered ecologically significant and sensitive to disturbance. Two significant ecosystem components were identified that could potentially be impacted by dredging activities in the area:

Seagrasses which have previously been recorded in the vicinity of the Terilbah Channel, around Yellawa Island south of the bridge and along each shore of The Entrance Channel; and

Syngnathids (e.g. seahorses and pipefish) which are known to occur in dense seagrasses within The Tuggerah Lakes.

WorleyParsons has been commissioned by Council to undertake a seagrass identification and mapping exercise to inform the Review of Environmental Factors (REF) for the maintenance dredging of The Entrance channels. The investigation would also serve to inform any application which may be required for a permit to harm marine vegetation under Part 7 of the *Fisheries Management Act 1994*. Specifically WorleyParsons aimed to:

1. Identify any seagrass beds within The Entrance Channel through field survey and review and verification of existing information.
2. Identify and record any syngnathids or other threatened or endangered species observed while completing the study.

1.2 Existing Mapping Information

Seagrass mapping in The Entrance was last undertaken via a 2005 field check by the NSW Department of Primary Industries (DPI) based on 2001-2002 imagery (Figure 1).

Council provided ortho-rectified aerial photography (Copyright Wyong Shire Council 2006) dated December 2006- January 2007. A hydrographic survey (Harvey Hydrographic Services, 15-17 December 2008) was overlaid onto the aerial photography to determine the extent of the areas likely to require dredging within the next five years (Figure 2).

2. STUDY METHOD

2.1 Study site

The study sites were established based on a previous site visit undertaken by WorleyParsons staff, on the extent of the proposed dredge footprint as determined from discussions with Councils dredge crew and on assessment of the hydrographic survey. From this information five specific sites both within and adjacent to the proposed dredge footprint warranting further investigation were determined (refer to

Figure 3).

2.2 Seagrass Identification and Verification

Field surveys were undertaken on 20 January 2009 and 16 April 2009.

Seagrass identification and verification of the existing DPI mapping and the most recent ortho-rectified aerial photography was undertaken via field observations using a hand held GPS unit (Garmin 76Csx) in the datum WGS84.

Study site A (inspected 20 January 2009) was surveyed via two boat based transects with snorkeler assisted validations.

Study site B (inspected 20 January 2009) was surveyed via one boat based and shore based transect from north to south along the shoreline.

Study site C (inspected 20 January 2009) was surveyed using 3 transects, one along either shore of Terilbah channel. The third was a wandering transect through the middle of the channel in which random seagrass beds were logged due to their abundance. A proportion of these were verified by snorkeler to validate the DPI seagrass survey.

Study site D (inspected 16 April 2009) was surveyed via a snorkeler transect along the southern shore of The Entrance Channel and a wandering boat and snorkeler based transect to identify seagrass beds in the remainder of the study site.

Study Site E (inspected 16 April 2009) was surveyed via snorkeler transects along the southern shore of The Entrance Channel.

2.3 Syngnathid Surveys

During the seagrass mapping survey, WorleyParsons staff monitored likely habitats for the presence of Syngnathids. Any Syngnathids observed were photographed and attempts were made to identify to species level. The location, type of habitat and time of any sightings were recorded.

3. RESULTS

3.1 Meteorological Conditions on 20 January 2009

On the survey date temperatures ranged from 18.9^{0}C to 26.7^{0}C at the nearby Bureau of Meteorology (BoM) Norah Head automatic weather station which is approximately 9.5km NE of the study sites. Wind was light in the morning (<5 km/h) increasing to gusts of >30 km/h in the afternoon at The Entrance.

3.1.1 Tidal conditions

Neap tidal conditions were occurring at The Entrance on 20 January 2009 as follows:

1.41m high at 5:36am

0.60m low at 12:31pm

1.02m high at 6:04pm

0.61m low at 11.40pm

Field investigations were undertaken from 8am to 2pm. Visibility was at approximately 10 m in the morning and progressively worsened as the tide ebbed resulting in visibility of less than 2 m by 2pm. This reduction in visibility and associated increase in ebbing current hindered the survey pace by greatly reducing the ability to differentiate between seagrass beds, algal beds and wrack from the boat. This meant that snorkeler identification was used more frequently as the survey progressed.

3.2 Meteorological Conditions on 16 April 2009

On the survey date temperature ranged from 15.2^{0}C to 24^{0}C at the nearby Norah Head BoM. Wind was light (<5 km/h) for the duration of the survey.

Due to the poor visibility conditions experienced, wrack and decaying and live macroalgae were not mapped to allow more time for seagrass verification.

3.2.1 Tidal conditions

Neap tidal conditions were occurring at The Entrance on 16 April 2009 as follows:

1.47m high at 12:05am

0.55m low at 7:10 am

1.03m high at 1:03pm

0.71m low at 6:00pm

Due to recent rainfall, Tuggerah Lake was experiencing a mild flood event with highly turbid water continuously being discharged for the entire survey period. The resulting 2 ft visibility (i.e. approximately 0.6 m) limited the effectiveness of boat based and snorkeler survey activities.

3.3 Site A: Seagrass Identification, Mapping/Verification

Survey results identified four distinct seagrass beds of ribbonweed (*Zostera capricorni*) in Site A as seen in Figure 4. These *Z. capricorni* beds were dense and covered with a thick layer of epiphytes (Photo 1). This investigation showed that the area of seagrass in the site has changed since last being mapped by DPI (Figure 1). For example the bed of seagrass to the south of Yellawa Island is no longer present. A new seagrass bed has established itself on the northern shore of the island (Photo 2). This was not present at the time of the DPI mapping exercise and has decreased in size since the latest ortho-rectified aerial imagery was taken.

Numerous small patches of seagrass and accumulations of decaying macroalgae and weed were present along the northern boundary of this site adjacent to the shoreline. These seagrass beds were not identified by DPI mapping and were not in the exact location as identified on the ortho-rectified aerial imagery. Due to the numerous nature of these small patches they could not all be verified. The small patches that were verified as seagrass were monocultures of *Z. capricorni*.

A macroalgae bed was identified on the drop off of a sandy shoal (Photo 3-4). This was the only live macroalgae bed in the site. The remainder of the site comprised sandy flats with scattered wrack accumulating on the sandy shoal drop off as well as in the channel between Yellawa Island and the bridge.

This site has changed significantly since the last ortho-rectified aerial imagery was taken. What appears to be a seagrass bed to the south east of Yellawa Island has silted up and is no longer present. Also the strips of dark material seen in the main channel in the southern half of Site A are no longer present. The main channel currently comprises bare sand which is predominant across the majority of the site.

The proposed ~30 meter wide dredged channel running through this site will require the removal of one small bed of *Zostera capricorni.* All seagrass beds within 50 metres of the proposed dredged area may be impacted during dredging operations through increased turbidity levels.

3.4 Site B: Seagrass Identification, Mapping/Verification

The DPI mapping showed a discontinuous band of seagrass along the shoreline of The Entrance Channel (Figure 1). Spot check validation was made against the DPI seagrass map (Figure 5). This confirmed the presence of discontinuous narrow beds of dense *Z. capricorni* with moderate epiphyte fouling (Photo 5) that currently exist along the shore of The Entrance Channel in Site B. The extent of the seagrass coverage in this site appears to have undergone no significant change since the DPI mapping was undertaken.

Seagrass beds identified in Site B are unlikely to be dredged due to their proximity to the foreshore and the need for a sufficiently wide batter slope to maintain the stability of the foreshore. However any dredging within this site may impact on local seagrass beds through increased turbidity levels associated with dredging.

3.5 Site C: Seagrass Identification, Mapping/Verification

Three transects were undertaken at Site C, one along each bank and a wandering transect up the centre of the channel.

The DPI mapping (Figure 1) identified a continuous bed of seagrass along each shore of the Terilbah channel.

Survey and spot check validation supports the DPI data for the continuous bed of *Z. capricorni* along the western shore of the channel. This is supported by the most recent ortho-rectified aerial imagery that also indicated an unbroken bed of seagrass. Two small beds of paddleweed (*Halophila ovalis*) were found in the north western corner of site C (Figure 6).

The eastern shore of the channel does not consist of a continuous seagrass bed as described by the DPI imagery. The survey found that the eastern shoreline consists of numerous discrete beds of *Z. capricorni* separated by patches of sand up to 8 metres wide (at the north eastern corner of the site) but averaging between 3-5 metres.

The wandering transect up the centre of the channel identified numerous small beds of *Z. capricorni* as seen in Figure 6. These small seagrass beds were not identified in the DPI image, they are however discernable from the last ortho-rectified aerial imagery.

The proposed dredging of a 50 meter channel through Site C will require the removal of all the small isolated patches of *Z. capricorni* that were identified in the centre of the channel. Given the lack of formal stabilisation of both shores of the Terilbah Channel, limited removal of the seagrass beds lining each shore of the Terilbah channel is likely. However they may be impacted by increased turbidity as a result of dredging activities.

3.6 Site D Seagrass Identification Mapping/Verification

Boat based survey was impractical for this site as the average depth was 2 metres and the turbid waters reduced visibility to two feet (i.e. less than 1 m). As a result numerous snorkeler transects were used.

Figure 7 shows that the southern shore of Site D was fringed by a narrow bed of seagrass which is consistent with the DPI mapping (Figure 1). This bed primarily comprised *Z. capricorni* (Photo 6), however two small patches of *H. ovalis* (Photo 7) were identified within the moored boats of The Entrance Boathouse.

The western boundary of the site marked the beginning of a large bed of *Z. capricorni*. This bed extended beyond the site boundary and appeared to cover the same area as identified in the DPI mapping.

Numerous snorkeler transects were carried out on the remainder of the site, however only nine *Z. capricorni* beds were identified. None of the beds observed in the middle of the channel in the DPI mapping were identified (Figure 1). The ortho-rectified aerial imagery shows numerous other locations in the middle of the channel that may have been seagrass beds, however snorkeler transects through many of these locations did not identify any seagrass present.

The identification of seagrass beds was somewhat limited due to the turbidity and poor visibility encountered on the day of survey (refer Photo 8).

The proposed dredging of an 80 metre channel in this Site may require the removal of up to three isolated patches and up to three small beds of *Z. capricorni* that were identified in the middle of site D (Figure 7). No other seagrass beds or patches identified in this site would require removal as they are either to close to the shore or outside the proposed dredging area. Impacts from turbidity to the surrounding seagrass beds may occur as a result of the dredging.

3.7 Site E Seagrass Identification Mapping/Verification

Snorkeler survey was used for this site as the site consisted of a gutter up to 1.5 metres deep close to the foreshore that progressively shallowed to 0.2 metres deep on the shoal crest. Five distinct beds (up to 3 metres wide) and three small patches of *Z. capricorni* were identified along the southern shoreline of The Entrance Channel (Figure 8 and Photo 9). No seagrass beds were identified in this area in the DPI mapping.

The proposed dredging of a channel along the southern shore line of The Entrance Channel may result in the removal of all seagrass beds identified in Figure 8.

3.8 Syngnathid Survey

One pipehorse was recorded throughout the duration of the survey (Photo 10). It was observed and photographed at 10:14am on 20 January 2009 adjacent to the small bed of *Z. capricorni* on the northern shore of Yellawa Island in Site A. This seagrass bed is outside of the proposed dredge area.

4. CONCLUSIONS

Seagrass was present in all five survey sites within 50 metres of proposed dredging locations. The most recent DPI mapping exercise focused on seagrass meadows fringing the shoreline and did not map seagrass beds in the middle of the channels. It is likely that these beds have established since the 2001-2002 imagery and 2005 field check on which the DPI mapping was based. The DPI seagrass imagery and the latest ortho-rectified aerial imagery require updating as The Entrance is a highly dynamic environment and significant changes to the extent of seasgrass coverage has occurred since the time these two exercises were undertaken.

It is acknowledged that the proposed dredging activities will result in the removal of several *Z. capricorni* beds and may impact on surrounding *Z. capricorni* and *H. ovalis* beds. However, failure to carry out the proposed maintenance dredging would result in reduced tidal exchange of Tuggerah Lake. Consequently, an increase in sediment loading and an increase in nutrient and contaminant concentrations in the waters of Tuggerah Lake would be expected. These effects would have a significant detrimental impact on the coverage and health of seagrasses and their ecological communities within The Entrance and Tuggerah Lake generally.

The presence of syngnathids adjacent to the proposed dredging locations was identified. Seagrass beds are a known habitat for syngnathids and it is considered likely that sygnathids occur in the seagrass that is proposed to be removed as part of the maintenance dredging operations. Maintaining the tidal exchange of is vital for syngnathids (and all other biota) that inhabit seagrass meadows.

