8. Sediment and Water Quality

Sediment and water quality were listed as key issues in the DGRs. This chapter addresses the DGRs for the assessment of sediment and water quality impacts.

The methodology outlined within this section closely relates to the assessments contained within Chapter 9 (Contamination), Chapter 10 (Hydrology) and Chapter 13 (Spoil Handling and Disposal). Please refer to these chapters for additional details including:

- Vibracoring investigations undertaken for the EIS.
- Sediment and river hydrodynamics.
- Hydrodynamic modelling.
- Types and quantities of materials to be dredged.
- Potential for Acid Sulfate Soils.

The DGRs for the Sediment and Water Quality component of the EIS are provided in Table 8-1.

Table 8-1 Sediment and Water Quality DGRs

Environmental Impact Statement Requirements	Where Addressed
Assessment of the volume and type of sediment to be dredged including potential Acid Sulfate Soils.	Section 8.3 (Potential Impacts on Water Quality) and Chapter 9 (Contamination).
Assess impacts on water quality, including sediment dispersion and suspension. Identify methods for sediment containment.	Section 8.3 (Potential Impacts on Water Quality). Section 8.4 (Recommended Mitigation Measures for Water Quality).
Assess the stability of banks, foreshores and structures adjacent the area to be dredged.	Section 8.3 (Potential Impacts on Water Quality) and Chapter 10 (Hydrology).
Consider the *Acid Sulfate Soil Manual* (ASSMAC), *Water Quality Guidelines for Fresh and Marine Waters* (ANZECC) and associated guidelines.	Section 8.2 (Existing Environment for Water Quality) and Chapter 9 (Contamination).

8.1 Introduction

A large number of previous studies have examined water quality in the Hunter Estuary. A review of this existing literature was combined with laboratory analysis of vibracore samples and hydrodynamic modelling to assess the Project’s potential impact on sediment and water quality.

Section 8.2.1 describes the general water quality of the Hunter estuary. Literature reviewed to establish known conditions within the estuary is detailed in Section 8.1.1 and Section 8.2.5 describing hydrodynamic modelling.

8.1.1 Literature Review

The following documents were reviewed as part of the sediment and water quality assessment:

- GHD 2003, *South Arm Dredging Project, Environmental Impact Statement.*
- Newcastle City Council NCC 2009*, Newcastle Floodplain Planning – Stage 1 Concept Planning Report.*
- Manly Hydraulics Laboratory 2003, *Hunter Estuary Processes Study.*
- Newcastle City Council 2009, *Hunter Estuary Coastal Zone Management Plan*.
- Sanderson, Dr Brian; Redden, Dr Anna and Matthew Smith 2002, *Salinity Structure in the Hunter River Estuary.*
- Herbert, J.B, and S.B Brahme 1991, *Literature review and technical evaluation of sediment resuspension during dredging*.

8.1.2 Legislation and Guidelines

Appropriate guidelines and legislation considered in the assessment of sediment and water quality included, but were not limited to, the following:

- ANZECC/ARMCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*
- CSIRO 2005, *Handbook for Sediment Quality Assessment.*
- ASSMAC 1998, *Acid Sulfate Soil Manual (Acid Sulfate Soils Management Advisory Committee.*

8.2 Existing Environment

8.2.1 Water Quality

Numerous investigations have previously been undertaken to study the water quality of the South Arm of the Hunter River. Additional hydrodynamic modelling has been undertaken by GHD specifically in relation to the proposed capital dredging activities and is described in Chapter 10. The key processes controlling water quality, through exchange and mixing, within the Hunter estuary are:

- Freshwater flows displacing the volume of the estuary, especially evident during floods.
- Salt intrusion, density-driven flow and tidal pumping against the freshwater flow, evident after floods.
- Upstream transport of salt by tidal dispersion during sustained periods of low flow (MHL, 2003).
- High concentrations of chlorophyll-a (GHD, 2003).
- Excessive levels of nutrients primarily due to point sources rather than diffuse catchment run-off sources. Point sources are points of direct discharge into the estuary such as industrial pipelines. About 98 percent of total nitrogen and 97 percent of total phosphorus entering the estuary come from point sources. Total nitrogen entering the estuary is about seven times greater than total phosphorus.

- The mean turbidity value is 15 Nephelometric Turbidity Units (NTU), with increasing values moving upstream. High turbidity values are common, with turbidity values highest during high freshwater flows.
- Temperature distributions in the Hunter estuary are mostly inversely related to those of salinity. Upstream temperatures are generally higher where saline levels are lower. The exception is for times of heat flux associated with warm or cold weather.
- Mean dissolved oxygen concentrations over the river are 6.4 mg/L, with increasing concentrations moving downstream, and often low in the upper estuary following increased freshwater flows.
- Salinity has a much greater effect on density than temperature in the Hunter estuary. Given that temperatures generally increase (except in winter) and salinities decrease moving upstream, densities usually decrease moving upstream.

In summary, the major water quality issues in the estuary have been found to be:

- Excessive levels of nutrients.
- High turbidity levels.

8.2.2 Soil Types in the Project Area

The soils within the Project area are predominantly gravel, sand, silt, clay 'Waterloo Rock', with marine and freshwater deposits (*NSW Department of Mines, 1:250 000 Geological Series Map Sheet S1 56-2, First Edition 1996*). The soil landscapes adjacent to the proposed berths are mapped as disturbed terrain due to post settlement human activities.

Potential acid sulfate soils (PASS) mapping of the surrounding soils are also classified as disturbed terrain. Previous investigations have identified the potential for minor risks of PASS within the sediments of the Hunter River Basin. Additional details outlining these sediments are outlined in Section 8.3.11.

Typical land uses within the Project area are primarily industrial and commercial operations.

8.2.3 Sediment Transport

Land clearing and flood mitigation works have altered the sediment transport processes in the Hunter catchment, resulting in increased riverbank erosion up river from the Port. In general, channel infilling has accelerated due to catchment erosion and impedance of sediment transport from flood mitigation works. Bank erosion upstream has also been exacerbated by the clearing of riparian vegetation and widespread cattle access to banks.

Previous studies have estimated that:

- The typical suspended sediment influx to downstream of Hexham is about one million tonnes per year, with a minimum bedload sediment flux of 25,000 tonnes per year.
- The average amount of sediment accumulating in the Hunter estuary downstream of Hexham is about 100,000 tonnes per year, based on measured bed elevation increases of 2.3 mm/year at Fullerton Cove.
- Maintenance dredging activities indicate that on average about 400,000 tonnes of sediment accumulates in the port each year.
- About 490,000 tonnes of sediment is discharged from the Hunter estuary and accumulates in a large mud deposit offshore each year.

Previous investigations have identified a discrepancy in predicted sediment accumulation rates. MHL 2003 noted that

> " . . *there is a disagreement between the amount of sediment accumulating in the lower Hunter estuary using the methods identified . . . and the amount removed by long-term dredging. There are many possible reasons for this, including enhanced deposition in the dredge sites, intensive dredging in the middle of the 20th century removing more than was deposited, and poor estimates from inadequate sedimentation rates and bathymetric information"*.

The 2003 GHD study determined that most sediment has been deposited between Singleton and Maitland during large floods. However, there is evidence that sediment is moving downstream towards Raymond Terrace, with the movement manifesting as erosion between Maitland and Morpeth and accretion between Morpeth and Hexham.

Patterson Britton & Partners (1989) described the suspended sediment concentrations in the Hunter estuary for various freshwater flow magnitudes as:

- In low freshwater flows, negligible quantities of sediment are carried downstream. Suspended sediment concentrations were estimated to be about 4 to 30 mg/L in the port area during these periods. The highest concentrations were in the vicinity of Hexham, at about 40 mg/L near the limit of saline intrusion in low freshwater flows (GHD, 2003).
- In wet weather flows (not extreme floods) there is concentrated deposition of sediment in the port area. In this case, the saline limit would be in the vicinity of the port. As flows increase, a greater amount of sediment is carried out to sea, typically in a fresh surface layer a few metres thick. For example, measurements in June 1989 indicated the suspended sediment concentration at the Hunter mouth was about 210 mg/L in the upper portion of the water column, with the lower layer at about 60 mg/L.
- In extreme floods, the estuary could be purged of all saline water and virtually no deposition would occur within it. It can therefore be inferred that medium floods are likely to cause greater sedimentation in the port compared to large floods where higher volumes and flow rates carry sediment out to sea.

Patterson Britton & Partners (1989) devised a suspended sediment rating curve at Hexham Bridge. Table 8-2 shows predicted suspended sediment concentrations at Hexham for a variety of flows ranging from median flow to the peak of a large flood. Flow magnitudes were derived from MHL (2003).