Figures

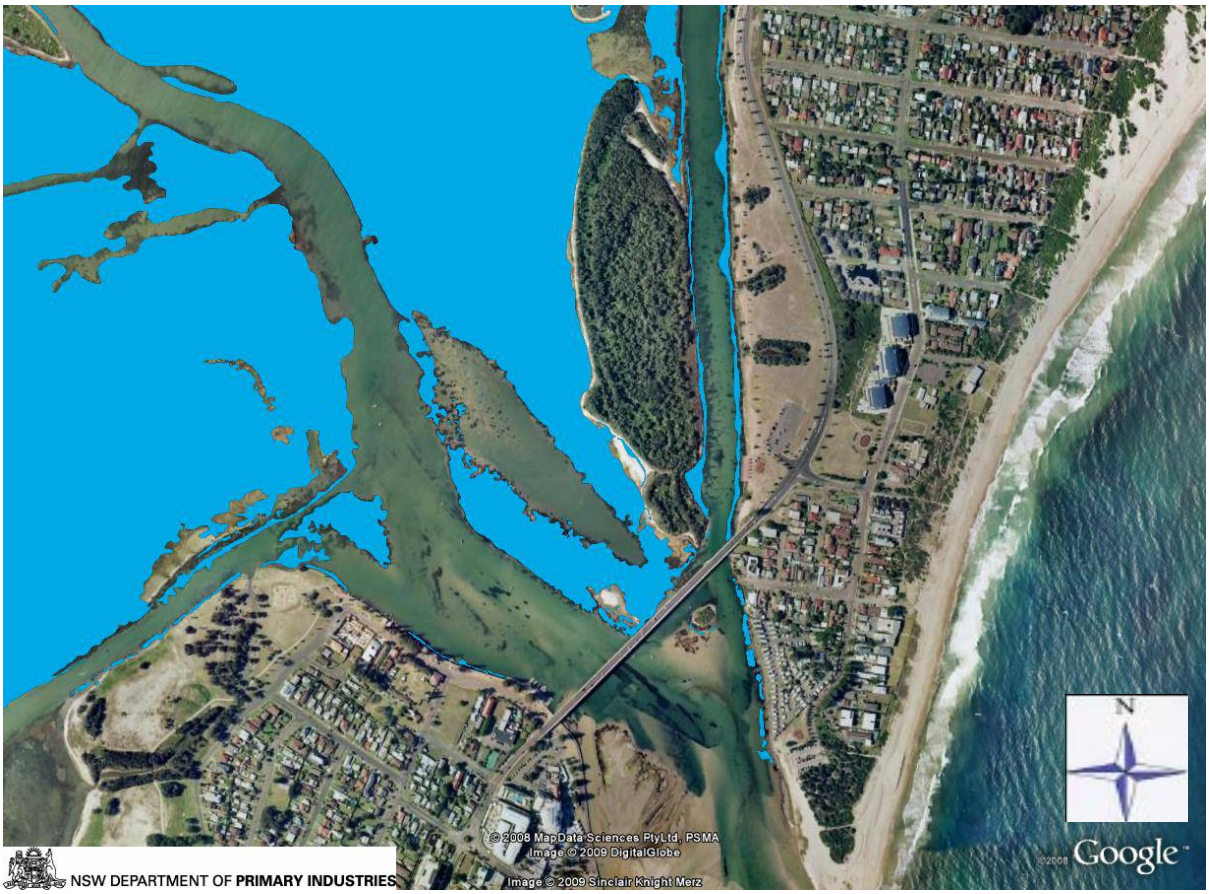


Figure 1: The Entrance Seagrass Habitat, based on 2001/02 imagery & spot checked in 2005 (DPI).

Figure 2: Harvey Hydrographic Services Survey (15-17 December 2008). Base aerial photo Copyright Wyong Shire Council 2006.

Figure 3: Study sites A-C (20 January 2009) and D-E (16 April 2009). Source Google Maps, 2009 (modified).

Figure 4: Site A Survey. Source Google Maps, 2009 (modified).

Figure 5: Site B Survey via spot check validation of previous DPI seagrass mapping data. Source Google Maps, 2009 (modified).

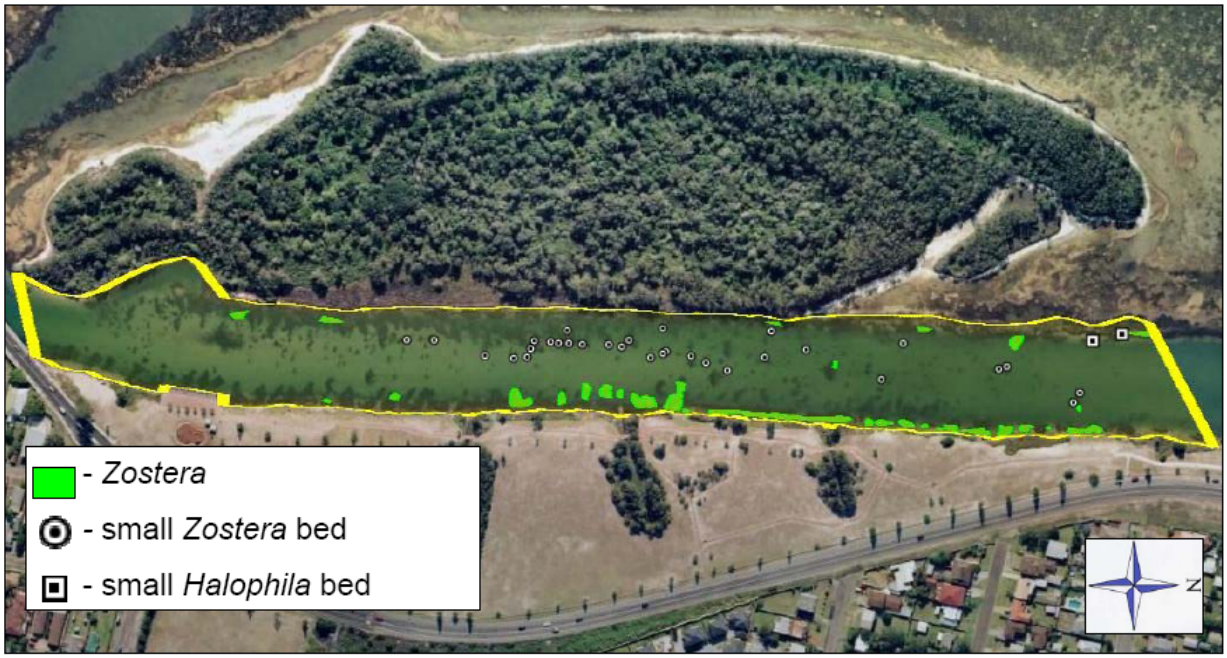


Figure 6: Site C Spot check validation of previous DPI seagrass mapping data. Source Google Maps, 2009 (modified).

Figure 7: Site D spot check validation of previous DPI seagrass mapping data. Source Google Maps, 2009 (modified).

Figure 8: Site E spot check validation of previous DPI seagrass mapping data. Source Google Maps, 2009 (modified).

Images

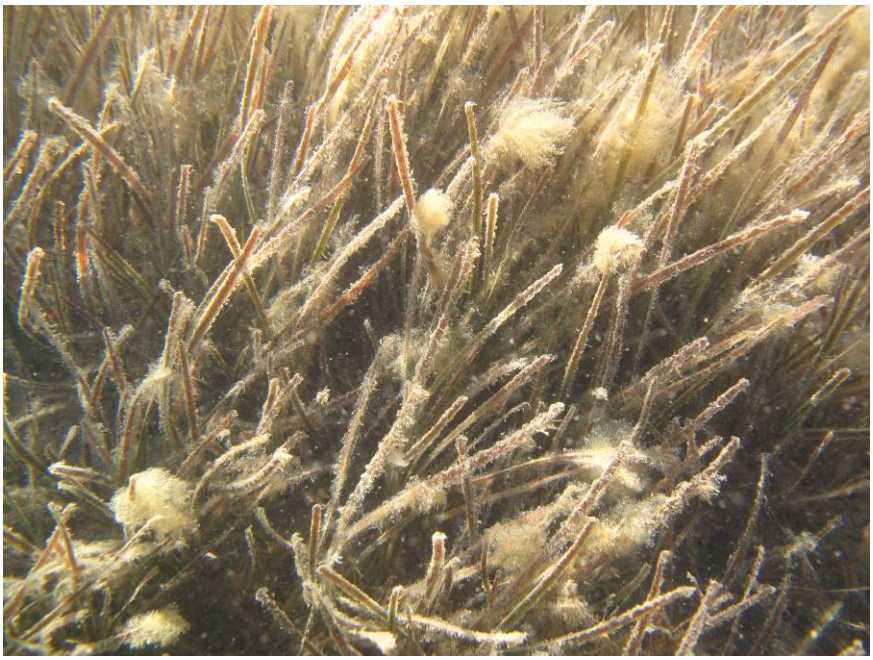


Photo 1 *Z. capricorni* covered with high density of epiphytes in Area A.

Photo 2 *Z. capricorni* bed in Area A.

Photo 3 Site A macroalgae bed on shoal drop off.

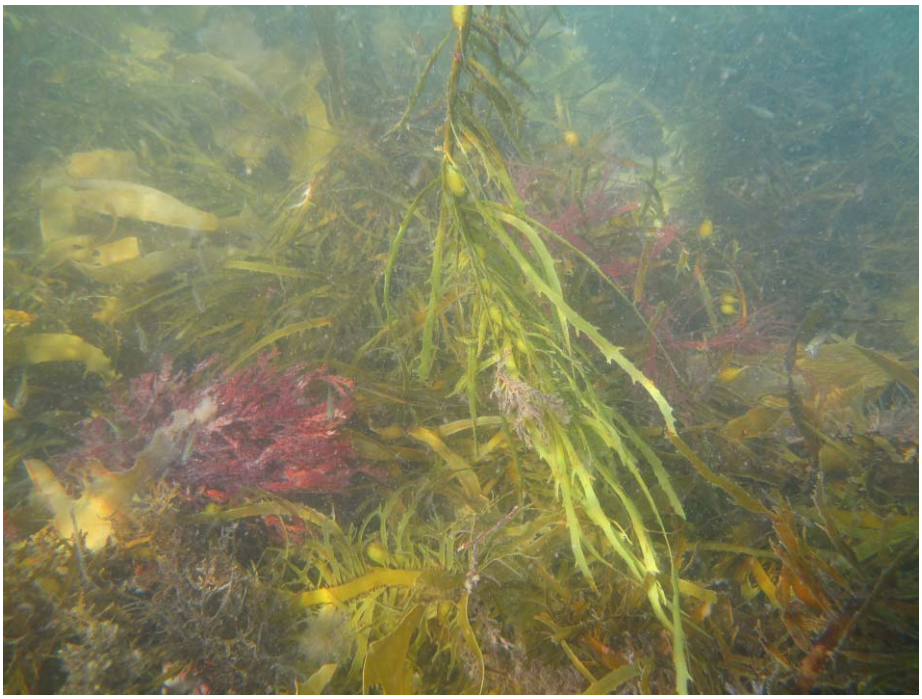


Photo 4 Site A macroalgae bed on shoal drop off.

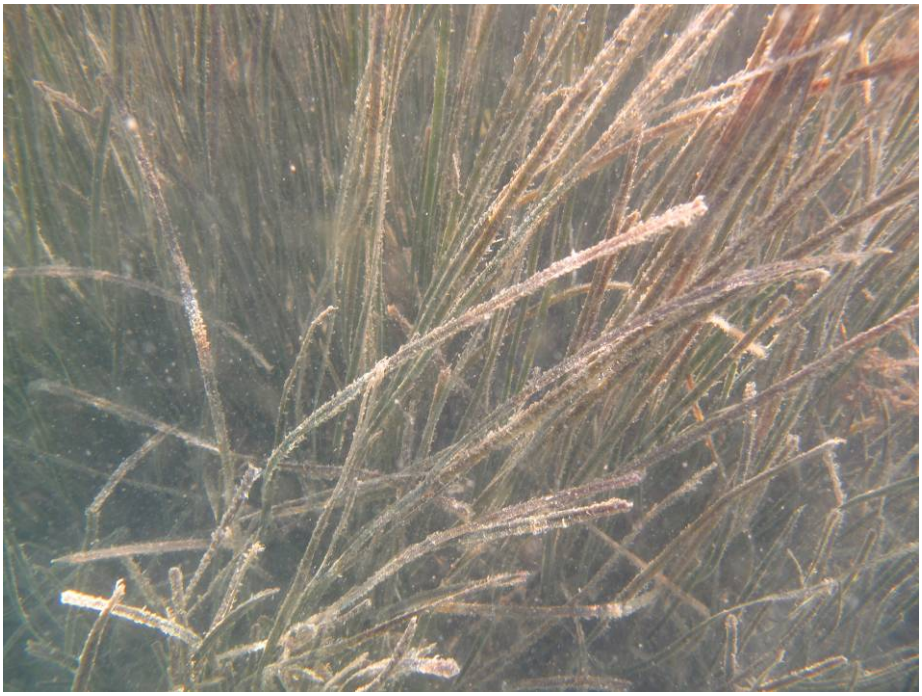


Photo 5 Site B - *Z. capricorni* with moderate epiphyte fouling.

Photo 6: Narrow *Zostera* bed on the southern shore of Site D.

Photo 7 Halophila bed on southern shore of Site D.

Photo 8 *Z. capricorni* bed in centre of Site D.

Photo 9 Narrow *Z. capricorni* bed in the southern shore of Site E.

Photo 10 Pipehorse found adjacent to *Z. capricorni* bed on northern shore Yellawa Island, Site A.

Appendix 3 EPBC Act Protected Matters Search Report

Australian Government
Department of the Environment, Water, Heritage and the Arts

Protected Matters Search Tool

You are here: Environment Home > EPBC Act > Search

3 June 2009 17:41

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

You may wish to print this report for reference before moving to other pages or websites.

The Australian Natural Resources Atlas at http://www.environment.gov.au/atlas may provide further environmental information relevant to your selected area. Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Search Type: Area

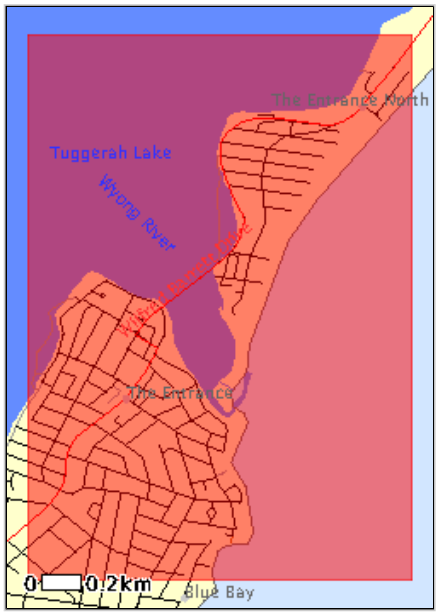
Buffer: 0 km

Coordinates: -33.32175,151.49025, -33.35613,151.49025, -33.35613,151.51440, -33.32175,151.51440

Report Contents:

Summary
Details
- Matters of NES
- Other matters protected by the EPBC Act
- Extra Information

Caveat
Acknowledgments



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance: (Ramsar Sites)	None
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	None

Threatened Species:	32
Migratory Species:	36

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html.

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Places on the RNE:	None
Listed Marine Species:	51
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Other Commonwealth Reserves:	None
Regional Forest Agreements:	1

Details

Matters of National Environmental Significance

Threatened Species [Dataset Information]	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater	Endangered	Species or species habitat likely to occur within area
Diomedea exulans antipodensis Antipodean Albatross	Vulnerable	Species or species habitat may occur within area
Diomedea exulans gibsoni Gibson's Albatross	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot	Endangered	Species or species habitat may occur within area
Macronectes giganteus	Endangered	Species or species habitat may occur within

Southern Giant-Petrel		area
Macronectes halli Northern Giant-Petrel	Vulnerable	Species or species habitat may occur within area
Pterodroma neglecta neglecta Kermadec Petrel (western)	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta salvini Salvin's Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta steadi White-capped Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris impavida Campbell Albatross	Vulnerable	Species or species habitat may occur within area
Frogs		
Heleioporus australiacus Giant Burrowing Frog	Vulnerable	Species or species habitat likely to occur within area
Litoria aurea Green and Golden Bell Frog	Vulnerable	Species or species habitat may occur within area
Litoria littlejohni Littlejohn's Tree Frog, Heath Frog	Vulnerable	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat	Vulnerable	Species or species habitat may occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population)	Endangered	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE mainland)	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus Grey-headed Flying-fox	Vulnerable	Species or species habitat likely to occur within area
Ray-finned fishes		
Prototroctes maraena Australian Grayling	Vulnerable	Species or species habitat may occur within area
Reptiles		
Chelonia mydas Green Turtle	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Endangered	Species or species habitat may occur within area
Sharks		
Carcharias taurus (east coast population) Grey Nurse Shark (east coast population)	Critically Endangered	Species or species habitat may occur within area
Carcharodon carcharias Great White Shark	Vulnerable	Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable	Species or species habitat may occur within area
Rhincodon typus	Vulnerable	Species or species habitat may occur within

Whale Shark		area
Plants		
Cryptostylis hunteriana Leafless Tongue-orchid	Vulnerable	Species or species habitat may occur within area
Eucalyptus camfieldii Camfield's Stringybark	Vulnerable	Species or species habitat likely to occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Pocket-less Brush Cherry, Scrub Cherry, Creek Lilly Pilly, Brush Cherry	Vulnerable	Species or species habitat likely to occur within area
Migratory Species [Dataset Information]	Status	Type of Presence
Migratory Terrestrial Species		
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail	Migratory	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch	Migratory	Breeding may occur within area
Myiagra cyanoleuca Satin Flycatcher	Migratory	Breeding likely to occur within area
Rhipidura rufifrons Rufous Fantail	Migratory	Breeding may occur within area
Xanthomyza phrygia Regent Honeyeater	Migratory	Species or species habitat likely to occur within area
Migratory Wetland Species		
Birds		
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper	Migratory	Species or species habitat likely to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover	Migratory	Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe	Migratory	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Migratory	Species or species habitat may occur within area
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift	Migratory	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross	Migratory	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross	Migratory	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel	Migratory	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Migratory	Species or species habitat may occur within area

Sterna albifrons Little Tern	Migratory	Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross	Migratory	Species or species habitat may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross	Migratory	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross	Migratory	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross	Migratory	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross	Migratory	Species or species habitat may occur within area
Migratory Marine Species		
Mammals		
Balaenoptera edeni Bryde's Whale	Migratory	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale	Migratory	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Migratory	Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin	Migratory	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale	Migratory	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca	Migratory	Species or species habitat may occur within area
Reptiles		
Chelonia mydas Green Turtle	Migratory	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Migratory	Species or species habitat may occur within area
Sharks		
Carcharodon carcharias Great White Shark	Migratory	Species or species habitat may occur within area
Rhincodon typus Whale Shark	Migratory	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Dataset Information]	Status	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper	Listed	Species or species habitat likely to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover	Listed	Species or species habitat likely to occur within area
Diomedea antipodensis	Listed	Species or species habitat may occur within

Antipodean Albatross		area
Diomedea gibsoni Gibson's Albatross	Listed	Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe	Listed - overfly marine area	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail	Listed - overfly marine area	Species or species habitat may occur within area
Lathamus discolor Swift Parrot	Listed - overfly marine area	Species or species habitat may occur within area
Limnodromus semipalmatus Asian Dowitcher	Listed - overfly marine area	Foraging known to occur within area
Macronectes giganteus Southern Giant-Petrel	Listed	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Listed	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch	Listed - overfly marine area	Breeding may occur within area
Myiagra cyanoleuca Satin Flycatcher	Listed - overfly marine area	Breeding likely to occur within area
Rhipidura rufifrons Rufous Fantail	Listed - overfly marine area	Breeding may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area
Sterna albifrons Little Tern	Listed	Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross	Listed	Species or species habitat may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross	Listed	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross	Listed	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross	Listed	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross	Listed	Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri	Listed	Species or species habitat may occur within

New Zealand Fur-seal		area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal	Listed	Species or species habitat may occur within area
Ray-finned fishes		
Acentronura tentaculata Hairy Pygmy Pipehorse	Listed	Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish	Listed	Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish	Listed	Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish	Listed	Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish	Listed	Species or species habitat may occur within area
Hippocampus abdominalis Eastern Potbelly Seahorse, New Zealand Potbelly, Seahorse, Bigbelly Seahorse	Listed	Species or species habitat may occur within area
Hippocampus whitei White's Seahorse, Crowned Seahorse, Sydney Seahorse	Listed	Species or species habitat may occur within area
Histiogamphelus briggsii Briggs' Crested Pipefish, Briggs' Pipefish	Listed	Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish	Listed	Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish	Listed	Species or species habitat may occur within area
Notiocampus ruber Red Pipefish	Listed	Species or species habitat may occur within area
Phyllopteryx taeniolatus Weedy Seadragon, Common Seadragon	Listed	Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse	Listed	Species or species habitat may occur within area
Solenostomus cyanopterus Blue-finned Ghost Pipefish, Robust Ghost Pipefish	Listed	Species or species habitat may occur within area
Solenostomus paradoxus Harlequin Ghost Pipefish, Ornate Ghost Pipefish	Listed	Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish	Listed	Species or species habitat may occur within area
Stigmatopora nigra Wide-bodied Pipefish, Black Pipefish	Listed	Species or species habitat may occur within area
Syngnathoides biaculeatus Double-ended Pipehorse, Alligator Pipefish	Listed	Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bend Stick Pipefish, Short-tailed Pipefish	Listed	Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish	Listed	Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish	Listed	Species or species habitat may occur within area
Reptiles		
Chelonia mydas Green Turtle	Listed	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Listed	Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake	Listed	Species or species habitat may occur within area
Whales and Other Cetaceans [Dataset Information]	Status	Type of Presence

Balaenoptera acutorostrata Minke Whale	Cetacean	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale	Cetacean	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale	Cetacean	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin	Cetacean	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Cetacean	Species or species habitat likely to occur within area
Grampus griseus Risso's Dolphin, Grampus	Cetacean	Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin	Cetacean	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale	Cetacean	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca	Cetacean	Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin	Cetacean	Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	Cetacean	Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin	Cetacean	Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Dataset Information]

Wyrrabalong National Park, NSW

Regional Forest Agreements [Dataset Information]
Note that all RFA areas including those still under consideration have been included.

Lower North East NSW RFA, New South Wales

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the *Environment Protection and Biodiversity Conservation Act 1999*. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under "type of presence". For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the migratory and marine provisions of the Act have been mapped.

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgments

This database has been compiled from a range of data sources. The Department acknowledges the following custodians who have contributed valuable data and advice:

- New South Wales National Parks and Wildlife Service
- Department of Sustainability and Environment, Victoria
- Department of Primary Industries, Water and Environment, Tasmania
- Department of Environment and Heritage, South Australia Planning SA
- Parks and Wildlife Commission of the Northern Territory
- Environmental Protection Agency, Queensland
- Birds Australia
- Australian Bird and Bat Banding Scheme
- Australian National Wildlife Collection
- Natural history museums of Australia
- Queensland Herbarium
- National Herbarium of NSW
- Royal Botanic Gardens and National Herbarium of Victoria
- Tasmanian Herbarium
- State Herbarium of South Australia
- Northern Territory Herbarium
- Western Australian Herbarium
- Australian National Herbarium, Atherton and Canberra
- University of New England
- Other groups and individuals

ANUCliM Version 1.8, Centre for Resource and Environmental Studies, Australian National University was used extensively for the production of draft maps of species distribution. Environment Australia is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Last updated: Thursday, 20-Nov-2008 14:17:56 EST

Department of the Environment, Water, Heritage and the Arts
GPO Box 787 Canberra ACT 2601 Australia
Telephone: +61 (0)2 6274 1111

Appendix 4 Consultation

Our reference: DOC09/13928; FIL06/928-04
Contact: Michael Howat, (02) 4908 6833

WorleyParsons Services Pty Ltd
141 Walker street
NORTH SYDNEY NSW 2060

Attention: Orla Murray

Dear Sir or Madam,

RE: PREPERATION OF A REVIEW OF ENVIRONMENTAL IMPACTS FOR THE ENTRANCE MAINTENANCE DREDGING PROJECT, ENVIRONMENT PROTECTION LICENCE NO. 3200

Reference is made to your letter dated 20 March 2009 to the Department of Environment and Climate Change (DECC) regarding the preparation of a Review of Environmental Factors (REF) report for The Entrance Maintenance Dredging Project, Environmental Protection Licence No. 3200.

DECC notes the preparation of an REF is required in accordance with Wyong Shire Council's ('Council's') intention to apply to renew the dredging permit issued by the Department of Primary Industries – Fisheries (DPI Fisheries), currently due to expire at the end of June 2009.

Environment Protection Licence No. 3200, currently held by Council, is continuous and independent of the dredging permit issued by DPI Fishers. Provided Council comply with all licence conditions under Environment Protection Licence No. 3200, DECC does not believe it is necessary to comment on or list requirements towards the preparation of the REF.

It is the responsibility of the licensee to determine whether an environment protection licence is required under Schedule 1 of the *Protection of the Environment Operations Act 1997* (POEO Act). However, should the licensee determine an environmental protection licence is not required, DECC expects strict compliance with section 120 of the POEO Act.

If you require any further information regarding this matter please contact Michael Howat on (02) 4908 6833.

Yours sincerely

15 APR 2009

MARK HARTWELL
A/Head Regional Operations Unit
North East Branch
Environment Protection and Regulation Group

PO Box 488G Newcastle NSW 2300
117 Bull Street, Newcastle West NSW 2302
Tel: (02) 4908 6800 Fax: (02) 4908 6810
ABN 30 841 387 271
www.environment.nsw.gov.au

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Our Ref: Cf09-076
Your Ref: It7291oam090210-DPI

27 March 2009

Orla Murray
Worley Parsons
141 Walker Street
NORTH SYDNEY NSW 2060

Dear Orla

Re: The Entrance maintenance Dredging Project – REF preparation

Thank you for giving the NSW Department of Primary Industries the opportunity to comment on the above proposal.

In reference to the above, the site has been assessed and predicted environmental impacts considered by officers of NSW Department of Primary Industries.

The Department would expect the following specific issues to be addressed in preparation of the REF:

- The requirement to dredge areas that have been stabilised by seagrass growth. This would not be looked upon favourably by the department without substantiation of the need to remove seagrass.
- Model or restate original modelling that requires the sand silting the entrance to be kept within The Entrance sand system, and the fate and behaviour of the entrance if sand deposition was moved further north past the "null" point.
- Justification of the nourishment of the Entrance Beach when the northerly natural movement of sand will just push it back in the Entrance.
- Management of Syngnathids if seagrass areas are going to be removed must be addressed.
- In relation to the haul out area, there needs to be an assessment of the potential impact of removal of the dredge from the water on the fringing seagrass. Also the potential for impact from stormwater and runoff from the site on the seagrass and estuarine system.

Further to these specific points, the REF should contain the information contained in the attached document outlining "Matters to be Addressed"

ABN 51 734 124 190

For further information, please contact me on (02) 4916 3931.

N.B. It is an offence to *dredge/reclaim in any waters and/or affect marine vegetation* without permits from NSW Department of Primary Industries. Penalties of up to $55,000 for an individual and/or up to $110,000 for a company or LGA can apply plus full site remediation costs.

Yours faithfully

Scott Carter
Senior Conservation Manager

Matters to be Addressed

1. General Requirements

The REF must include the information outlined below:

A topographic map of the locality at a scale of 1:25 000 should be provided. This map should detail the location of all component parts of the proposal, any areas locally significant for threatened species (such as aquatic reserves), and areas of high human activity (such as townships, regional centres and major roads).

A recent aerial photograph (preferably colour) of the locality (or reproduction of such a photograph) should be provided, if possible. This aerial photograph should clearly show the subject site and indicate the scale of the photograph.