Table 8-2 Predicted Suspended Sediment Concentrations at Hexham for Varying Flows

Flow Type	Flow Value (ML/d)	Predicted Suspended Sediment Concentration at Hexham (mg/L)
Median	720	7
Mean	3,120	40
95th percentile	11,920	200
Peak of small flood	20,000	365
Peak of large flood	200,000	5,400

Hexham was previously used as a location for calibration of the existing hydrodynamic model, which was developed in consultation with the relevant government agencies during the preparation of the South Arm Dredging EIS completed in 2003. At the time of model development, Hexham represented the most complete data set available (water levels, tidal currents, turbidity etc). The current assessment of suspected sediment / turbidity levels was completed using the existing hydrodynamic model, which was updated to reflect recent dredging works completed within the Hunter River's South Arm, including those associated with the NCIG and PWCS developments and the Hunter River Remediation Project. As noted, the development and calibration of this model was undertaken in consultation with the relevant government agencies at the time of development to confirm the agreed model was capable of providing accurate estimates of changes to the hydrodynamics of the Hunter River's South Arm

Regardless of the discrepancies noted in these previous studies concerning deposition rates, the accumulation of sediment in the estuary poses restrictions on safe navigation and the utilisation of port facilities. Maintenance dredging is undertaken daily, with approximately 400,000 tonnes of material on average removed annually. NPC has approval to remove 500,000 tonnes annually.

8.2.4 Field Investigations

The pilot study geotechnical and geochemical field investigations used a barge mounted vibracore to collect sediment samples within the Project area. The vibracore samples were collected from 24 locations within the footprint of the proposed berths at the Walsh Point berth pocket, Kooragang 1, Dyke 3 and Mayfield Berths 1 and 2. Existing samples from remediation validation testing at the Mayfield 5, 6, and 7 berths were also used to complete the data set for all proposed berths.

The Commonwealth approved (SEWPaC) SAP geochemical field investigations also used a vessel mounted vibracore to collect samples within the project berths. Phase II (total sediment concentrations) and initial Phase III testing (elutriate and bioavailable concentrations) has taken place, with results relevant to Mayfield berths 3 and 4 discussed herein. It is also important to note that the sediment sampling and analysis program is still underway at the time of this EIS.

Samples were collected from a number of depth profiles throughout each core, to a maximum depth of 6.35 metres. Cores were submitted to laboratory for analyses. Details of sampling locations and the findings of the geotechnical and geochemical investigations are presented in Chapter 9 (Contamination).

Previous investigations have identified minor risks of potential acid sulfate soils (PASS) within the sediments of the Hunter River Basin. As part of the geotechnical and geochemical investigations, field pH (pHF) and field peroxide (pHFOX) analyses were undertaken.

8.2.5 Hydrodynamic Modelling

An existing hydrodynamic model, originally prepared by Patterson Britton and Partners in association with GHD as part of the South Arm Dredging EIS, was refined to incorporate the Project's concept design. The refined model was used to quantify the existing suspended sediment and water quality conditions, and provide estimates of the likely conditions during and following completion of the proposed dredging activities. The methodology used to refine and customise the existing model is described in more detail in Chapter 10 (Hydrology).

8.3 Potential Impacts

8.3.1 Excavation of Fill Material

In the order of 1,250 square metres of landside material will be excavated for the construction of Mayfield berths 1 and 2. This equates to about 20,600 cubic metres of landside material consisting of fill, dredged mud and sands being removed. The average depth of fill material reported within this area is between 1.3 and 2 metres. The excavation, storage and transportation of this material has the potential to affect sedimentation and water quality.

8.3.2 Effect of Deepening on Water Quality

At the completion of dredging, the dredged areas would be deeper than under existing conditions. The deepening would represent a minor increase in the cross section flow area of the South Arm, and would not result in any significant change to water quality. The deepening of each berth would reduce water velocity in the local area, and reduce potential for erosion in that area but increase the sedimentation potential.

8.3.3 Foreshore and Structure Stability

The proposed batter designs considered the geotechnical characteristics of the materials that would form the channel batters, along with the geometric constraints of each berth. These foreshore works would stabilise the banks and limit the potential for erosion and sedimentation and potential to adversely affect water quality.

Additional details outlining foreshore stability and batter design are discussed in Section 2.3.4. This section summarises the primary design philosophies for the berths and associated batters.

8.3.4 Flushing Characteristics

The potential for the proposed dredged areas to alter the flushing characteristics of the estuary was assessed by using the hydrodynamic model. The model was manipulated to include the presence of a hypothetical pollutant in order to represent a potential pollutant release. The movement of this hypothetical pollutant was modelled to assess the reaction of the estuary and its flushing characteristics after the completion of dredging.

The hydrodynamic model was manipulated with an initial concentration of 100 g/m^3 of this hypothetical pollutant in order to represent a potential pollution release. The reduction of the pollutant's concentration was observed during a 29-day tidal simulation in which unpolluted oceanic waters were to mix in the estuary and dilute the pollutant. Table 8-3 compares existing conditions with predicted conditions after dredging.

Table 8-3 Hypothetical Pollutant Concentrations after 29 Day Simulation

Location	Pollutant Concentration Relative to Initial (%)		Average Difference in Concentration Pre and Post Dredging (%)
	Existing	Post-Dredging	
Kooragang Berth No. 6	84	86	0.56
Kooragang Berth No. 2	71	72	1.15
Stockton Bridge	56	56	0.01
North/South Arm Junction	42	42	0.18
Walsh Point	55	54	0.22
Tourle Street Bridge	96	97	0.02
Ironbark Creek	90	90	-0.02
Tomago	91	91	-0.02
Fullerton Cove	91	91	0.00
Stockton Crossing	37	37	-0.05
Entrance	2	2	0.03
Hannell Street	92	92	-0.02
Hexham Bridge	95	95	-0.01
Railway Bridge	94	93	0.00

The modelling results in Table 8-3 show that there is effectively no change to the pollutant flushing durations within the estuary. Average differences in pollutant concentrations before and after dredging range from 0 to 1.15 percent.

Simulation of the hypothetical pollutant being released at a constant rate into the ambient water column of the South Arm (assumed to be initially contaminant free) was also undertaken. In the model, the pollutant was released around 1.6 kilometres downstream of the Tourle Street Bridge, at a rate of 100 gram per second (g/s).

The reduction of the pollutant concentration with time was observed over a 29-day tidal simulation. Table 8-4 shows the resulting pollutant concentrations at the end of the simulation under existing and dredged conditions, together with the predicted difference between the two conditions. [3]

Table 8-4 Pollutant Concentrations at Various Locations

Location	Pollutant Concentration after 29 Days (g/m^3)		Average Difference in Concentration Pre and Post Dredging (g/m^3)
	Existing	Post-Dredging	
Kooragang N6 Berth	2	2	-0.02
Kooragang N2 Berth	1	1	0.00
Stockton Bridge	1	1	0.00
N+S Junction	0	0	0.00
Walsh Point	0	0	-0.01
Tourle Street Bridge	20	19	-0.09
Ironbark Creek	9	8	-0.06
Tomago	3	3	-0.02
Fullerton Cove	0	0	0.00
Stockton Crossing	0	0	0.00
Entrance	0	0	0.00
Hannell Street	0	0	0.00
Hexham Bridge	2	2	-0.01
Railway Bridge	15	14	-0.09

The modelling results in Table 8-4 show that there is effectively no change to the pollutant concentrations within the estuary as unpolluted ambient waters mixed in the estuary and diluted the pollutant. Average differences in pollution concentrations pre and post dredging range from 0 to -0.09 g/m$^{3.}$

8.3.5 Stratification

Stratification is where columns form in the water, based around temperature and salinity. The hydrodynamic model was also used to assess the Project's potential to alter the likelihood of stratification.

Since no significant changes to salinity levels and salinity flows are predicted, the Project would not have any significant effect on the likelihood for stratification to occur after high freshwater flows. Consequently, no significant changes would be observed in dissolved oxygen levels or the likelihood for formation of algal blooms.

8.3.6 Contamination

Preliminary results from the most recent sediment quality data (SAP data) has indicated that further testing is still required to support a Sea Dumping Permit (SDP). Currently further testing is being undertaken for lead (Pb) and zinc (Zn) in the proposed berths M3 and M4 in accordance with the staged approach outlined in the NAGD (2009) guidelines. A complete summary of sampling results to date is located in Appendix D (Preliminary SAP Summary).

It is also noted in Chapter 9 (Contamination), that previous investigations identified a localised area of potentially contaminated sediments adjacent to Walsh Point. These sediments could potentially affect water quality through mobilisation of contaminants. A Dredge Management Plan will be developed prior to dredging, and any identified contamination will be managed through measures contained within this Plan.

Landside material excavated for the construction of the Mayfield 1 and 2 berths will be classified at the time of excavation and testing. It is likely to be classified as Hazardous or Restricted waste in accordance with the *DECC Waste Classification Guidelines* (2008). Material that is confirmed as Hazardous would be treated by cement stabilisation prior to disposal. This is the current standard method used for stabilising contaminated material. More details are provided in Section 9.3.2 of Chapter 9 (Contamination).

8.3.7 Turbidity

The hydrodynamic model was used to assess the potential for dredging operations to increase the turbidity of the water through agitation and suspension of sediments. At mean flow in the Hunter River, previous modelling has shown that the suspended sediment background concentration at Hexham would be about 40 mg/L (GHD, 2003). This level is relatively high, indicating the Hunter estuary has high levels of existing turbidity. Catchment erosion is the main contributing factor.

It is recognised that whilst the levels of turbidity are likely to reduce further downstream (between Hexham and the entrance to the Hunter River) due to increased tidal flushing, the recent results indicate that the average turbidity levels generated by the dredging works will not represent a significant increase above background levels at either upstream or downstream locations. The predicted levels of suspended sediment and turbidity are in accordance with expected and recorded levels for similar dredging projects in the South Arm.

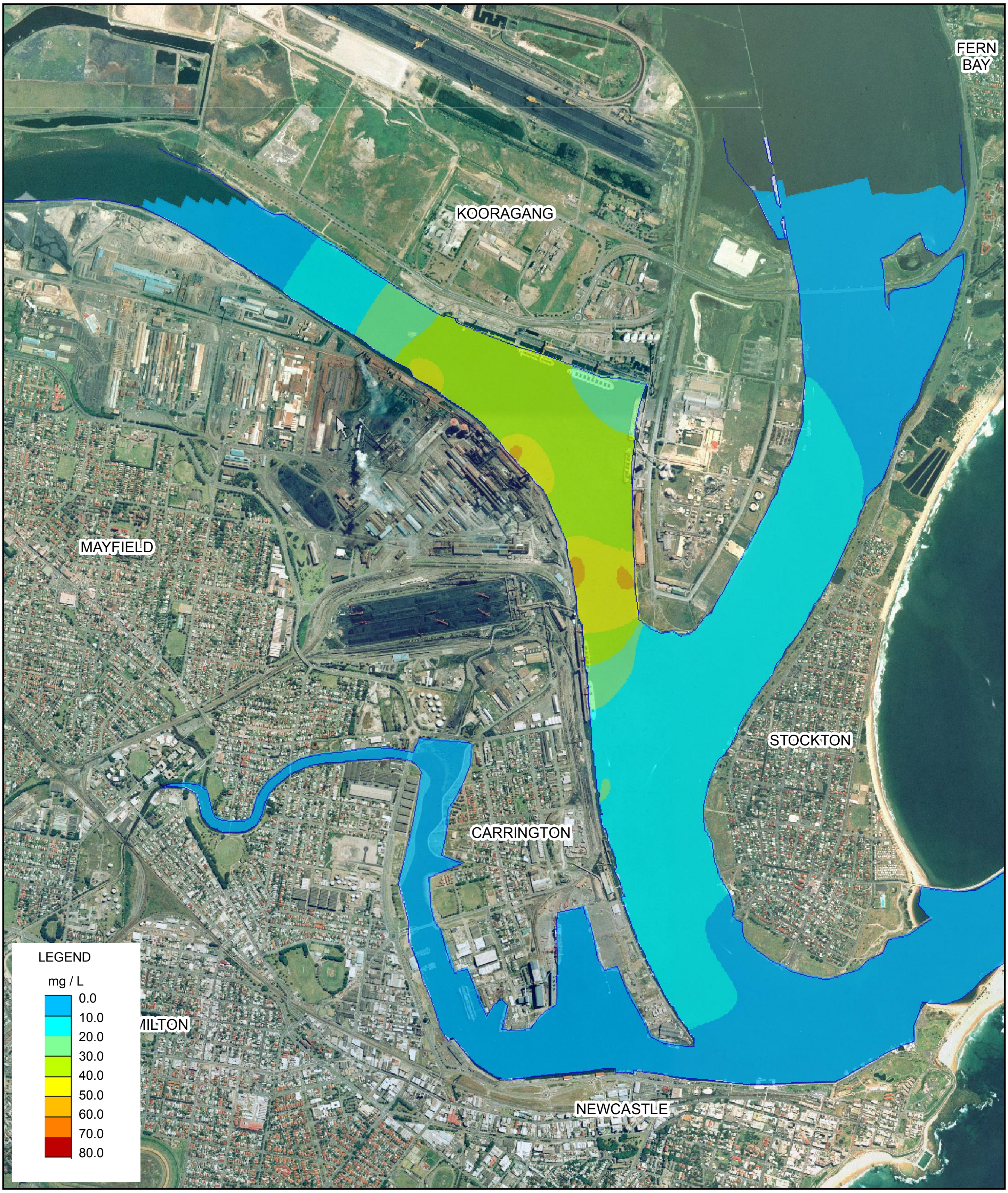
Existing concentrations are similar to those predicted to occur in much of the dredged area during the dredging operations. Modelling shows suspended sediment concentrations would be in the range between 30 to 70 mg/L near the dredging operations. This figure is therefore not a significant increase above existing conditions.

The modelling incorporated the use of a trailer suction hopper dredge to remove overlying silts and clays. A backhoe dredge or cutter suction dredge would produce less turbidity as these methods can incorporate silt curtains. Therefore the dredging activities used in the modelling represent the worst case for turbidity generating activities.

Given the operational constraints associated with dredging in a relatively small area of isolated sediments, a backhoe dredge or cutter suction dredge would be the most likely method used to undertake the works. Both of these would result in lower levels of suspended sediment concentrations than the trailer suction hopper dredge. Section 2.6 in Chapter 2 (Description of the Project) provides more details on the types of dredges available for use.

It is envisaged that future proponents would agree the locations for nearfield impact and background level monitoring in consultation with the relevant government agencies (EPA) prior to works commencing. Full details of the proposed monitoring and mitigation measures would be documented in the Water Quality Management Plan. This plan (as listed in the EIS SoC table) would specify the nearfield and background monitoring locations, as well as turbidity limits at the agreed monitoring locations.

With the existing suspended sediment concentrations already high in the Hunter estuary, the Project would not add significantly to turbidity in the Project area. Figure 8.1 shows the suspended sediment concentrations at the end of the 29-day tidal simulation. Figure 8.2 shows non-cohesive suspended sediment concentrations.



(29 day Tidal Simulation)

1:30,000 (at A4)
0 112.5 225 450 675 900
Metres
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Suspended Sediment Concentrations

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Figure 8.1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

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Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay

(29 day Tidal Simulation)

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Non-Cohesive Suspended Sediment Concentrations

Figure 8.2

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Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay

8.3.8 Deposition at the Dredge Sites

As the South Arm would be deepened and widened at each of the proposed berths, water velocities in these localised areas would reduce relative to existing conditions. Therefore, “natural” sedimentation of this dredged area would be expected to increase marginally in the future.

Deposition at the dredge sites would occur in a similar manner to the existing deepened port area, which is in a zone of sediment deposition, particularly during floods. There would be little change to the volume of future annual maintenance dredging requirements for the port.

8.3.9 Sediment Transport

Dredging activities will result in the release of sediment into the water column. The type of dredger, dredging method, sediment type, and local hydrodynamics determine the degree of sediment suspension and subsequent dispersion and deposition (Herbich, 2000).

Fine material, such as clay and silt, has the greatest tendency to remain suspended in the water column. Depending on tidal conditions, these sediments can be transported away from the area since the fall velocity of these materials is very low. Coarse-grained particles such as sand and gravel would settle relatively quickly close to the dredge area.

There would be no alteration to upstream sediment concentrations as a result of the dredging. Upstream areas are affected by catchment processes and other upstream activities remote from the dredging site. Chapter 10 (Hydrology) details the tidal and catchment factors that influence the hydrology of the estuary. Hydrodynamic modelling shows that the estuary’s water quality is affected by runoff from across the catchment, rather than tidal influences. Sediment within the water column caused by dredging would predominantly flow downstream.

The location and extent of the existing sediment deposition within the port area would change marginally. Deposition would be spread over a slightly greater area than at present. Deepening and widening each proposed berth would reduce water velocities in the local area. As velocity decreases, so would the potential for erosion to affect the stability of banks, foreshores and structures adjacent to the berths.

8.3.10 Volumes of Suspended Sediment

In order to assess the potential worst-case for suspended sediments to impact on the water quality of the Hunter River, modelling was undertaken using the trailer suction hopper dredge as the dredging method. The stages of dredging with a trailer suction hopper dredge that generate suspended sediment include:

- Movement of the suction pipes and suction heads through the water at a velocity in the order of 1 to 2 m/s, suspending sediments near the bed.
- Return flow under and along the dredge, especially with low keel clearance.
- Propeller wash during manoeuvring of the dredge. More sediment is suspended in this operation compared to trailing.
- Hopper overflows during the loading process. The risk occurs particularly towards the end of a dredging session when the overflowing mixture would contain dense levels of sediment.
- Release of any gas from the bed due to disturbance of the sediment.

The likely mass of sediment is measured in kilograms of dry material that may be resuspended in the water column per cubic metre (in situ). Previous investigations conducted by GHD (2003) provided estimates of the likely mass of sediment that could be resuspended during dredging. These estimates were based on measurements of a trailer suction hopper dredge and other dredging operations undertaken by Pennekamp *et al.* (1996). Most values (termed 'S') were found to be in the range from 0 to 20 kg/m^3. Given that the dry density of the material to be dredged is about 700 kg/m^3, an S value of 20 kg/m^3 would mean that 3 percent of the dredged mass would enter the surface water column as suspended sediment from the above possible sources.

Approximately 375,000 cubic metres of soft marine silts and clays would be dredged as part of the initial trailer suction hopper dredge operation. This is equivalent to a dry mass of 260,000 tonnes. Modelling shows that with three percent of this mass estimated to be generated as suspended sediment, there would be about 7,800 tonnes of sediment released into the estuary over the course of a five week dredging program. The effective average rate of loading of sediment in the water column is about 2750 g/s. This program assumes that an effective dredging rate of 80,000 cubic metres in situ per week would take up to five weeks to complete this component of the dredging works.