GENERAL REQUIREMENTS

- Area which may be affected either directly or indirectly by the development or activity should be identified and shown on an appropriately scaled map (and aerial photographs).
- All waterbodies and waterways within the proposed area of development are to be identified.
- Description of aquatic vegetation, snags, gravel beds and any other protected, threatened or dominant habitats should be presented.
- Area, density and species composition should be included and mapped.
- Identification of recognised recreational and commercial fishing grounds, aquaculture farms and/or other waterways users.
- Presented maps or plans
- Description of proposal and study area
- Details of the location of all component parts of the proposal, including any auxiliary infrastructure, timetable for construction of the proposal with details of various phases of construction
- Size of the area affected
- Aspects of the management of the proposal, both during construction and after completion, which relate to impact minimisation eg Environment Management Plans
- Plan of study area
- Locations and types of landuses present
- Locations of streams and other waterbodies
- Land tenure details for all land parcels
- For each freshwater body identified on the plan, the plan should include, either by annotation or by an accompanying table, hydrological and stream morphology information such as: flow characteristics, including any seasonal variations, bed substrate, and bed width
- For each marine or estuarine area identified on the plan, the plan should include, either by annotation or by an accompanying table, hydrological and stream morphology information such as: tidal characteristics, bed substrate, and depth contours

DREDGING AND RECLAMATION ACTIVITIES

- Purpose of works
- Type(s) of marine vegetation in the vicinity of the proposed works
- Distance of adjacent marine vegetation from the outer boundary of the proposed works
- Method of dredging to be used
- Duration of dredging works
- Time of dredging works
- Dimension of area to be dredged
- Depth of dredging activities
- Nature of sediment to be dredged, including Acid Sulphate Soil
- Method of marking area subject to works
- Environmental safeguards to be used during and after works
- Measures for minimising harm to fish habitat under the proposal
- Spoil type and source location for reclamation activities
- Method of disposal of dredge material
- Location and duration of spoil stockpiling, if planned
- Volume of material to be extracted or placed as fill

ACTIVITIES THAT DAMAGE MARINE VEGETATION

- Type of marine vegetation to be harmed
- Amount of marine vegetation to be harmed, map distribution of marine vegetation

- Reasons for harming marine vegetation
- Methods of harming marine vegetation
- Construction details
- Duration of works/activities
- Measures for minimising harm to marine vegetation under the proposal
- Environmental measures to be employed, if necessary
- Method and location of transplanting activities or disposal of marine vegetation

ACTIVITIES THAT BLOCK FISH PASSAGE

- Type of activity eg works in a stream that change flow or morphological characteristics
- Length of time fish passage is to be restricted
- Timing of proposed restriction
- Remediation works

THREATENED SPECIES

- Threatened aquatic species assessment (Section 5c, EP&A Act 1979)
- Eight Part Test

2. Initial Assessment

A list of threatened species, endangered populations and endangered ecological communities must be provided. In determining these species, consideration must be given to the habitat types present within the study area, recent records of threatened species in the locality and the known distributions of these species.

In describing the locality in the vicinity of the proposal, discussion must be provided in regard to the previous land and water uses and the effect of these on the proposed site. Relevant historical events may include land clearing, agricultural activities, water abstraction/diversion, dredging, de-snagging, reclamation, siltation, commercial and recreational activities.

A description of habitat including such components as stream morphology, in-stream and riparian vegetation, water quality and flow characteristics, bed morphology, vegetation (both aquatic and adjacent terrestrial), water quality and tide/flow characteristics must be given. The condition of the habitat within the area must be described and discussed, including the presence and prevalence of introduced species. A description of the habitat requirements of threatened species likely to occur in the study area must be provided.

In defining the proposal area, discussion must be provided in regard to possible indirect effects of the proposal on species/habitats in the area surrounding the subject site: for example, through altered hydrological regimes, soil erosion or pollution. The study area must extend downstream and/or upstream as far as is necessary to take all potential impacts into account.
Please Note: Persons undertaking aquatic surveys may be required to hold or obtain appropriate permits or licences under relevant legislation.

For example:

Fisheries Management Act 1994

- Permit to take fish or marine vegetation for research or other authorised purposes (Section 37)
- Licence to harm threatened (aquatic) species, and/or damage the habitat of a threatened species (Section 220ZW).

Animal Research Act 1985:

- Animal Research Authority to undertake fauna surveys.

It is recommend that, prior to any field survey activities taking place, those persons proposing to undertake those activities give consideration to their obligation to obtain appropriate permits or licences which may be required in the specific context of the proposed survey activities.

3. Assessment of Likely Impacts

The REF must:

- describe and discuss significant habitat areas within the study area;

- outline the habitat requirements of threatened species likely to occur in the study area;
- indicate the location, nature and extent of habitat removal or modification which may result from the proposed action;
- discuss the potential impact of the modification or removal of habitat;
- identify and discuss any potential for the proposal to introduce barriers to the movement of fish species; and
- describe and discuss any other potential impacts of the proposal on fish species or their habitat.

For all species likely to have their lifecycle patterns disrupted by the proposal to the extent that individuals will cease to occupy any location within the subject site, the REF must describe and discuss other locally occurring populations of such species. The relative significance of this location for these species in the general locality must be discussed in terms of the extent, security and viability of remaining habitat in the locality.

4. Ameliorative Measures

The REF must consider how the proposal has been or may be modified and managed to conserve fisheries habitat on the subject site and in the study area.

In discussing alternatives to the proposal, and the measures proposed to mitigate any effects of the proposal, consideration must be given to developing long term management strategies to protect areas within the study area which are of particular importance for fish species. This may include proposals to restore or improve habitat.

Any proposed pre-construction monitoring plans or on-going monitoring of the effectiveness of the mitigation measures must be outlined in detail, including the objectives of the monitoring program, method of monitoring, reporting framework, duration and frequency.

In the event of a request for concurrence or consultation of the Director of NSW Fisheries, one (1) copy of the REF should be provided to NSW Fisheries in order for the request to be processed.

It should be noted that NSW Fisheries has no regulatory or statutory role to review draft REFs unless they are accompanied by or are requested as part of a licence application under Part 7A of the FM Act. However, NSW Fisheries is available to provide advice to consent and determining authorities regarding Fisheries' opinion as to whether the requirements have been met if requested, pending the availability of resources and other statutory priorities.

Murray, Orla (Sydney)

From: scott.carter@industry.nsw.gov.au
Sent: Friday, 30 October 2009 1:09 PM
To: Murray, Orla (Sydney)
Subject: RE: FW: Confirmation of Monday's phone call required
Attachments: Lands_licence.pdf

Yes that covers the area in question and is for dredging. No approvals are required from the Department

Scott Carter | Senior Conservation Manager - Central Region, Aquatic Habitat Protection Unit
Division of Primary Industries `·.><((((º>`·. .· `·. .· `·... ><((((º>
Industry & Investment NSW | Locked Bag 1 | NELSON BAY NSW 2315
Port Stephens Fisheries Institute, Taylors Beach Road, Taylors Beach TAYLORS BEACH NSW 2316
T: 02 4916 3931 | F: 02 4982 1232 | M: 0419 185 508 | E. scott.carter@industry.nsw.gov.au
W: www.industry.nsw.gov.au | www.dpi.nsw.gov.au

"Murray, Orla (Sydney)" <Orla.Murray@WorleyParsons.com>

30/10/2009 12:21 PM

To "scott.carter@industry.nsw.gov.au" <scott.carter@industry.nsw.gov.au>
cc
Subject RE: FW: Confirmation of Monday's phone call required

Thanks Scott.

Council have a 34A Licence for the use of Crown land (attached). The licence will be modified to cover the proposed extend of works. Would this suffice?

Regards,

Orla Murray
Coastal Environmental Scientist
WorleyParsons

orla.murray@worleyparsons.com

Tel: +61 2 8456 7251
Fax: +61 2 8923 6877
Level 11
141 Walker St.
Nth Sydney NSW 2060

Mailing Address:
P.O. Box 1812
North Sydney, NSW, 2059

From: scott.carter@industry.nsw.gov.au [mailto:scott.carter@industry.nsw.gov.au]
Sent: Friday, 30 October 2009 12:12 PM
To: Murray, Orla (Sydney)
Subject: Re: FW: Confirmation of Monday's phone call required

they need dredge and rec permit unless the dredging is done under a licence issued by the lands Department..
they need a harm marine veg permit

they will be covered for seahorses as they will have a permit under the FMAct to carry out the works.

Scott Carter | Senior Conservation Manager - Central Region, Aquatic Habitat Protection Unit
Division of Primary Industries `·.><((((º>`·. .· `·. .· `·... ><((((º>
Industry & Investment NSW | Locked Bag 1 | NELSON BAY NSW 2315
Port Stephens Fisheries Institute, Taylors Beach Road, Taylors Beach TAYLORS BEACH NSW 2316
T: 02 4916 3931 | F: 02 4982 1232 | M: 0419 185 508 | E. scott.carter@industry.nsw.gov.au
W: www.industry.nsw.gov.au | www.dpi.nsw.gov.au

"Murray, Orla (Sydney)" <Orla.Murray@WorleyParsons.com>

30/10/2009 12:06 PM

To "scott.carter@dpi.nsw.gov.au" <scott.carter@dpi.nsw.gov.au>
cc "Hannaford, Nick (Sydney)" <Nicholas.Hannaford@WorleyParsons.com>
Subject FW: Confirmation of Monday's phone call required

Hi Scott,

Can you please clarify Nick's request below.

There is some confusion as to whether a permit to harm marine vegetation is required if a permit to dredge is already being obtained.

I am going on leave for a month today and this matter needs to be tied up before I do.

Regards,

Orla Murray
Coastal Environmental Scientist
WorleyParsons

orla.murray@worleyparsons.com
Tel: +61 2 8456 7251
Fax: +61 2 8923 6877
Level 11
141 Walker St.
Nth Sydney NSW 2060

Mailing Address:
P.O. Box 1812
North Sydney, NSW, 2059

From: Hannaford, Nick (Sydney)
Sent: Tuesday, 27 October 2009 12:02 PM
To: scott.carter@industry.com.au
Cc: Murray, Orla (Sydney)
Subject: Confirmation of Monday's phone call required
Importance: High

Hi Scott,

Further to our conversation yesterday can you please confirm the following.

Council is required to apply for:
1) a Permit to dredge under Part 7
2) a Permit to harm marine vegetation under part 7

A Section 37 permit in relation to Syngnathids is no longer required as Council has now removed previously mentioned management recommendations.

Regards,

Nick Hannaford
Environmental Scientist
WorleyParsons
Tel: +61 2 8456 7357
Fax: +62 2 8923 6877
WorleyParsons Services Pty Ltd
Level 11, 141 Walker St
Nth Sydney NSW 2060
WorleyParsons | www.worleyparsons.com

This message is intended for the addressee named and may contain confidential information. If you are not the inten

Murray, Orla (Sydney)

From: Rob Micheli [Rob.Micheli@lands.nsw.gov.au]
Sent: Friday, 15 May 2009 12:40 PM
To: MCooper@wyong.nsw.gov.au
Cc: Samuel Fallico; Allan Thorley; Anthony Signor
Subject: FW: Dredge Haul Out at Terilbah Reserve, The Entrance North

Hi Megan

The following points are offered for Council's consideration on the subject proposal for a dredge haul out area at Terilbah Reserve, The Entrance North.

1. It is evident that there is some concern in the community and from government agencies over both the dredging program in general and the maintenance of the dredge on this reserve.
2. Authorisation will be needed from Lands for the proposed dredge haul out. A Licence (34A Licence) from Lands would be the likely mechanism following approval of the REF.
3. The REF to be prepared by Worley Parsons needs to ensure that impacts from the proposed haul out on public recreation, environment & neighbours are minimised.
4. The REF should ensure that alternative options are well explored and adequate justification for this proposal is provided.
5. Some form of community & agency consultation by Council would be warranted.
6. The new single licence could be reissued for the existing dredge site and cover the proposed new dredge site and the haul out area. Sam Fallico, Team Leader Land Administration can advise further about licensing requirements following the preparation of an REF.

I will forward this information to Orla Murray from Worley Parsons who has referenced this Department with regard to our requirements for the REF.

Regards

Rob Micheli
Team Leader – Environment,
Central Coast Hunter Region, Crown Lands Division
Department of Lands, PO Box 6 East Maitland 2323
Ph (02) 4937 9343 **Mob** 0427 949382 **Fax** (02) 4934 8417
rob.micheli@lands.nsw.gov.au

From: Cooper, Megan [mailto:MCooper@wyong.nsw.gov.au]
Sent: Friday, 1 May 2009 10:47 AM
To: Rob Micheli
Subject: FW: Owner's Consent

Good morning Rob,

Could you please send me a receipt email to let me know that you have received this email ok

Cheers,

Megan.

From: Cooper, Megan
Sent: Wednesday, 22 April 2009 11:35 AM
To: 'rob.mecheli@lands.nsw.gov.au'
Subject: Owner's Consent

Good morning Rob,

After a brief conversation with Les Conrad this morning I have been given your contact details in order to address the following matter;

Council proposes the construction of a temporary dredge haul-out area at Terilbah Reserve, The Entrance North, south of the first stormwater treatment zone, and north of the public jetty. The site previously employed to launch the dredge (Picnic Point) is at present too shallow to accommodate this activity. The area is no longer considered a viable launch site.

Currently, the dredge is maintained by dismantling the dredge onsite and transporting its parts off site for repair and cleaning. This method is not considered cost effective and promotes an increase in operational downtime. Council proposes the establishment of an interim structure upon which to perform this year's onsite maintenance of the dredge.

The area must be accessible to, and able to withstand incursion of heavy plant. Geotechnical analysis of the proposed site at Terilbah Reserve has been undertaken, with the site deemed capable of supporting this Activity and the incursion of associated plant. Worley Parsons, the hydro-engineering company engaged by Council to complete the REF for The Entrance Channel Dredge Program, has designed an interim dredge haul-out and maintenance area complete with appropriate bunding and a waterproof membrane to collect any waste which may result from onsite dredge maintenance.

Council has completed a Part 5 assessment and associated Part 7 assessmentsof the proposed dredge haul-out area and would now like to ascertain if, as appointed trustee of the Crown Reserve (a cleared recreational reserve), Council will need to obtain owner's consent from Lands for this development?

If you require further information regarding this proposal please do not hesitate to contact me via email or telephone.