For modelling purposes the suspended solids loading was distributed to five locations to represent the spatial extent of dredging. The loading areas were located at the centre of each of the main dredge areas and were modelled at an average rate of 550 g/s.

These loadings were applied in the modelling for a 29-day tidal simulation. A scaling factor of 1:2 was applied to deposited sediment depths at the end of the simulation in order to account for the dredging period continuing for longer than the 29 model. This equates to approximately 34 days to cover the five week dredging program.

The modelling shows that the suspended sediment would predominantly deposit in the existing port area. Suspended sediment would not travel upstream beyond the Tourle Street bridge area. Downstream, the majority of the sediment would deposit in the area upstream of Dyke Berth 3. Figure 8.3 shows the modelled depths of the non-cohesive sediment and the deposition areas. Figure 8.4 shows the modelled depths of deposited cohesive sediment deposition areas.

(Post Dredging)

1:30,000 (at A4)

0 112.5225 450 675 900

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Deposited Non-Cohesive Sediment Depths

Figure 8.3

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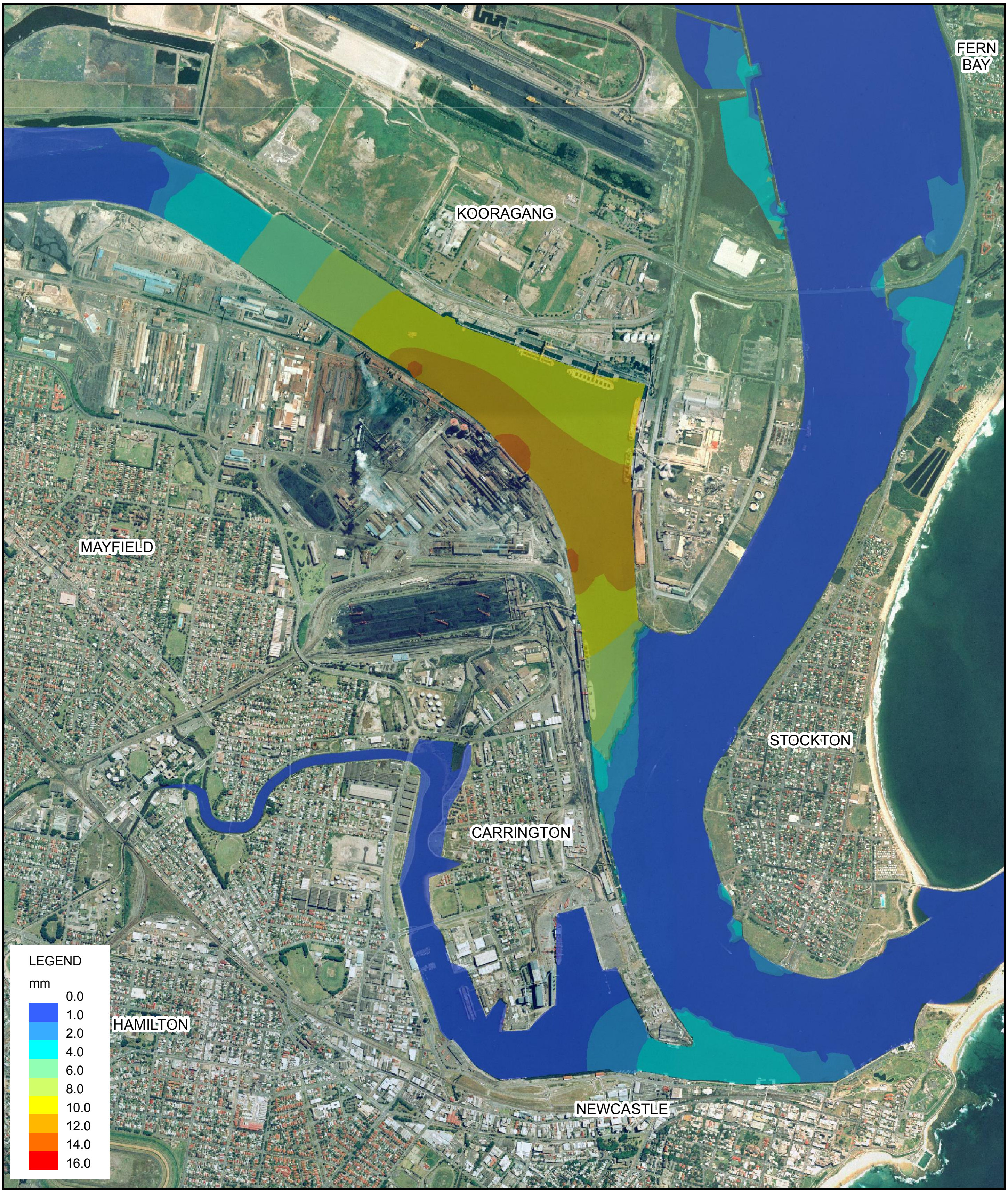
Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay



(Post Dredging)

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Deposited Cohesive Sediment Depths

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Figure 8.4

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Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay

The non-cohesive sediments would settle immediately adjacent to the proposed dredge areas. The cohesive sediments would take longer to settle and would be deposited over a greater distance, in a much thinner layer. Sediment deposition would be largely confined to existing port areas. No environmentally sensitive locations would be impacted through sediment deposition from the proposed dredging activities. Chapter 15 (Flora and Fauna) provides more details on environmentally sensitive areas.

The cohesive sediment would be deposited and spread thinly across the port area. The Project would not impact the frequency of the regular maintenance dredging operations undertaken by NPC.

8.3.11 Potential Acid Sulfate Soils

Previous investigations have identified the potential for minor risks of potential acid sulfate soils (PASS) within the sediments of the Hunter River Basin. As part of the geotechnical and geochemical investigations, 72 vibracoring samples were analysed by laboratory. Samples were collected from different depth profiles throughout each core, to a maximum depth of 6.35 metres. Samples were analysed using field pH (pH_F) and field peroxide (pH_{FOX}) analyses. The pHf test assesses actual acid sulfate soils, and the pH_{FOX} assesses changes in pH after peroxide is added to determine PASS.

The results reported pHF ranging from 7.2 to 8.8, indicating neutral to slightly alkaline conditions with no ASS present. The results of the pH_{FOX} analyses ranged from 1.7 to 7.1. The highest change in pH and vigorous rate of reaction was found in sediment samples collected off Walsh Point. Two samples reported pH_{FOX} of less than 3, indicating potential acid sulfate soil conditions.

Samples from the area of the Walsh Point berth pocket (berth W2) were collected from a depth of greater than five metres. The samples comprised thin layers of peat based sediment with clay and sand. Four samples reporting the highest change in pH, low pH_{FOX} results and vigorous reaction rates were selected for further analyses including chromium reducible sulphur and Suspension Peroxide Oxidation Combined Activity (sPOCAS).

The results of the sediment sampling program indicate PASS conditions are present in some portions of the Walsh Point berth pocket footprint. An Acid Sulfate Soil Management Plan (ASSMP) will be prepared in line with the requirements of the *Acid Sulfate Soils Management Advisory Committee Guidelines* (ASSMAC, August 1998 and as updated). The ASSMP will be prepared to identify, manage and treat the PASS encountered during dredging to minimise the production of acid leachate.

Offshore sea disposal would limit the potential for oxidisation of the sediments. The potential for ASS generation would reduce greatly due to sediments being dumped immediately after dredging, limiting time for oxidation. In addition, the materials generally exhibit sufficient buffering capacity so that when mixed with materials such as marine shell fragments, the calcium carbonate could neutralise the acid generating potential of the sediments.

8.4 Recommended Mitigation Measures

Potential changes in water quality as a result of the Project would be minimised by environmental controls contained within an Environmental Management Plan (EMP) to be developed by the dredging contractor. Controls would be documented in a number of supporting plans such as a Soil and Water Management Plan (SWMP) and Dredge Management Plan (DMP) prior to commencement of construction. The EMP and supporting plans would require approval prior to construction.

The contents of the EMP and supporting plans would depend on the dredging method selected by the construction contractor. Specific water quality management measures would be documented for the specific type of dredge to be used.

Dredging activities would be undertaken in accordance with all appropriate legislation and guidelines, including conditions of approval and measures contained within the Project Approval. The selection of appropriate plant, equipment and associated technologies would minimise potential impacts on water quality.

Measures that would be included in the EMP and supporting plans would be:

- Turbidity curtains around the land-based excavators, cutter suction dredge and backhoe dredge activities.
- A heavy-duty turbidity curtain if required, around some of the environmentally sensitive areas upstream on the South Arm when trailing suction hopper dredges were using overflows. This would control turbidity spreading upstream beyond the disturbed waterway area.
- A water quality monitoring strategy would be developed as part of the SWMP. The monitoring strategy would monitor and improve adherence to conditions of approval during sediment removal and handling.
- The strategy would specify regular measurements and/or visual inspections of the area immediately surrounding the dredge area. The plan would specify actions to be undertaken if a significant change in turbidity levels is detected, including ceasing dredging at this location until turbidity has returned to agreed levels.
- Stockpiles are to be located in bunded areas and covered where feasible.

9. Contamination

9.1 Introduction

Contamination was listed as a key issue in the DGRs. This chapter addresses the DGRs for the assessment of contamination. This chapter closely relates to Chapter 8 (Sediment and Water Quality), Chapter 10 (Hydrology), and Chapter 13 (Spoil Handling and Disposal). The Sediment Geochemical Assessment Report is located in Appendix D.

The Project has potential to disturb contaminated material in two key areas. These are:

- Contaminated landside material associated with historical land uses and filling activities.
- Contaminated sediment being disturbed from dredging activities.

It is estimated that approximately 1,870,000 cubic metres of material would be removed by dredging and land-based excavation to create the proposed berths. Of this amount, approximately 30,000 cubic metres (or around 1.6 percent of the total volume) has been identified as potentially contaminated material that may require some form of treatment before disposal or reuse.

The assessment of the Project's potential impacts has been undertaken in two stages. The first examines the potential landside contamination risks, and the second examines estuarine contamination. The DGRs for the Contamination component of the EIS are provided in Table 9-1.

Table 9-1 Contamination DGRs

Environmental Impact Statement Requirements	Where Addressed
Identify potential land contamination, contaminated sediments and groundwater and their disturbance during excavation and dredging works.	Section 9.3 (Potential Impacts on landside contamination) and Section 9.4 (Potential Impacts from contaminated river sediments).
Identify the potential risk to human health and the environment.	Section 9.3 (Potential Impacts on landside contamination), Section 9.4 (Potential Impacts from contaminated river sediments) and Section 16.4 (Risks and Hazards).
Consider the *Sediment Quality Guidelines* (CSIRO) in sampling and characterising the distribution of contamination.	Section 9.4 (River sediments).
If required, prepare a remediation action plan (RAP) or other appropriate materials handling procedure in accordance with the *Contaminated Lands Management Act 1997*.	Section 9.6 (Recommended Mitigation Measures for Contamination).

9.1.1 Literature Review

A large number of contamination assessments have been undertaken on areas surrounding the proposed berths. The following reports were reviewed as part of the Soil and Groundwater Contamination Assessment:

- Robert Carr & Associates (RCA), 9 February 2007, Environmental Site Assessment, Greenleaf Road, Kooragang Island.
- HLA, 2007, Environmental Assessment, Kooragang Island Bulk Liquid Storage Facility, Marstel Terminals.
- Egis Consulting Australia, December 2000, Newcastle Steelworks Closure Area, Summary Site Audit Report.
- ENSR Australia Pty Ltd (ENSR), 20 June 2008, Environmental Assessment Scoping Report: Planning Approval for Uprating of Ammonia Nitrate Facility, Kooragang Island.
- AECOM June 2009, Environmental Assessment, Proposed Ammonium Nitrate Facility Expansion, Greenleaf Road, Kooragang Island.
- ERM, September 1996, PWCS Kooragang Coal Terminal, Stage Three Expansion, Environmental Impact Statement.
- GHD 2003, South Arm Dredging Project, Environmental Impact Statement.
- Newcastle City Council, Information Sheet 2011, Industrial Filling Used in Carrington *http://www.newcastle.nsw.gov.au/laws_and_permits/pollution/contaminated_land (accessed August 2011).*

9.2 Landside Soil and Groundwater Contamination

The former BHP Steelworks site (BHPB site) and the Carrington area have been subject to historical filling from land reclamation and industrial activities. Fill within the BHPB site includes dredged river sediments and various wastes from BHPB operations. Fill at Carrington includes black slag and ballast waste. Contamination from former reclamation activities together with past and current land uses is present on Kooragang Island. Walsh Point is located on the eastern end of Kooragang Island. Soil contamination has been recorded within these areas. Figure 9.1 shows the location of the former BHPB site, the suburb of Carrington and Walsh Point.

As shown in Figure 9.1, the project does not extend beyond the M7 berth and will not encroach on the OneSteel declaration area. No further studies are required, as M5, 6 and 7 have been remediated. Based on the site history, no further assessment is needed at this stage and no issues are anticipated at this site.

No land excavation works will be undertaken in the construction of berth K1. In addition, the use of vertical retaining structures such as a sheetpiled wall in the construction of berth K1 will reduce the impacts to groundwater flow and quality. Subject to design and groundwater modelling, it is considered that berth at K1 will have minimal impact on groundwater contamination identified at the nearby Orica plant.

LEGEND

- Berth Locations
- BHPB Site
- Land to be Excavated
- Primary Remediation Zone
- Secondary Remediation Zone
- Approximate Location of PAH Hotspot

1:15,000 (at A4)

0 55 110 220 330 440

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Newcastle Port Corporation
Capital Strategic Dredging Project

Job Number 22-15683
Revision 0
Date 10 Sep 2012

Areas of Potential Environmental Concern

Figure 9.1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

G:\22\15683\GIS\Maps\Deliverables\Environmental Assessment\Contamination\2215683_C001_AreasOfConcern_20110823_A.mxd

Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay

9.2.1 Mayfield

The proposed Mayfield 1 to 7 berths are located adjacent to the former BHPB site shown on Figure 9.1. This area has been subject to historical filling as the result of land reclamation and industrial activities. Fill within the BHPB site includes dredged river sediments and waste from BHPB operations including slag, coal washery reject, flue and sinter plan dusts, fly ash, steel works refuse, tar, oils and acids. The depth of fill range between 5 and 12 metres with an average of 8 metres (GHD, 2003). The fill overlies natural estuarine sediments.

As a result of historical filling, contamination has been reported within soils and groundwater at the site. Contaminants reported in soils in excess of the assessment guidelines for commercial/industrial sites include iron, manganese, polycyclic aromatic hydrocarbons (PAH) including benzo(a)pyrene (BaP), benzene, toluene, ethyl benzene and total xylene (BTEX) and total petroleum hydrocarbons (TPH) (Egis, 2000).

Groundwater within the BHPB site is contained within three discrete aquifer units, the Fill aquifer, Estuarine aquifer and the Bedrock aquifer. The Fill aquifer is encountered within the fill material of the site. Given the nature of the fill, groundwater contamination has been reported within this aquifer.

Underlying the Fill aquifer is the Estuarine aquifer. This aquifer generally consists of a grey/white fine to medium sand and is generally separated from the above Fill aquifer by dark/grey brown silty sands or clays considered representative of the previous landform. This layer is variable in consistency and there is evidence to suggest that this layer is semi-confined with hydraulic connections between the two aquifers (GHD, 2003).

The Bedrock aquifer is comprised of the Tomago Coal Measures and is a sequence of mudstones, siltstones and shales. Groundwater within the BHPB site generally flows in a north easterly direction towards the Hunter River. Contaminants reported in groundwater in excess of the assessment guidelines include heavy metals (arsenic, aluminium, cadmium, copper, iron, manganese, chromium, nickel, lead, mercury and zinc), ammonia, BTEX, cyanide and phenols (Egis, 2000).

In 2007-2008 a groundwater barrier wall of 1.4 kilometres long and 31 metres deep was constructed within a portion of the BHPB site which was deemed to contain significant contamination. In conjunction with capping and modification of site drainage, the aim of this barrier wall was to divert groundwater around the area of concern. This would result in a reduction of the hydraulic gradient and reduce the migration of contaminants into the Hunter River.

9.2.2 Carrington

The area surrounding the proposed Dyke 3 berth has been historically filled to reclaim estuarine areas for industrial and port activities. Material used for fill at Carrington included black slag and ballast waste.

The hydrogeology of the Carrington area is similar to the BHPB site. Groundwater flows in an easterly direction towards the Hunter River. It is possible that groundwater contamination is present.

9.2.3 Walsh Point

The proposed Walsh Point berth pocket and Kooragang 1 berths are located at Walsh Point. At the eastern end of Kooragang Island. Contamination from former reclamation activities together with past and current land uses is present on Kooragang Island.

Walsh Point originally consisted of a series of low-lying islands that were progressively filled with sediment dredged from the Hunter River between 1866 and the 1960s. Walsh Point now occupies the original area of Walsh Island, one of the islands that filling connected as part of the reclamation works. The Department of Public Works and Services undertook drilling on Walsh Island in 1964 and found sands to a depth of 65 metres followed by bedrock (ENSR 2008).

Groundwater at Kooragang Island is generally present within three aquifers. The fill aquifer consists of reclaimed dredged sediments and fill, ranging in depth between 0.5 and 5 metres thick. The fill aquifer is separated by the estuarine aquifer by a clay layer, which is representative of the natural ground surface prior to reclamation. This unit is variable in vertical extent but is generally 2 to 3 metres thick but has been reported to extend to 14 metres. Underlying this aquifer is a silty sand aquifer up to 30 metres thick which extends to bedrock (ERM, 1996).

Groundwater generally flows towards the Hunter River in the fill aquifer and towards the ocean in the lower silty sand aquifer (ERM, 1996). Hydraulic connections have been noted between the upper fill aquifer and the underlying sand aquifers.