Kindest regards,

Megan Cooper
Student Project Assistant
Open Space and Recreation
Wyong Shire Council
P.O. Box 20 , WYONG NSW 2259
Tel: 02 4350 1642 Fax: 02 4351 2098
E-mail: Megan.Cooper@wyong.nsw.gov.au WWW: http://www.wyong.nsw.gov.au/

Murray, Orla (Sydney)

From: Charlie Dunkley [Charlie.Dunkley@maritime.nsw.gov.au]
Sent: Monday, 23 March 2009 1:17 PM
To: Murray, Orla (Sydney)
Subject: RE: Maintenance Dredging of The Entrance Channel - Tuggerah Lakes

Dear Orla, thank you for the information regarding the REI for dredging at The Entrance Channel. The proposed scope of works will impact on the marked navigation channel at The Entrance. NSW Maritime will need to be notified prior to the commencement of any works that will require the relocation of navigation aids so an appropriate Marine Notice may be promulgated.
The dredge will need to display the required day shapes and lights when operating and signage advising of the dredging hazard are to be displayed at the relevant boat ramp that access the dredging area.
Should you require any further information please contact Senior Boating Safety officer Brett Boehm on 49628515.

Charlie Dunkley
Regional Manager
Hunter Inland
Recreational Boating and Regional Services
NSW Maritime

Serving our Boating Community - Safe Waterways and Support for the Maritime Community

T: 02 49628516| F: 02 49628588| M: 0427 452743
PO Box 653| Newcastle NSW | 2300
www.maritime.nsw.gov.au

-----Original Message-----
From: Brett Boehm
Sent: Monday, 23 March 2009 12:23 PM
To: Charlie Dunkley
Subject: FW: Maintenance Dredging of The Entrance Channel - Tuggerah Lakes

FYI and comment?

Brett Boehm

Senior Boating Safety Officer
Hunter/Inland Region
NSW Maritime

Serving our Boating Community - Safe Waterways and Support for the Maritime Community

T: 02 49628515 | F: 02 49628588 | M: 0428 626603
PO Box 653 | Newcastle NSW 2300
www.maritime.nsw.gov.au

-----Original Message-----
From: Murray, Orla (Sydney) [mailto:Orla.Murray@WorleyParsons.com]
Sent: Friday, 20 March 2009 2:22 PM
To: Brett Boehm
Subject: Maintenance Dredging of The Entrance Channel - Tuggerah Lakes

Dear Brett,

Please find attached a consultation letter regarding the environmental assessment of maintenance dredging in The Entrance Channel, Tuggerah Lakes. If there is a more relevant section of Maritime to send this letter to, could you please provide me with their details.

Kind regards,

Orla Murray
Environmental Scientist
WorleyParsons
Incorporating Patterson Britton and Partners
Tel: +61 2 8456 7251
Fax: +61 2 8923 6877
Level 11
141 Walker St.
Nth Sydney NSW 2060

Appendix 5 Review of Current and Proposed Dredging and Beach Nourishment Practices at The Entrance

WorleyParsons
resources & energy

Level 12
141 Walker Street
North Sydney NSW 2060 Australia
Telephone: +61 2 8456 7200
Facsimile: +61 2 8923 6877
worleyparsons.com
WorleyParsons Services Pty Ltd
ABN 61 001 279 812

8 July 2009

Ref: lt301015-00962gwb_oam080709_final.doc

Ms Megan Cooper
Wyong Shire council
PO Box 20
WYONG NSW 2259

Dear Megan

REVIEW OF CURRENT AND PROPOSED DREDGING AND BEACH NOURISHMENT PRACTICES AT THE ENTRANCE

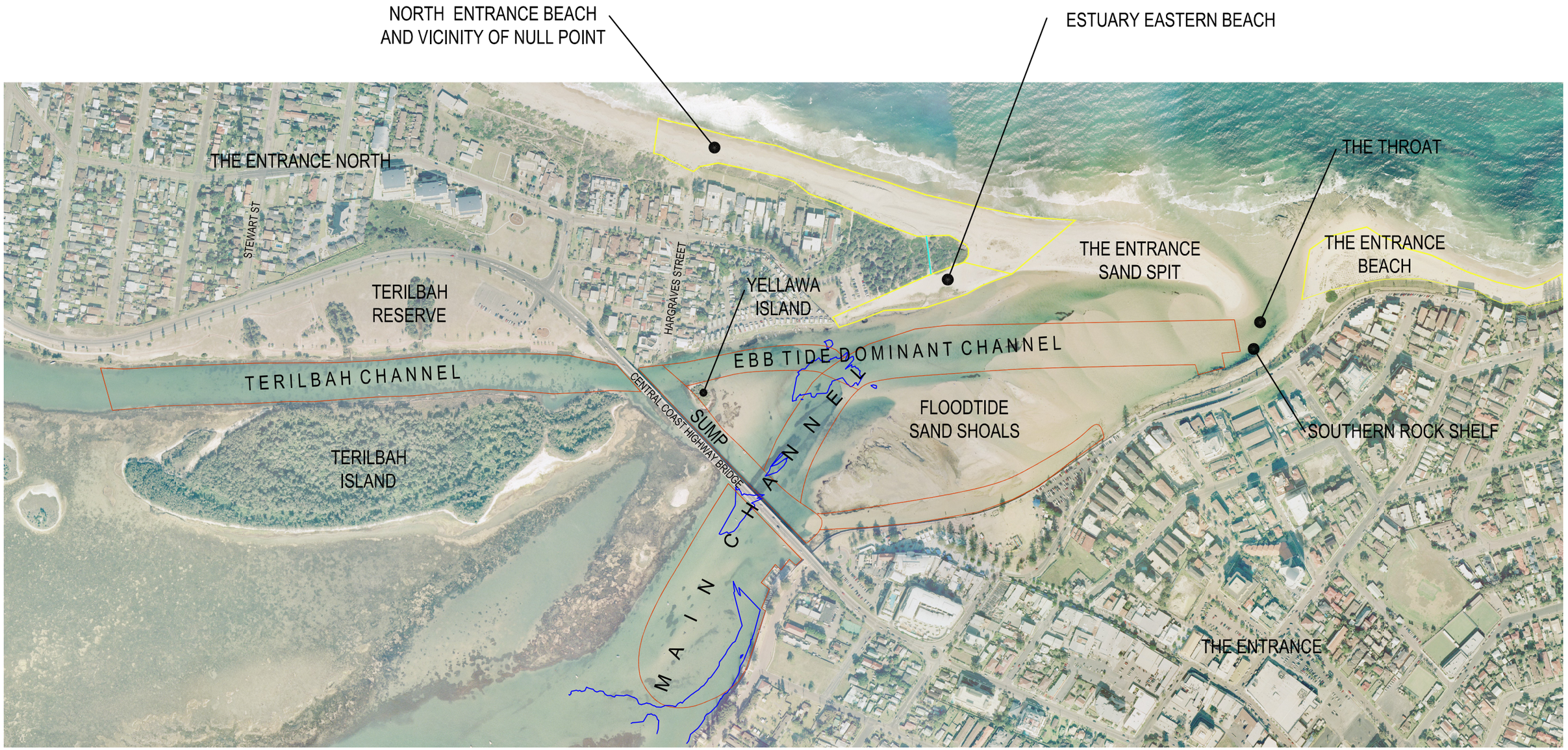
This letter sets out a review of the current and proposed dredging and beach nourishment practices employed by Wyong Shire Council at The Entrance. The review is based on discussions with Council officers and Council's dredge crew, observations by the writer of dredging activities undertaken at The Entrance since the early 1990s (most recently in early 2008), the experience of the writer in dredging and nourishment projects generally, and the understanding of the writer of the physical processes operating at The Entrance based on studies dating from the late 1980's.

The letter assumes some general knowledge by the reader of The Entrance area. **Figure 1** shows the location of a number of features referred to in the letter, based on a 2006 aerial photograph (Copyright Wyong Shire Council 2006).

The review covers seven main issues raised in Council's Brief:

- suitability of the use of M2 tidal constituents as a decision support tool for the commencement of dredging;
- identification of appropriate trigger values and improvements to the current decision support tool;
- investigation of the past exceedances of the Environmental Protection Licence (EPL) limits and identification of potential necessary revisions to the EPL;
- assessment of the potential for erosion to islands within and adjacent to the dredge areas as a result of current dredging practices;
- recommendations for prevention of erosion to islands within and adjacent to the dredge areas;
- assessment of suitability of current areas of beach nourishment;
- Identification of appropriate beach nourishment methods for the project and determination of the pipe outlet for deposition.

The opportunity is also taken in this letter to address a number of comments on the proposed dredging outlined in correspondence from The Entrance Community Precinct Committee, which



LEGEND:

- APPROXIMATE DREDGE FOOTPRINT
- LOCATION OF BEACH NOURISHMENT AREAS
- LOCATION OF FIXED DISCHARGE PIPELINE

0 200 m
SCALE

WorleyParsons
resources & energy

EcoNomics™

File Identity : N:\7291 Tuggerah Lake Entrance\11.0 Drawings\Drgs\COASTAL\Figure_1.dwg

Source :

Base Photo: Copyright WSC 2006

Date Modified : 07/07/2009 03:51:44 PM

NORTH

PROPOSED DREDGE FOOTPRINT AND BEACH NOURISHMENT AREAS

FIGURE 1

were based on a report prepared on behalf of the Committee by Mr Rod Slater. These comments were as follows:

- the proposed area of dredging does not appear to be based on a detailed hydraulic study of the channel and the entry to the ocean;
- the proposed channel is directed towards a rock shelf which will result in a very inefficient outflow and inflow, thus not achieving optimum tidal exchange;
- the proposed channel finishes approximately 100 metres short of the shoreline and again will achieve only minimal tidal exchange;
- no mention is made of a programme to remove the sand plug to the ocean, even in the event of a major flood.

1. REVIEW OF ISSUES RAISED IN COUNCIL'S BRIEF

1.1 Use of M2 Tidal Constituents as a Decision Support Tool for Commencement of Dredging

The decision support tool was developed on behalf of Wyong Shire Council by the NSW Department of Commerce Manly Hydraulics Laboratory (MHL) and can be found at: http://www.mhl.nsw.gov.au/www/tugg.htmlx. It is understood from discussions with MHL (Mr Bronson McPherson) that the only background information available for the tool is a letter prepared by MHL to Mr Tom Wallace at Council dated 15 July 2004 (refer **Attachment A**).

The basis for the decision support tool is that a relationship has been shown to exist between the M2 tidal constituent and the degree of constriction of an estuary entrance (demonstrated by MHL for Lake Conjola on the NSW South Coast), which can potentially be utilised for entrance management purposes such as selective dredging.

Even though the decision support tool has potential, it is not considered to offer the only or necessarily the best means of determining when dredging at The Entrance should be undertaken, for a number of reasons:

- the relationship at Tuggerah Lakes Entrance between the M2 tidal constituent and the occurrence of dredging, at least over the example period provided in the MHL letter, does not appear to be a particularly strong relationship. This is likely to be because the M2 tidal constituent, and the tidal range generally, is small in magnitude and does not appear to vary markedly in response to the range of entrance conditions at times when the entrance is open;
- the entrance area is located a relatively short travel distance from the Council offices and thus allows the ready opportunity for regular visible observation of entrance conditions, rather than reliance on a remote decision tool;
- the Council has a dredge crew with long experience of The Entrance conditions, who can often predict the need for dredging in advance and thereby ensure time for pre-dredging activities such as survey, if required, and checking of plant and equipment;
- a number of other factors can influence the timing of the dredging, not just the level of entrance constriction although this is clearly important. Some of these other factors include social factors, eg. recreation (avoidance of peak summer periods), and environmental factors, eg. avoidance of breeding and nesting times of Little Terns. On occasions, pre-emptive dredging may be required, ie. prior to an M2 decision tool trigger, when a deteriorating entrance situation can be observed and a future timing constraint on dredging is apparent.

In summary, it is considered that regular direct observation of the entrance conditions and assessment of other factors that influence the timing of the dredging will be the prime determinants of when dredging should take place for the foreseeable future. At the same time, it is suggested that the M2 decision support tool not be abandoned at this time. It would be useful for Council to update, and continue to update, the temporal pattern of the M2 tidal constituent and dredging history illustrated for the year 2000 in the MHL letter (**Attachment A**) and review this over time.

1.2 Identification of Appropriate Trigger Values and Improvements to the Current Decision Support Tool

On the basis of the response in **Section 1.1** above, identification of an appropriate trigger value for the M2 tidal constituent decision support tool is not considered relevant at this time.

Given that direct observations of the entrance conditions are considered to form the best decision support tool for initiation of dredging, the following trigger values are suggested. Due to the variability of entrance conditions it is recommended these triggers be adopted as a trial and re-evaluated over time.

- the throat[1] of the channel at the entrance reduces to an estimated width of less than 15m measured at mid tide level, and/or
- the flood tide sand shoals threaten to block[2] the ebb tide dominant channel along the northern/eastern side of the entrance area, and/or;
- the flood tide sand shoals threaten to block[2] the main channel east of the bridge.

Adoption of the above triggers may necessitate some survey of the entrance area over time. As discussed in our earlier advice to Council dated 1 April 2008, regular surveys would provide valuable information for refinement of the trigger values and the dredging strategy generally, and a continued understanding of the physical processes in the entrance area including quantification of these processes.

1.3 Investigation of the Past Exceedances of the Environmental Protection Licence (EPL) Limits and Identification of Potential Necessary Revisions to the EPL

The EPL requires monitoring of the pH of the slurry at the discharge point of the pipeline in the nourishment area, within 30 minutes of the start-up of the dredge each day. The licence limits for pH are 6.5 to 8.5 (slightly acidic to slightly alkaline).

The only exceedance of the EPL limits during past dredging is understood to be a single reading of pH 8.6, ie. slightly more alkaline than the EPL limit. The reason for the exceedance was not apparent. It is of interest that the exceedance related to an alkaline condition rather than an acidic condition which is generally of greater concern, as it may be indicative of the oxidation of potential acid sulphate soils.