Investigations undertaken by RCA as part of the Environmental Site Assessment for Marstel Terminals Bulk Liquid Storage Facility (RCA, 2007) at Walsh Point reported concentrations of TPH in soils above the National Environmental Protection Measure (NEPM, 1999) assessment guidelines for commercial/industrial land use at 2 of 37 testpits at depths of 1.2 and 2 metres.

The investigations identified zinc 3.3 to 3.9 times the site guidelines (four of seven wells), arsenic 1.3 times the site guidelines (one of seven wells) and copper 4.3 times the guidelines (one of seven wells). The potential for TPH was not ruled out based on the limited soil sampling.

All other parameters (BTEX, heavy metals, PAHs, organochlorine pesticides (OCP) and organicphosphorus pesticides (OPP)) were reported below the NEPM 1999 assessment criteria for commercial/industrial land use.

Elevated levels of arsenic in groundwater have been identified at the Orica site in a narrow band that runs from a former sludge disposal pit in the north western sector of the site in a north westerly direction towards the Hunter River (AECOM 2009). Two locations with minor, localised arsenic contamination were also identified to the east of the Ammonia Plant and at a former pit in the Nitrates area.

Ammonia has also been identified across the Orica site. The highest concentrations of total ammonia were observed in the vicinity of the Borrow Pit/Ammonium Nitrate Effluent Pond and down gradient of the Ammonia Storage Tank. Lower concentrations were also found surrounding the Former Sludge Disposal Pit and the southern portion of the site as well as an isolated hot spot near the Bagging and Dispatch Area (AECOM 2009). Offsite monitoring wells isolated down gradient of the Ammonia Storage Tank also reported elevated concentrations of ammonia (AECOM 2009). Ongoing monitoring of groundwater since 2003 has indicated that concentrations of total ammonia has decreased over time through natural attenuation.

9.3 Potential Impacts on Landside and Groundwater Contamination

The concept design has limited the potential for significant contaminated fill material to be disturbed during construction. The use of vertical retaining structures, such a sheet piled wall will reduce the area of potential disturbance. The potential installation of an anchor wall landside of the river-based sheet pile wall, and the connecting ties between the two walls, may require minor excavation of surface layers. This material would be backfilled and reused on site, and would be covered in the future by the construction of port infrastructure.

Subject to detailed design, the proposal is expected to have minimal impact on groundwater flow and quality. The implementation of design features such as vertical retaining structures would further reduce the migration of groundwater and any potential contamination.

It is noted that a groundwater licence would be required from the NSW Office of Water under the Water Management Act 2011, for any excavations that may extend to groundwater as part of construction (e.g. installation of anchor walls).

9.3.1 Dyke 3 and Mayfield 3 to 7

The Project will have minor impacts to soils and groundwater in the area around the proposed Dyke 3 and the Mayfield 3 to 7 berths. No underlying landside soils will be disturbed by the construction of the berths or dredging activities.

Although contamination is known to be present within soils and groundwater on the BHPB site adjacent to Mayfield 3 and 7 berths, this is currently being managed through capping, modification of drainage and a groundwater barrier wall. These measures are designed to reduce the groundwater hydraulic gradient and thus minimise the rate of migration of contaminants into the Hunter River. As a result the proposed berth design is expected to have a minimal impact on groundwater in this area.

If landside fill materials require disturbance during the construction of foreshore treatments at the proposed Mayfield 3 to 7 berths, appropriate management controls would be used to limit any risks posed to workers or the environment.

Based on soil sampling results and comparison against the *NSW Department of Environment and Climate Change (2009) Waste Classification Guidelines Part 1: Classifying Waste*, fill materials would generally be classified as solid. However, in some areas soils may be classified as either industrial or restricted waste (depending on the extent of contamination). Underlying natural materials would be classified as virgin excavated natural materials and as such could be used for other developments if required.

9.3.2 Mayfield 1 and 2

The construction of Mayfield berths 1 and 2 would require the removal of potentially contaminated material. A small area of land, in the order of 1,250 square metres, will require excavation as part of the construction of Mayfield berths 1 and 2. Approximately 20,600 cubic metres of landside material (consisting of fill, dredged mud and sands) would be removed. The average depth of fill material reported within this area is between 1.3 and 2 metres. However, fill may be deeper in areas which have been reclaimed from the Hunter River as dredged sand was likely to be similar in appearance to estuarine sediments(Egis, 2000).

Contaminants within these areas (together with an 95 percent upper confidence limit (UCLav) concentration) were reported to include iron (75,000 - 88,101 mg/kg), manganese (Mn) (12,775 mg/kg), PAH (319 - 932 mg/kg), BaP (24-55 mg/kg), benzene (14.9 mg.kg). These results are based on sampling across a larger portion of the former BHPB site and within the top 2 metres of fill.

Based on the above results, the material would be classified as either Hazardous or Restricted waste in accordance with the *DECC Waste Classification Guidelines* (2008). Assuming these contaminants area present within the top two metres of fill, a total of 2,500 cubic metres would require disposal to a landfill licenced to accept such material. Hazardous waste would need to be initially treated prior to disposal. Kemps Creek Landfill in Sydney is currently the only landfill within NSW licenced to accept restricted and treated hazardous material. Underlying fill material would be classified as general solid waste, while the underlying natural material would be classified as Excavated Natural Materials (ENM). These classifications are based on total concentration of contaminants. This classification maybe reduced by leachability testing of these contaminants.

Material excavated from this area would be stockpiled close to the excavation area for separation, sampling and treatment (if required). Material that is confirmed as Hazardous would be treated by cement stabilisation prior to disposal. Cement stabilisation is a simple mixing process in which the contaminated material is mixed with cement or other immobilisation agents. This process is normally undertaken using equipment similar to that of a standard concrete batching plant. Ideally, this would be located adjacent to the stockpiled material on site.

Cement stabilisation is the current standard method used for stabilising contaminated material. Methods for this type of stabilisation may improve in the future, and would be considered at the time of dredging. Section 9.6 outlines the mitigation measures developed for managing contaminated material.

As for Mayfield 3 to 7, the impacts on the proposal on groundwater is considered to be minimal.

9.3.3 Walsh Point Berth Pocket and Kooragang 1

No landside excavations are proposed for the Walsh Point Berth Pocket and Kooragang 1 berth and as such, the proposal will have minimal impact on any potential landside contamination.

Due to historical filling and industrial activities, there is a potential for contamination to be present within the fill material and Fill aquifer near the proposed berths. However, the use of vertical retaining structures such as a sheetpiled wall will reduce the potential disturbance of contaminated material, and would minimise the impact on groundwater flow and quality. Subject to detailed design and modelling, it is expected that the proposal would not significantly impact on groundwater contamination reported for the Orica site.

9.4 River Sediments

Previous and present industrial activities on the South Arm of the Hunter River have introduced contaminants to the river's sediments. Remediation works are complete on river sediments in front of the former BHPB site as part of the Hunter River Remediation Project. However, varying degrees of contaminated sediments are still present elsewhere within the river where remediation has not been completed. Section 9.4.2 outlines previous reports that have documented contamination in the Hunter River.

9.4.1 Existing Environment

The geochemical (contamination) analysis of the material to be dredged for the Project is a key issue listed in the DGRs. The geochemical analysis was a key component in identifying a range of potential impacts, and has guided a number of assessments for other key issues in the EIS. These issues include the design of the Project, the disposal options for the dredged material, and the potential environmental impacts generated from these activities.

The sediments of the South Arm of the Hunter River have been examined in detail by numerous previous studies including the South Arm Dredging Environmental Impact Statement (EIS) completed by GHD in 2003. During this study a "geotechnical model" was developed. The model showed the following material types, in sequence from riverbed level down:

- Variable fill from dredging and industrial activities placed for reclamation purposes outside the proposed dredge areas.
- Soft soil including very soft river-bed sediments and soft alluvial (non-river) clay.
- Marine sands, typically fine to medium grained with occasional alluvial clay lenses/layers.
- Bedrock comprising sandstone, siltstone, shale and minor coal seams.

9.4.2 Literature Review

Numerous geotechnical and geochemical investigations have been undertaken within the sediments of Newcastle Harbour as part of routine monitoring and previous dredging assessments. In addition, a number of investigations have been undertaken to assess the extent of contamination associated with the former BHPB site and toxicity investigations have been undertaken by CSIRO as part of the South Arm Dredging Project.

Previous sediment quality investigations undertaken within the South Arm of the Hunter River include:

- Dames & Moore 1990, *Sediment sampling.*
- Douglas & Partners, 1993, *Kooragang Coal Terminal Sampling.*
- Robert Carr & Associates, 1995, *River and Shoreline sediment sampling.*
- GHD-Longmac, 1996, *KCT Stage 3 Expansion vibrocoring*.
- Robert Carr & Associates, 1999, *MPT Stage 1 sampling*.
- Robert Carr & Associates, 2000, *MPT Stage 2 sampling*.
- Patterson Britton & Partners, 2000(a), *South Arm vibrocoring*.
- Patterson Britton & Partners, 2000(b), *MPT Stage 1 vibrocoring*.
- Patterson Britton & Partners, 2001, *Surface sampling adjacent to former BHP site*.
- GHD-Longmac, 2001(a), *MPT Stage 1 vibrocoring*.
- GHD-Longmac, 2001(b), *MPT Stage 2/K7 vibrocoring*.
- GHD-Longmac, 2001(c), *South Arm vibrocoring*.
- Patterson Britton & Partners, 2002, *Surface sampling adjacent to former BHP site*.
- GHD-Longmac, 2002, *Vibrocoring adjacent to former BHP site*.
- Patterson Britton & Partners, 2003(a), *Vibrocoring along southern bank of the South Arm of the Hunter River from the former BHP steelworks site to Tourle Street Bridge*.
- Patterson Britton & Partners, 2003(b), *Bulk sampling adjacent to former BHP steelworks site*.
- Patterson Britton & Partners, 2003(c), *Surface sampling in Kooragang Swing Basin*.
- URS, 2004(a), *Human Health Risk and Ecological Risk Assessment of sediments in the South Arm of the Hunter River*.
- URS, 2004(b), *Vibrocoring for Assessment of Depth of Contamination and Collection of Bulk Materials for Bench Scale Treatment Trials, South Arm Hunter River*.
- Patterson Britton & Partners, 2005, *Surface sediment sampling in NPC maintenance dredging areas.*
- URS, 2006, *Vibrocoring to Assess Depth and Extent of Sediment Contamination in the South Arm of the Hunter River*.
- Connel Hatch, 2006, *Kooragang Berths K8 and K9 Boreholes for Newcastle Coal Infrastructure Group*.
- Douglas Partners, 2006, *Kooragang Berths K7 boreholes for Port Waratah Coal Services*.
- URS, 2007, *Final Definition of Sediment in the South Arm of the Hunter River Beyond the Primary Remediation Zone*.

- URS, 2008, *Hunter River South Arm Additional Sediment Coring in PRZ*.
- CH2MHill, December 2010, *Hunter River South Arm – Nearshore Sediment Validation*.
- GHD, January 2011(a), *Hunter River Remediation Project, Interim Validation Report – Surgical Dredging Area (SDA)*.
- GHD February, 2011(b), *Hunter River Remediation Project – Interim Validation Report, Zone 1*.
- GHD May 2011(c), *Hunter River Remediation Project – Interim Validation Report, Zones 2-6.*

GHD examined this documentation as part of the preliminary stage of works and the development of the Sampling and Analysis Plan (SAP). Whilst a significant volume of the available data is greater than five years old, the comprehensive nature of the previous sampling regime provides a detailed background on the nature and extent of contamination within the sediments of Newcastle Port and assists with the evaluation of trends in geochemical data.

Details of the literature review are presented in the Sediment Geochemical Assessment Report (Appendix D). In summary, the following points are noted:

- Contamination has been reported within the sediments (soft silty clays) found in the South Arm of the Hunter River, primarily comprising heavy metals (cadmium, chromium, copper, lead, mercury, nickel, and zinc), PAH and TPH.
- Contaminant concentrations generally increase towards the southern foreshore of the South Arm in the Mayfield area near the former BHPB site.
- Concentrations of total PAH and BaP in the silty clays varied according to depth and location.
- Contaminants were typically reported from the riverbed surface down to the interface between the silty clays and the underlying estuarine sands.
- A potential hotspot has been identified in the area of the proposed Walsh Point Berth Pocket (berth W2), where previous investigations have revealed elevated levels of PAHs near the southern end of Heron Road (refer to Figure 9.1).
- Sediment toxicity data from the South Arm Dredging Project by CSIRO has shown that the metals present with the soft silty clays of the South Arm of the Hunter River are not bioavailable (Patterson Britton & Partners, 2005).
- Elevated levels of contaminants, in particular PAHs, were reported in the vicinity of proposed berths Mayfield 3-7, adjacent to the former BHPB site.

Contaminated sediments associated with the former BHPB site were delineated and subsequently remediated in accordance with the requirements of the Remedial Action Plan (CH2MHill, 2009), Validation Protocol (BHPB, 2010) and other regulatory requirements.

Validation of the Secondary Remediation Zone (SRZ) was completed by CH2MHill (2010). Validation of the sediments within the Primary Remediation Zone (PRZ) was completed by GHD in May 2011 and documented in Interim Validation Reports (GHD 2011(a), GHD 2011(b) and GHD 2011(c)). The approximate extent of the PRZ and SRZ are shown in Figure 9.1.

9.4.3 Legislation and Guidelines

Appropriate guidelines and legislation considered in the assessment of potential contamination included, but were not limited to, the following:

- ANZECC/ARMCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000).
- CSIRO, 2005, *Handbook for Sediment Quality Assessment.*
- Environment Australia 2009, *The National Assessment Guidelines for Dredging* (NAGD; Commonwealth of Australia, 2009).
- National Environmental Protection Council (NEPC) 1999, *Schedule B of the National Environmental Protection Measure* (NEPM, 1999).
- NSW DECC, 2008, *Waste Classification Guidelines, Part 1: Classifying Waste*.

9.4.4 Pilot Study

Methodology

A pilot study to investigate the sediment within the project area was undertaken during May 2011 using a barge based vibracore. Sampling locations are shown in Figure 9.2. Sediment samples were collected from 24 locations across three areas including:

- Kooragang Island and Walsh Point (11 locations)
- Dyke Berth 3 (five locations)
- Mayfield Berths 1 and 2 (eight locations)

Mayfield 5, 6 and 7 are located within the footprint of the former primary remediation zone and sediments with this area have been subject to remediation and subsequent validation (GHD 2011(a), GHD 2011(b) and GHD 2011(c)). As such, no additional samples were collected from Berths M5, M6 and M7. Mayfield 3 and 4 were not tested during the pilot study as they were added to the Project after the pilot study was completed.

A vibracore was used for sampling sediments, as this equipment collects sediments in vertical profile to a depth of up to 6 metres or at core refusal (if shallower). Upon collection, the sediments were extruded from the vibracore into sterile plastic sleeves, prior to processing. Recovered vibracore samples were subsequently photographed, logged and sub-sampled for laboratory analysis. Full details of sampling, analytical and quality control procedures implemented during the sampling program are presented in the Sediment Geochemical Assessment Report (Appendix D).

The following suite of analytes were tested for during the pilot study:

- Moisture content and total organic carbon (TOC)
- Heavy metals (including arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni) and zinc (Zn)
- Total Petroleum Hydrocarbons and (TPH) and Benzene, Toluene, Ethylbenzene and Xylene (BTEX)
- Polycyclic aromatic hydrocarbons (PAH)

- Phenols
- Organochlorine pesticides (OCP)
- Polychlorinated biphenyls (PCB)
- Tributyltin (TBT)
- Nutrients including ammonia, nitrate, nitrite, nitrogen and phosphorus

Sample ID	Easting (MGA56)	Northing (MGA56)
D3-1	385,106	6,357,995
D3-2	385,096	6,358,064
D3-3	385,099	6,358,117
D3-4	385,082	6,358,189
D3-5	385,081	6,358,251
M1-1	384,967	6,359,141
M1-2	384,965	6,359,213
M1-3	384,950	6,359,274
M1-4	384,936	6,359,312
M2-1	384,907	6,359,407
M2-2	384,891	6,359,465
M2-3	384,884	6,359,532
M2-4	384,836	6,359,599
W1-1	385,293	6,358,897
W1-2	385,287	6,359,026
W1-3	385,279	6,359,095
W2-1	385,290	6,359,154
W2-2	385,263	6,359,215
W2-3	385,255	6,359,280
W3-1	385,259	6,359,369
W3-2	385,251	6,359,433
W3-3	385,225	6,359,482
K1-1	385,241	6,359,578
K1-2	385,248	6,359,670

Note: The final sampling locations may be subject to some change pending site conditions encountered during sampling.

LEGEND

- Sediment Sampling Locations
- Berth Locations

1:10,000 (at A4)

0 35 70 140 210 280

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Newcastle Port Corporation
Capital Strategic Dredging Project

Job Number 22-15683
Revision 0
Date 10 Sep 2012

Sediment Sampling Locations

Figure 9.2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com.au W www.ghd.com.au

G:\22\15683\GIS\Maps\Deliverables\Environmental Assessment\Contamination\2215683_C002_ProposedSampleLocations_20110823_A.mxd

Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay

Summary of Results

The concentrations of four metals; specifically lead, mercury, nickel and zinc, returned concentrations greater than the *National Assessment Guidelines for Dredging* (NAGD) screening levels. All other tested analytes returned concentrations less than their respective NAGD screening levels.

Following review of available historical data, concentrations of metals were generally consistent with those reported previously within the south arm of the Hunter River. Concentrations of lead and zinc reported during the pilot study were generally lower than those previously reported.

Comparison of the current data with historical data (PBP 2005, GHD 2003) indicates that concentrations of some metals, including lead, mercury, nickel and zinc have historically been reported at elevated concentrations within the south arm of the Hunter River. In addition, these materials have successfully been disposed of at sea through a Commonwealth approved Sea Dumping Permit (SDP) after further analysis.