The single slight exceedance of the EPL limit in the monitoring data is not considered to be a significant environmental concern nor warrant revisions to the EPL. The licence limits for pH of 6.5 to 8.5 are typical for dredging projects in estuarine environments.

---

[1] The throat is that section of the channel near the southern tip of the sand spit having minimum cross-section dimensions.

[2] Some judgment would be required to assess when actual blockage could occur so as to allow adequate time to initiate dredging and avoid constraints such as peak recreational use of the waterway and ecological impacts, eg. Little Tern breeding and nesting.

1.4 Assessment of the Potential for Erosion to Islands within and adjacent to the Dredge Areas as a Result of Current Dredging Practices

Dredging takes place adjacent to two islands; within the Terilbah Channel adjacent to Terilbah Island and adjacent to Yellawa Island for the formation of the 'sump' immediately downstream of the Central Coast Highway Bridge and for maintenance of the northern channel downstream of the Terilbah Channel.

Terilbah Island

Terilbah Channel has been dredged on three occasions since maintenance dredging commenced in 1993, the last occasion in 2008, ie. the frequency of dredging is about every five years.

History has demonstrated that the past dredging practices within the Terilbah Channel have not led to any erosion of Terilbah Island. The extent of dredging (depth, width, distance upstream) has been aimed at simply re-establishing the natural channel cross-section and thereby has not altered the hydrodynamic and sediment transport behaviour within the channel beyond the natural tidal regime conditions.

Providing future dredging within Terilbah Channel remains consistent with past dredging practices, erosion issues along Terilbah Island would not be anticipated. Visual monitoring of the Island foreshore by Council staff for any signs of erosion should continue.

Yellawa Island

Current practice is for dredging of the sump immediately downstream of the Central Coast Highway Bridge to take place every year, and for dredging of the northern channel downstream of the Terilbah Channel to take place every two years. The purpose of the sump is to trap sand migrating upstream on the flood tide thereby mitigating the need for dredging upstream of the bridge.

Some concerns are understood to have been raised by the community regarding the possibility that dredging activities have caused erosion of Yellawa Island and that continued erosion of the Island may result in loss of the Canary Island date palm on the Island, which is of cultural significance. This palm is located on the western side of the Island adjacent to the sump.

It is understood that Council staff, in late 2008, inspected a photograph of Yellawa Island taken in 1934 which indicates there has been no significant erosion of the island over the 74 year period 1934-2008. In addition, it is understood Council staff undertook a comparison of vertical aerial photographs taken of the Island in December 2003, February 2007, May 2008 and August 2008, which showed no apparent evidence of erosion over this five year period.

Notwithstanding the findings of the photographic analysis undertaken by Council staff, dredging of the sump takes place very close to the Island and there is considered to be a risk of foreshore erosion by means of undercutting or regrading of the underwater dredge batters. While the concept of a sump is considered generally beneficial to management of sedimentary processes, that portion of the sump that lies in the flood tide 'shadow' zone behind Yellawa Island may not be capturing a significant proportion of the overall flood tide sediment transport approaching the bridge.

Taking a precautionary approach, it is recommended that the current dredging practice is revised so that the portion of the sump in the flood tide shadow zone behind Yellawa Island is not dredged in future campaigns. Infilling of this portion of the sump should be monitored by survey.

Monitoring of the shoreline of Yellawa Island by Council staff should also continue, by visual means, review of aerial photography and by survey if required.

Subject to the findings of the monitoring programs, which should be documented, dredging of the portion of the sump behind Yellawa Island could be possibly re-introduced in the future.

1.5 Recommendations for Prevention of Erosion to Islands within and adjacent to the Dredge Areas

In accordance with the discussion in **Section 1.4** above, the following is recommended to prevent erosion of the subject Islands:

- future dredging of Terilbah Channel should be consistent with the dredging practices employed over the past 15 years, and the shoreline of Terilbah Island should be visually monitored; and

- the portion of the sump in the flood tide shadow zone behind Yellawa Island should not be dredged in future campaigns. The sump infilling behaviour should be monitored by survey. Monitoring of the shoreline of the Island should also take place, by visual means, review of aerial photography and by survey if required.

1.6 Assessment of Suitability of Current Areas of Beach Nourishment

The current areas of beach nourishment comprise:

- North Entrance Beach, which is nourished on an annual basis, ie. each dredging campaign, using sand dredged from the downstream sections of the entrance area;

- the so-called estuary eastern beach, along the foreshore downstream of the Dunleith Caravan Park adjacent to Karagi Foreshore Park. This area is nourished on an annual basis using sand dredged from the upstream sections of the entrance area and, approximately every five years, by sand dredged from Terilbah Channel; and

- The Entrance Beach, which is nourished on a less frequent (as required) basis, generally every five years, using sand dredged from the downstream sections of the entrance area.

Selection of the above three areas is considered to represent a sensible balance between practical issues such as available pumping distances, an understanding of coastal processes such as the movement of sand in the entrance area and adjacent beaches, and social and ecological objectives, eg. maintenance of beach amenity and foreshore habitats. As such, all current nourishment areas are considered to remain suitable for ongoing beach nourishment purposes.

1.7 Identification of Appropriate Beach Nourishment Methods for the Project and Determination of the Pipe Outlet for Deposition

The method of beach nourishment employed by Council generally involves pumping the dredge slurry to the nourishment area, discharge of the slurry in a manner to avoid localised erosion (spraying upwards to dissipate energy), and spreading and shaping of the sand by dozers, after some initial dewatering and drying, to achieve a natural profile.

It is important that the cross-shore and alongshore profiles be as natural as possible so as to avoid a ‘disequilibrium bulge’ in the sand profile (in cross-section or in plan) which can lead to rapid readjustment of the profile and apparent ‘loss’ of sand, and the formation of potentially dangerous, overly high and steep, scarps. The desired profiles can be established from land survey data or photogrammetric data based on natural profiles taken under ‘beach full’ conditions. When re-creating dune profiles the seaward slope should typically not exceed 1 vertical : 5 horizontal.

The location of the pipe outlet for deposition is most critical in the case of nourishment of North Entrance Beach. Along this beach, in the typical vicinity of Hargraves Street, is a so-called 'null point' which defines the position at which sediment transport along the beach is to the north (away from the estuary entrance) as opposed to the south (towards the estuary entrance). Advice to Council since commencement of the dredging in the early 1990's has been to generally place material south of the null point so that dredged material is maintained within the local sand circulation system at the entrance[3].

The location of the fixed dredge pipeline and outlet onto North Entrance Beach is well south of Hargraves Street and thus complies with the above advice. Depending on the location of the null point at the time, extension of the pipeline to the north would be possible, subject to any practical pumping distance limitations.

In the event that sand was continually placed to the north of the null point and thereby lost to the local sand circulation system at the entrance, there would be a net reduction over time in the quantity of sand in the entrance area. While on the one hand this may be seen to be advantageous, it also needs to be recognised that the existence of the sand spit and flood tide shoals are the natural controls on lake levels and protection of upstream areas from ocean storms.

The periodic dredging and return of material to North Entrance Beach south of the null point is aimed at maintaining the natural sedimentary processes as much as possible, but augmenting the processes to address the bias for flood tide sediment transport, thereby keeping an entrance of typical dimensions open for longer periods.

2. COMMENTS ON REPORT OF MR ROD SLATER

2.1 The Proposed Area of Dredging does not appear to be based on a Detailed Hydraulic Study of the Channel and the Entry to the Ocean

A range of hydraulic and sedimentary processes studies have been undertaken of the entrance area (refer **References**). These studies have included the trial dredging program in 1991 and an entrance conditions monitoring program in 1991 and 1992. In addition, the behaviour of the entrance area in response to actual dredging activities has been observed by Council staff for the past 15 years.

---

[3] There is a circulation of sand involving the entrance sand bar, entrance sand spit and the upstream sand shoals. As the transport of sand by the flood tide is assisted by wave action, there is more sand, on average, going onto the upstream entrance shoals than leaves them. Hence they gradually build up over time.

When the entrance channel is wide, tidal flows are strong and they can carry the sand almost to the bridge. However as the upstream sand shoals grow, they gradually throttle tidal flows and the limit of effective sand movement retreats towards the entrance throat. This gradual contraction of the area of active sand movement, as an entrance heads towards closure, is a feature of all unstable estuary entrances.

A local southerly reversal of littoral drift causes the entrance sand spit to grow southwards. This forces the entrance channel and throat onto the southern rock shelf. As the entrance channel and throat narrows, against the southern rock shelf, tidal flows are restricted even further. Ultimately, the throat can become so narrow and tidal flows so weak, that the entrance sand bar can move onshore and close the entrance.

Floods rejuvenate the closure cycle by scouring a wide and relatively deep channel through the entrance sand spit. Floods generally remove a substantial portion of sand from the surface of the upstream entrance shoals. They may even cut a pronounced channel through them. After a flood, the wide, scoured entrance allows strong tidal flows which promote rapid sand infeed and the process of build up of the entrance shoals and southerly migration of the sand spit, leading to throttling of the entrance, commences anew. Thus the cycle repeats itself.

The observations during the trial dredging in 1991 and over the past 15 years essentially represent direct feedback from a 1:1 scale model of the study area. As such, they form a powerful tool for the design of the proposed maintenance dredging and a basis for prediction of outcomes.

2.2 The Proposed Channel is directed towards a Rock Shelf which will result in a very Inefficient Outflow and Inflow, thus not achieving Optimum Tidal Exchange

The proposed alignment of the channel along the northern / eastern side of the entrance area has been selected to enhance the natural ebb tide flow in the estuary. It is directed toward the rock shelf on the southern side of the entrance because this is the natural alignment of the channel prior to it making a rapid turn to flow to sea.

As noted in **Footnote 3**, the entrance channel is naturally forced toward the southern rock shelf due to the southerly growth of the sand spit, as a result of the local net littoral drift to the south along North Entrance Beach. The existence of the rock shelf in fact assists in maintaining the entrance channel open by training the flows on one side.

To direct the channel to a location where it is not as naturally stable, such as through the central portion of the sand spit, could be expected to result in more rapid closure.

The proposed channel alignment is considered to provide the optimum tidal exchange in that it seeks to generally mimic the natural entrance under typical conditions and therefore keep the entrance open for as long as possible. Other dredging scenarios might generate greater tidal exchange but over a shorter time period. It is also noted that increasing the tidal exchange beyond that which typically occurs naturally can have significant effects on the mean lake level and lake tidal range and adversely affect lake ecology.

2.3 The Proposed Channel finishes approximately 100 metres short of the Shoreline and again will achieve only Minimal Tidal Exchange

Practice has shown that it is not necessary to dredge the channel all the way to the shoreline. This is because the energy in the ebb tide flow naturally scours the remainder of the sand. This is one of the reasons why dredging of the ebb tide dominant channel proceeds in a downstream direction.

2.4 No Mention is made of a Programme to Remove the Sand Plug to the Ocean, even in the Event of a Major Flood

It is not the intention of the proposed dredging to remove the ‘sand plug to the ocean’ (presumably meaning the sand spit). As noted earlier, the intention of the dredging is to sustain an entrance representative of average or typical tidal conditions.

The sand spit is naturally scoured during major flood events. It is not practical or necessary to undertake dredging of the sand spit in the event of a major flood.

3. REFERENCES

1. *“Tuggerah Lakes Entrance Improvements Investigation of a Mobile Dredge System”* prepared by Patterson Britton & Partners Pty Ltd for Wyong Shire Council, August 1990
2. *“Tuggerah Lakes Entrance Improvements Dredging Trial (April to May 1991)”* prepared by Patterson Britton & Partners Pty Ltd for Wyong Shire Council, June 1991
3. *“Tuggerah Lakes Entrance Improvements – Tender for Detailed Design, Manufacture, Supply and Commissioning of a Mobile Dredge System for the Entrance to Tuggerah Lake”* prepared by Patterson Britton & Partners Pty Ltd for Public Works Department, October 1991

4. *"Tuggerah Lakes Entrance Monitoring Program (December 1991 to February 1992)"* prepared by Patterson Britton & Partners Pty Ltd for Public Works Department, March 1992
5. *"Tuggerah Lakes Entrance Improvements – Detailed Design, Manufacture, Supply and Commissioning of a Mobile Dredge System for the Entrance to Tuggerah Lake – Tender Evaluation"* prepared by Patterson Britton & Partners Pty Ltd for Wyong Shire Council, May 1992
6. *"The Tuggerah Lakes Restoration Project – Status Report as of June 1992"* prepared by Patterson Britton & Partners Pty Ltd for Wyong Shire Council, December 1992
7. *"Tuggerah Lakes, Entrance Training Walls: Technical Discussion"* prepared by Patterson Britton & Partners Pty Ltd for Wyong Shire Council, April 1994

I trust the above information satisfies Council's current requirements. Please do not hesitate to contact me should you require any clarification or additional information.

Yours faithfully
WorleyParsons

Greg Britton
Select Manager, Coastal and Marine (Southern Operations)

Attachment A - MHL Letter Regarding Tuggerah Lakes Decision Support Tool

Manly Hydraulics Laboratory

NSW Department of Commerce
110B King Street
Manly Vale NSW 2093

Telephone 02 9949 0200
Facsimile 02 9948 6185
TTY 1300 301 181

ABN 54 625 095 406
www.mhl.nsw.gov.au

Mr Tom Wallace
Wyong Shire Council
P.O. Box 20
Wyong 2259
15th July 2004

Dear Tom

The Tuggerah Lakes Entrance Decision Support System (DST)

Manly Hydraulics Laboratory (MHL) was commissioned by Wyong Shire Council (WSC) to undertake investigations into a Decision Support Tool (DST) for the entrance management procedures of the Tuggerah Lakes Estuary.

Background

Tuggerah Lakes is located about 100 km north of Sydney and has a catchment area of approximately 790 km^2. The estuary comprises three inter-connected lakes; Tuggerah Lake, Lake Budgewoi and Lake Munmorah. The total area of the lakes is 80 km^2 and is shallow with an average depth of only 1.9 m. The lake water level, which is affected by rainfall more than tide, varies between 0.0 and 0.5m above mean sea level in dry weather and up to 2.2m for 100yr ARI floods (2.1m in 1949). At present the entrance to Tuggerah Lakes is intermittently/mechanically opened and untrained.

The source of the data used for the analysis is council's ALERT system gauge No 7411 located at The Entrance Boathouse about 30 m west of The Entrance Bridge. Council will keep the diary log including the data about dredging dates in Council's file that deals with Tuggerah Lakes Entrance Decision Support Tool.

Decision Support System

MHL conducted a harmonic analysis of the tide levels in Tuggerah Lakes to determine its tidal constituents, in particular the amplitude of the M2 constituent. M2 is the principal semi-diurnal constituent that represents the rotation of the earth with respect to the moon. In layman terms, it is approximately the average daily amplitude of the tide. It has previously been determined that the M2 tidal consituent shows a good correlation with the level of constriction of the entrance. This relationship is based on observations and records of rainfall and storm events in Lake Conjola. As the entrance begins to be constricted by sand deposition the M2 tidal constituent in the lake is reduced. Long-term monitoring of the tidal range recorded by a water level recorder in the entrance channel therefore provides an easy means of detecting shoaling of the entrance.

The Decision Support System is operated by MHL on behalf of Wyong Shire Council. A real time web based monitoring system with this information has been developed and displays a rolling assessment of M2 tidal constituent and dredging dates against time. The following figure gives a year example.

Yours Sincerely

David van Senden
Manly Hydraulics Laboratory

Note for Council
To operate council should record dredge dates and pass over to MHL yearly. Notes should be kept about relevant events such as breakouts, flood and ocean storms.

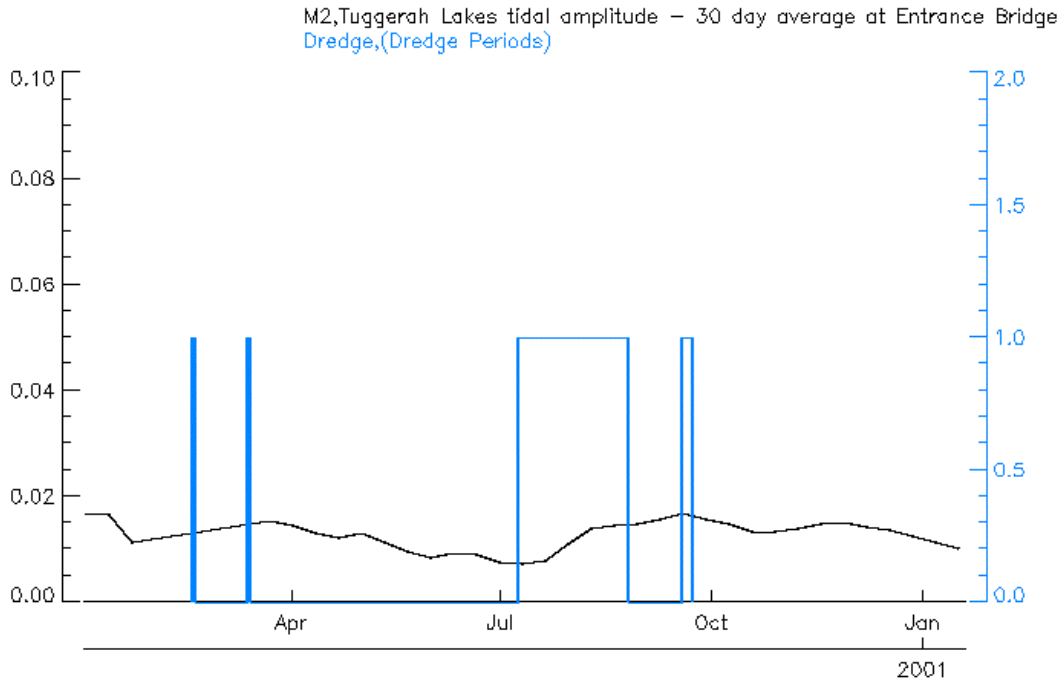


Figure 1: Example of a web-based plot showing M2 tidal constituents and dredging dates against time.

Appendix 6 Threatened Species – Assessment of Significance

Threatened species, populations and ecological communities are listed under Schedules 1, 1A and 2 of the *Threatened Species Conservation Act 1995* (TSC Act) and Schedules 4, 4A and 5 of the *Fisheries Management Act 1994* (FM Act).

Those species and communities which have been recorded in the study area or which are likely to have habitat in the vicinity of the area to be affected by the proposed works are listed in **Table 1**. No threatened populations were identified.

Table 1 Threatened, Populations and Ecological Communities scheduled under the FM Act and the TSC Act recorded in the vicinity of the proposed works.

Threatened Species	**CommonName**	**Status**	**Relevant Act**	**Likelihood of occurrence**
Carcharius taurus	Grey nurse shark	Critically endangered	FM Act	Potentially
Pristis zijsron	Green sawfish	Presumed extinct	FM Act	Potentially
Carcharadon carcharias	Great white shark	Vulnerable	FM Act	Potentially
Epinephelus daemelii	Black cod	Vulnerable	FM Act	Potentially
Eubalaena australis	Southern Right Whale	Vulnerable	TSC Act	Unlikely
Megaptera novaeangliae	Humpback Whale	Vulnerable	TSC Act	Unlikely
Chelonia mydas	Green Turtle	Vulnerable	TSC Act	Potentially
Physeter macrocephalus	Sperm Whale	Vulnerable	TSC Act	Unlikely
Arctocephalus forsteri	New Zealand Fur-Seal	Vulnerable	TSC Act	Unlikely
Arctocephalus pusillus doriferus	Australian Fur-Seal	Vulnerable	TSC Act	Unlikely
Macronectes giganteus	Southern Giant-Petrel	Endangered	TSC Act	Unlikely
Charadrius mongolus	Lesser Sand Plover	Vulnerable	TSC Act	Likely
Sterna albifrons	Little Tern	Endangered	TSC Act	Likely
Calidris tenuirostris	Great Knot	Vulnerable	TSC Act	Likely
Limicola falcinellus	Broad-billed Sandpiper	Vulnerable	TSC Act	Likely
Xenus cinereus	Terek Sandpiper	Vulnerable	TSC Act	Likely
Haematopus fuliginosus	Sooty Oystercatcher	Vulnerable	TSC Act	Likely
Haematopus longirostris	Pied Oystercatcher	Vulnerable	TSC Act	Likely
Ninox strenua	Powerful Owl	Vulnerable	TSC Act	Unlikely
Tyto novaehollandiae	Masked Owl	Vulnerable	TSC Act	Unlikely
Endangered Ecological Communities		**Status**	**Relevant Act**	**Likelihood of occurrence**
Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions		Endangered	TSC Act	Likely
Littoral Rainforest in the NSW North Coast, Sydney Basin and South East Corner Bioregions		Endangered	TSC Act	Unlikely
Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions		Endangered	TSC Act	Unlikely

Several of the species including whales, fur-seals, giant petrel's and owls are unlikely to utilise the habitat provided within the study area or be influenced by off-site impacts from the proposal. Similarly, no impact to the endangered ecological communities including Littoral Rainforest and Swamp Oak Floodplain forest is expected from the proposed works.

The remaining species, populations and ecological communities are subject to *assessments of significance* under Section 5A of the *Environmental Planning and Assessment Act 1979*

(EP&A Act). Information obtained for these assessments has been obtained from the following websites unless otherwise cited:

- http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/home_species.aspx
- http://www.environment.nsw.gov.au/threatenedspecies/ThreatenedSpeciesPublications.htm
- http://pas.dpi.nsw.gov.au/Species/All_Species.aspx

Assessment of Significance for the Grey Nurse Shark

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Grey nurse sharks (*Carcharius Taurus*) are generally found in groups in inshore coastal waters in the vicinity of rocky reefs or islands. The species are generally found in groups in inshore coastal waters in the vicinity of rocky reefs or islands.

The shark typically mates in Autumn and gives birth in winter at aggregation sites. They generally aggregate in rocky caves or sandy-bottomed gutters in water depths of 15-40m. There are fourteen known aggregation sites along the NSW coast with these characteristics, the nearest being at Little Broughton Island (north of Nelson Bay) and at Magic Point, Sydney.

Relevant habitat within the study area for Grey burse sharks would be limited to the reef offshore of The Entrance Channel. This area is not a known aggregation site. Impacts to this area are considered unlikely as turbidity from the works would be quite localised due to the sandy nature of the material being dredged. These factors indicate that there would be no risk of any viable local population of the grey nurse shark being placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

While not listed as an endangered population under NSW legislation, the east coast population of the grey nurse shark is listed as critically endangered under the Commonwealth Environment Protection Biodiversity Conservation Act 1999 (EPBC Act). Due to lack of suitable habitat likely within the study area that would be impacted by the proposal, the east coast population of the grey nurse shark is unlikely to be placed at risk of extinction.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

Preferred habitat for the grey nurse shark includes inshore reefs and sandy bottom gutters at depths of 15-40m. Such habitat would not be removed, modified, fragmented or isolated during the proposed works.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No known aggregation sites occur within the study area. Known aggregation sites along other areas of the east coast of NSW have been declared critical habitat for the species however no impact to these sites would occur as a result of the proposed works.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan for the species is in draft form. The overall objective of this plan is to prevent the extinction and ensure the recovery and ongoing viability in nature of grey nurse shark populations along the entire NSW coast. Other objectives include the addressing of key threats, provision of habitat protection at aggregation sites, improving understanding and increasing awareness of the ecology, status and threats to the grey nurse shark populations, and ongoing monitoring.

Priority recovery strategies listed by DPI (Fisheries) and by the Commonwealth of Australia for the grey nurse shark include: dissemination of information, survey and mapping, research, monitoring, fisheries management regulation, community awareness/education, and of most relevance, habitat protection of aggregation sites.

The proposed works would not interfere with the objectives or actions of the recovery plan or of the priority recovery strategies identified for the species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The proposed works have no association with a key threatening process with regards to the grey nurse shark.

<u>Assessment of Significance for the Green Sawfish</u>

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The green sawfish (*Carcharius Taurus*) favours shallow inshore areas with muddy or sandy-mud bottoms and estuarine areas such as is present within The Entrance Channel and adjacent areas in the Tuggerah Lakes. The proposed study area is within the natural distribution range of the species which is now assumed extinct.

If individuals or populations of the species were present within the study area during the proposed works, these individuals would potentially be impacted by turbidity associated with the works and alteration of the small area of habitat available in The Entrance Channel. However the proposed dredging would also facilitate the use of the Tuggerah Lakes estuary for the species which would otherwise be closed to the marine environment due to the shoaling sands prograding across The Entrance Channel.

Therefore, the works would have a beneficial impact to any viable local population of the species due to an increase in available habitat area.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

A small area of habitat (ie. shallow inshore areas with muddy or sandy-mud bottoms) would be modified as a result of the proposed works. These modifications would allow for the mobility of the species between the estuary and the open ocean and therefore increase the habitat availability of the species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the species is listed.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan has been prepared for the species. However, key actions which would be incorporated into such a plan would include reduction of fishing impacts, education of fishers, and further research into the ecological requirements of the species. The proposed works do not interfere with these actions.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The proposal does not constitute a key threatening process in regards to the green sawfish. However, several threats to the species have been identified including accidental by-catch, deliberate capture and degradation of soft bottom habitats. Modifications to small areas of soft bottom habitat would be expected within The Entrance Channel due to the proposed works however it is considered that these works would substantially increase the habitat area available for the species.

<u>Assessment of Significance for the Great White Shark</u>

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The great white shark (*Carcharadon carcharias*) is a highly mobile species which is typically found in the vicinity of inshore rocky reefs and islands. The species is more common off the southern coast of Australia than in temperate waters in NSW. Relevant habitat within the study area would be limited to the reef offshore of The Entrance Channel.

No impacts to this habitat in would be expected due to the proposed works (refer **Section d** below). As such, no impacts to the life cycle of the species are likely and the species is unlikely to be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

Impacts to the typical habitat of the great white shark (inshore rocky reefs and islands) are considered unlikely as a result of the proposal. Due to the sandy nature of the material being dredged, any turbidity impacts from the proposed works would be localised within the Entrance Channel and within areas directly adjacent to the proposed beach nourishment areas.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

There is no listed critical habitat for the great white shark.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan for the species is available. However, priority recovery strategies include fisheries management regulations and community and landholder liaison, awareness and education. These proposed works do not conflict with these strategies.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The proposal does not constitute a key threatening process as determined by the Fisheries Scientific Committee.

<u>Assessment of Significance for the Black Cod</u>

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The study area is within the natural distribution range of the black cod (*Epinephelus daemelii*). Relevant habitat for territorial adults in the study area include caves and beneath bomboras which may be associated with the reef offshore of The Entrance Channel. The reef would also provide typical habitat for juveniles which are generally found in coastal rock pools and rocky shores around estuaries. No impacts would be expected to the offshore reef as a result of the proposed works.

Juveniles fish also utilise estuarine nursery habitats such as found within the Tuggerah Lakes estuary. Impacts to juveniles may be expected from temporary increases in turbidity in the estuary, and the removal of some seagrass areas which may provide nursery habitat.

However, the dredging would also facilitate the movement of juveniles into the estuary and the large areas of nursery habitat provided within.

The proposed works would therefore result in a beneficial impact to any viable local population of the species. No viable local population of the species would be placed at risk of extinction from the proposed works.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

Limited modification to nursery habitat within the estuary would be expected due to the removal of small areas of seagrass within the dredge footprint and as a result of temporary and localised increases in turbidity.

The proposed works would not result in the fragment or isolation of habitat but would rather remove these barriers to the population associated with the closing of The Entrance Channel due to the natural prograding of the sand shoals.

Estuarine nursery habitat is important to the long-term survival of the species and the proposed works would assist in the preservation of this habitat.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the species is listed.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan for the species has been prepared. However, priority recovery strategies for the species include research, fisheries management regulations and the preparation of a recovery plan. The plan would be likely to incorporate the conservation and restoration of estuarine nursery habitat. The proposed dredging works are consistent with this action through maintaining passage for the species between the ocean and estuarine habitats and through the maintenance of the tidal range and water quality characteristics necessary for the continuing health of estuarine nursery areas.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

No key threatening processes are listed as relevant to the species. However, known threats to the species include fishing, loss of estuarine nursery habitat and lack of research into their biology and diet. The proposal would not increase impact from these threats.

Assessment of Significance for the Green Turtle

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The coastal waters of the NSW central coast are within the natural distribution range of the green turtle (*Chelonia mydas*). The species is known to occasionally reside in one area for prolonged periods of time. The species nests on beaches where eggs are laid in hole dug in the sand. Several nesting sites have been recorded on northern NSW beaches however nesting sites are generally found north of latitude 27° (Cogger, undated).

Existing disturbance to the proposed beach nourishment areas would negate the use of these areas as nesting sites. No known nesting sites for the turtle occur within the study area. Therefore, no viable local population of the species is at risk of extinction from the proposed works.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The seagrasses within the Tuggerah Lakes estuary could potentially provide habitat for the green turtle. The dredging and removal of small areas of seagrass from The Entrance Channel would not result in the fragmentation or isolation of habitat for the species. However the proposal may increase the availability of habitat for the species by maintain passage for the species from the ocean to the greater seagrass areas available within the estuary.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat is listed for the species.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

There are 17 priority actions which have been identified for the recovery of the species. The proposed works do not compromise the success of these actions.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The proposal is not recognised as a key threatening process in regards to the green turtle.

References:

Cogger, H. G. (undated) The Status of Marine Reptiles in New South Wales. A report prepared for the New South Wales National Parks and Wildlife Service.

<u>Assessment of Significance for the Little Tern</u>

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Little Tern (*Sterna albifrons*) is a partly migratory seabird which migrates from eastern Asia to Australia. In NSW, the species generally arrives between September and November.

Sheltered coastal locations associated with dunes, wetlands, harbours, inlets and rivers are favoured by the species. The species feeds in the shallows of channels and estuaries such as the intertidal areas around Terilbah Island (refer **Photo 1**), and in the surf zone. These areas are not expected to be significantly impacted by the dredging works.

The Little Tern generally breeds from October to May and nests in solitary breeding pairs or in colonies near the mouths of estuaries on low dunes or just above the high mark on sandy beaches. Incubation and fledging of young takes approximately four to five weeks. The species is generally present up until May however some sightings have also been recorded during winter.

A known nesting site for the species is located on The Entrance sand spit at Karagi Point. This site is one of 18 nesting colonies that were established along the NSW coastline during a study of six breeding seasons from 1998/99 to 2003/04. No direct disturbance is proposed to this area, however Council aim to complete dredging prior to the summer holiday periods regardless which avoids much of the breeding season. However, the nesting site is susceptible to predation, sea surges, wind-storms, flooding and human disturbance. The site is monitored and fenced off by Council during the breeding season to minimise human disturbance. As the proposed dredging works would encourage flooding through the existing mouth of the channel rather than overtopping of the sand spit, the risk of flooding to the known nesting site would be reduced.

No impact to the life cycle of the local migratory population is expected and therefore the proposed works would not place the population at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

No habitat is likely to be removed, fragmented or isolated due to the proposed works. Modifications to the nesting habitat located on The Entrance sand spit would take the form of fencing to prevent disturbance by humans. However this measure has successfully been implemented in recent breeding seasons since the re-emergence of a successful nesting colony at The Entrance following a 50 year absence.

The dredging would also result in the preservation of the existing tidal regime in the estuary. This is important in terms of the availability of foraging habitat and species composition available in foraging areas.

The nearest known nesting colonies are at Taree and in Botany Bay.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the species is listed.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

In-situ habitat management including physical protection of habitat is a primary objective of the Little Tern Recovery Plan. This proposal is consistent with this objective including:

- the minimisation of disturbance to nesting sites from estuary openings. The overtopping and erosion of The Entrance sand spit which may potentially occur during flooding is minimised by encouraging a more formal entrance to the estuary through the dredging of The Entrance Channel. In addition, the spit is protected from erosion through the beach nourishment activities proposed at North Entrance Beach as the sand placed in these areas would naturally drift south, encouraging the protection of the sand spit.

- the minimisation of human disturbance. This would be achieved through the completion of the majority of the dredging and beach nourishment activities prior to the start of the spring-summer breeding season.

The proposed works would not intervene with the other recovery objectives including survey, monitoring, research and education.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

No key threatening processes have been listed in regards to the species.
However, the threat from habitat loss/ change has been identified. This threat is associated with the “alteration to the natural flow regimes of rivers, streams, floodplains & wetlands” which is listed as a key threatening process. Rather than altering the hydrological regime of The Entrance Channel, the proposed works would maintain the existing tidal regime and the preservation of the existing wetland habitat areas.

References:

Keating, J., and Jarman, M. R. (2004) Little Terns in New South Wales: A Six Year Review; Breeding Seasons 1998/99 to 2003/04. Report Prepared for the Department of the Environment and Conservation.

<u>Assessment of Significance for the Sooty Oystercatcher</u>

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Sooty Oystercatcher (*Haematopus fuliginosus*) is found in small numbers along the entire NSW coast.

The species is non-migratory and is present year round. Breeding takes place in spring and summer almost exclusively on offshore islands and remote rocky outcrops. No such areas are present within the study area.

The species otherwise favours rocky headlands, rock shelves, exposed reeds, beaches and estuaries. Foraging generally occurs at low tide on exposed rocks but also on sandy beaches near intertidal mudflats. Habitat present within the proposed study area includes the reef offshore of The Entrance Channel, rocky headlands to the south of The Entrance Beach, and intertidal areas within the estuary. The proposed works would have no impact to the preferred rocky habitat areas and would not impact on intertidal areas other than to maintain the existing tidal regime. It is therefore unlikely that any viable local population of the species would be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The proposal would not result in the removal, modification, fragmentation or isolation of any habitat for the species, other than to maintain the existing hydrological regime of the estuary which is important for the preservation of intertidal flats which are occasionally used for foraging.

The long-term survival of the species would not be adversely impacted by the proposed works.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat for the species is listed.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan is available for the species. However several priority recovery strategies have been identified. The proposal would not interfere with these strategies and would be consistent with the strategies for the maintenance of natural hydrological regimes and maintenance of known habitat.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

No key threatening processes are listed for the species. However the proposed works would minimise the threat associated with changes to the hydrological regime within the estuary by ensuring maintenance of the tidal characteristics and minimising flooding.

<u>Assessment of Significance for Pied Oystercatcher</u>

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Pied Oystercatch (*Haematopus longirostris*) is a non-migratory species, found year round scattered thinly along the NSW coast. The species is typically found foraging above the high water mark of exposed sand beaches or sand bars or of the margins of estuaries at low tide. Roosting habitat includes sandy beaches, spits and dunes or sheltered bays near mudlfats. The species breeds in pairs between August and January, nesting on coastal estuarine beaches and occasionally in saltmarsh or grassy areas.

The Entrance Channel provides typical foraging, roosting and nesting habitat for the Pied Oystercatcher. Two pairs have been noted to reside in the estuary in recent years with one pair frequenting The Entrance/ Chittaway Point area (Morris, as cited in Roberts and Dickinson, 2005).

So long as any nesting sites that may be identified in the study site are protected, the proposed works are unlikely to impact on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction. A pre-dredging survey of all beach nourishment areas and areas which may be impacted by the pipeline or plant and equipment should be undertaken prior to the start of work in each area.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the

endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

Impacts to potential foraging, roosting and nesting habitat are expected through the dredging of a channel through the shoaling sand bars within The Entrance Channel. Due to the continually shifting nature of these sand bars, they are unlikely to contain an abundant food source for the species and their removal is unlikely to be significant in relation to the greater area of suitable habitat provided close by within the estuary. The beach nourishment activities proposed on North Entrance Beach would take place near the potential nesting habitat of The Entrance sand spit and dunes.

The majority of the works would be complete prior to the commencement of the breeding season from August to January. Provided that a pre-dredge survey of the beaches, dunes and sand spit is undertaken and protection measures such as fencing implemented to protect any identified nesting sites, the proposed beach nourishment activities are would not impact on the long-term survival of the species.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

There is no critical habitat listed for the species.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan is available for the species. However several priority recovery strategies have been identified. The proposal would not interfere with these strategies and would be consistent with the strategies for the maintenance of natural hydrological regimes and maintenance of known habitat.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

No key threatening processes are listed for the species. However the proposed works would minimise the threat associated with changes to the hydrological regime within the estuary by ensuring maintenance of the tidal characteristics and minimising flooding. Provided that survey of areas to be disturbed and management of any nests identified is undertaken, the works would not increase the impact from the threat of disturbance to nesting habitat.

References:

Roberts, D.E. and Dickinson, T.G. (2005) Tuggerah Lakes Estuary Management Study. Prepared for Wyong Shire Council and Department of Infrastructure, Planning and Natural Resources. BIO-ANALYSIS: Marine, Estuarine and Freshwater Ecology, Narara.

Assessment of Significance for Non-Breeding Migratory Birds

There are four listed non-breeding migratory birds under the TSC Act that have been recorded in the vicinity of The Entrance Channel. These include the Lesser San Plover (*Charadrius mongolus*), the Great Knot (*Calidris tenuirostris*), the Broad-billed Sandpiper (*Limicola falcinellus*) and the Terek Sandpiper (*Xenus cinereus*). Due to their many similarities in migratory habits, habitat preferences and other ecological requirements, they have been assessed in parallel.

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

All four species are known to arrive along the NSW coast from late August and September and depart between March and May. Small numbers of each species, predominantly juveniles, are also known to overwinter in NSW.

These species favour the sheltered coastal beaches, intertidal flats and spits and rock platforms such as in found within The Entrance Channel and surrounds. These species feed in intertidal areas at low tide, or in the case of the Broad-billed Sandpiper, forage by wading in intertidal flats and saltmarshes.

All four migratory species are non-breeding migrant visitors which breed in Eurasia in the northern summer and migrate south to forage in the southern hemisphere over the northern winter. These species are therefore unlikely to nest within the study area. These species are not expected to be impacted by the proposed works to the degree that any viable local population of the species is likely to be placed at risk of extinction.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The study area contains likely foraging and roosting habitat for each species in the form of intertidal flats, saltmarsh, sandy beaches, spits, rocky shores and dead trees. The proposed works would not result in the removal or adverse modification to any of these areas. Due to the erosion of sandy beach habitat in proposed beach nourishment areas, it is unlikely that these beaches would provide suitable roosting or foraging habitat. The long-term survival of these species would therefore not be impacted by the proposed works.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat is listed for these four species.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plans have been prepared for these species. However, several priority actions for the recovery of each species have been identified. These actions typically include:

- community awareness;
- survey and further research into ecological requirements;
- protection from predation (ie control of dogs);
- protection from accidental destruction;
- protection from coastal pollution;
- maintenance of natural hydrological regimes; and
- protection and maintenance of known habitat including physical protection.

The proposal would not intervene with the implementation of these actions and would be consistent with the latter two actions through the preservation of the existing tidal regime and consequently, the preservation of the existing intertidal habitats and species composition.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The proposed works do not constitute a key threatening process for the species and would not result in the operation of, or increase the impact of, a key threatening process.

Assessment of Significance for Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

No known threatened flora species have been recorded in the study area.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

No known threatened flora populations have been recorded in the study area.

c) ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

There is a narrow strip of saltmarsh vegetation fringing the eastern shoreline of Terilbah Island (refer **Photo 2**). No survey of this area has been undertaken. However, during site visits in the adjacent channel, the shoreline was observed to have a continuous bed of seagrasses, and a narrow sand margin covered in seagrass wrack behind which a dense stand of rushes is present. Likely species of rushes visible may include *Juncus krausii*, *Sarcocornia quinqueflora* and/or *Sporobolus virginicus*.

In the Wyong region, the occurrence of this ecological community is not known however the presence is predicted within the estuary and would be restricted to the intertidal zones of the estuary.

Much of the foreshore of the estuary has been highly modified or reclaimed in the past, minimising the potential environment in which this habitat can establish.

The proposed dredging works would not require any removal of saltmarsh or any placement of dredged material on saltmarsh areas. There is no evidence of erosion of the foreshore or undercutting of the bank in the vicinity of the island. No impact to the foreshore of the island

is expected from the continuation of the dredging works which have occasionally been undertaken in the channel over the past 16 years. Consequently, the proposal is not likely to adversely affect the ecological community, or substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

No removal, modification, fragmentation or isolation of the habitat would occur as a result of the proposed works. The dredging would assist in the preservation of the hydrological regime to which this ecological community has adapted.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

No critical habitat has been listed for the ecological community.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan or threat abatement plan has been listed for the ecological community. However, several priority actions for recovery have been identified including seed collection/propagation, community awareness and education, feral control, site protection, development of EIA guidelines, research, survey and mapping of communities. The proposed works would not interfere with these actions.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

No key threatening processes are listed for the ecological community. However, several threats to the ecological community have been identified including infilling, weed invasion, physical damage, pollution, catchment runoff of nutrients, mangrove invasion, fire, alteration of salinity and nutrient levels, and modification of tidal flows.

The dredging works assist in minimising several of these threats by maintaining the tidal exchange of estuarine waters.

Photo 1 - Intertidal flats on the southern side of Terilbah Island used for roosting and foraging by wading birds.

Photo 2 - Saltmarsh fringing the eastern shoreline of Terilbah Island.