Conclusions

Based on the literature review, pilot study and GHD's understanding of the nature and extent of contamination within the sediments of the Hunter River, and with appreciation of the analytical requirements outlined in the relevant guidelines, the primary contaminants of potential concern (COPC) were identified as:

- Polycyclic aromatic hydrocarbons (PAH)
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX)
- Total Petroleum Hydrocarbons (TPH)
- Metals including arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni) and zinc (Zn)
- Tributyltin (TBT)

Subsequently, further testing in accordance with a Commonwealth Government (SEWPaC) approved Sampling and Analysis Plan (SAP) has been undertaken, which investigates these COPC in more detail.

9.4.5 Sediment Sampling and Analysis Plan

Methodology

As part of NPC's broader Project objectives for the development of the Port of Newcastle sediment sampling in accordance with a Commonwealth government (SEWPaC) approved Sampling and Analysis Plan (SAP) was conducted for berths M2, M3, M4, M7 and D3. This is to support a Sea Duming Permit (SDP) being prepared for the identified berths. The results for M3 and M4 from the SAP investigation have been included herein as these berths were not sampled during the pilot study. It is also important to note that the sediment sampling and analysis program is still underway at the time of this EIS and therefore data presented below is preliminary only.

For the current project, a vibracore was used to collect sufficient volumes of sediments at locations SC11 and SC10 within M3 and M4, respectively (Figure 9.4 in Preliminary SAP Summary, Appendix D). Additionally, sediment sampling took place at a reference area at Fullerton Cove using a van veen grab. This area was used to provide an understanding of the natural ambient levels of analytes within the Project surrounds.

For sediment samples collected using the vibracore, once individual cores were collected and field information and logging completed, sediment from each 0.5 metres sample interval was mixed well to ensure a thoroughly homogenised sample. An exception to this procedure was a portion of the core that was analysed for volatiles, which was not mixed and was collected from midway of each interval along the cores, in accordance with the NAGD.

All samples collected from the M3 and M4 berths were tested for:

- Heavy metals and metalloids (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc)
- Acid sulfate soils (ass)

In addition, samples collected from the top 1 metre of sediments were tested for:

- moisture content and TOC
- TPH and BTEX
- PAH
- TBT

At Fullerton Cove, only heavy metals and metalloids were tested.

Appendix D (Preliminary SAP Summary) details the methodology and preliminary results of the Sediment Sampling and Analysis Plan.

Summary of Results

The results of Phase II testing (in accordance with NAGD 2009 – Figure 9.3 in Preliminary SAP Summary, Appendix D) indicated that the concentrations of four metals (lead, mercury, nickel and zinc) returned concentrations greater than the NAGD screening levels. The concentrations of lead, nickel and zinc returned 95 percent upper confidence limit (UCL) greater than their respective NAGD screening levels. There was also a single exceedance for mercury.

For nickel, although the concentrations were greater than the NAGD screening levels, when compared to the control site (Fullerton Cove), the overall concentration was less than ambient conditions. As such, no further testing was required for nickel, but was required for lead, mercury and zinc. These results therefore identified lead, mercury and zinc within M3 and M4 as contaminants of potential concern (COPC).

All other tested analytes returned concentrations less than their respective NAGD screening levels.

Phase III testing to date has included bioavailability and elutriate testing. It was found that for elutriate testing the concentrations for lead, mercury and zinc returned concentrations less than the NAGD screening levels. For bioavailability testing (using dilute acid extractions), concentrations of lead and zinc were greater than the NAGD screening levels, indicating that further Phase III testing is required which will be undertaken in support of the SDP application with SEWPaC.

Figure 9.5 (Preliminary SAP Summary, Appendix D) provides the results that were observed from the Mayfield berths 3 and 4 during Phase III testing.

Conclusions

Analysis of the results show concentrations generally below the NAGD screening levels, with preliminary bioavailability testing returning concentrations of zinc and lead greater than the screening levels. Further testing is to be carried out to support a SDP.

A complete outline of this work is provided in Appendix D (Preliminary SAP Summary).

9.5 Potential Impacts from Contaminated River Sediments

The results of the completed pilot study sediment investigation are presented in the Sediment Geochemical Assessment Report (Appendix D). As part of NPC's broader Project objectives for the development of the Port of Newcastle (PoN) sediment sampling in accordance with a Commonwealth government approved Sampling and Analysis Plan (SAP) was conducted (Preliminary SAP Summary is provided in Appendix D). A summary of the key findings of the investigation, and the most recent results, are provided in Table 9-8.

Table 9-2 Summary of Sediment Geochemical Assessment Key Findings

Issue	Discussion of Results
Metal concentrations in sediments	For the pilot study, concentrations of some metals, including mercury, lead, nickel and zinc, were reported at concentrations exceeding the sediment quality guidelines (SQG) at several locations. Concentrations were generally consistent across each of the investigation areas. Concentrations of metals in sediments were generally consistent with those reported previously within the South Arm of the Hunter River. Selected samples were submitted for elutriate testing for lead, mercury, nickel and zinc to assess potential impacts to water quality owing to the presence of elevated concentrations of metals in sediments. The analytical results were compared against the ANZECC/ARMCANZ (2000) marine water quality trigger values for 95 per cent protection. Additionally, previous elutriate testing has been completed by CSIRO (2001). Available data indicates that effects on organisms in the water column, associated with the presence of elevated concentrations of metals in sediments, would not be expected during disposal. For the SAP, samples from M3 and M4 were submitted for Phase II testing in accordance with the NAGD. All analytes were less than their respective NAGD screening levels, with the exception of the metals lead, mercury and zinc which required Phase III testing to determine their bioavailability within the marine environment. The preliminary results from the bioavailability testing is summarised below.
PAH concentrations in sediments	For the pilot study, concentrations of PAH in sediments were reported below the SQG in all samples submitted for analysis. It is noted that the PAH hotspot, previously identified in the vicinity of proposed Walsh Point Berth Pocket (W2) was not identified during the pilot study sediment sampling program despite sampling the sediment at the same location. Concentrations of PAH in sediments off Walsh Point were all reported below the SQG-low. It is noted however noted that evidence of slag and coal fragments were reported at three locations off Walsh Point and the potential for PAH impact in surrounding sediments cannot be discounted. For the SAP, concentrations of normalised PAH (to TOC) in sediments ranged from 60 µg/kg to 7181.6 µg/kg, which were below the NAGD screening levels of 10,000 µg/kg. As such, Phase III testing was not required.

Issue	Discussion of Results
Hydrocarbon concentrations in sediments	For the pilot study, concentrations of hydrocarbons in sediments were low and below the practical quantitation limit (PQL) of the laboratory in most samples submitted for analysis. TPH in the fraction C_{10}-C_{36} was reported in one surface sample (0-0.5 m) collected from W3-2 at a concentration of 187 mg/kg, which is below the SQG of 550 mg/kg. Concentrations of volatile TPH C_6-C_9 and BTEX were reported below the laboratory PQL in all samples selected for analysis. Hydrocarbon odours were noted in sediments at three locations however, it is noted that subsequent analyses of samples from these locations reported concentrations of TPH and BTEX below the laboratory PQL. For the SAP, concentrations of hydrocarbons were also low. The sum of total TPH from M3 and M4 ranged from 15 mg/kg to 64.78 mg/kg (normalised to 1% TOC), which were less than the NAGD screening level of 550 mg/kg. For BTEX, all concentrations were less than the PQL for each respective analyte. As such, Phase III testing was not required for TPH or BTEX.
Other organic compounds in sediments	For the pilot study, concentrations of OCPs, PCBs and phenols were reported below the laboratory PQL in all samples submitted for analysis. Consistent with previous investigations, concentrations of TBT in sediments selected for analysis were low or below the laboratory PQL. No samples reported concentrations of TBT exceeding the SQG. For the SAP, only TBT was assessed. The concentrations of TBT were less than the PQL in M4, and ranged from 7 µgSn/kg to 7.6 µgSn/kg (normalised to TOC), which was less than the NAGD screening level of 9 µgSn/kg. As such, Phase III testing was not required for TBT.
Bioavailability testing	For the pilot study, bioavailability testing was not undertaken as part of the current investigation. However, it is noted that toxicity testing has been undertaken previously by CSIRO as part of the South Arm Dredging EIS process. The initial CSIRO toxicity investigations demonstrated that the contaminants of concern in the South Arm of the Hunter River were most likely to be PAHs and toxicity of the sediments was found to correlate reasonably well with total PAH concentrations. The extent of maximum PAH impact was delineated and identified as the Primary and Secondary Remediation Zones. These areas were subsequently remediated and validated. Further, it is noted that concentrations of PAH in sediments were reported below the SQG-low in all samples submitted for analysis as part of the current investigation. For the SAP, Initial Phase III testing for PAH, TPH, BTEX and TBT were not required, as noted above. Phase III testing for lead, mercury and zinc included elutriate and dilute acid extraction analyses. Elutriate testing completed for lead, mercury and zinc resulted in concentrations less than the NAGD screening levels. The results of dilute acid extraction testing, however, found concentrations of lead and zinc only, greater than their respective NAGD screening levels. As such, further phase III testing is required, with the possibility of Phase IV toxicity testing to support a Sea Dumping Permit (SDP) application with SEWPaC.

Issue	Discussion of Results
Suitability of material for ocean disposal	Previous investigations estimated the extent of the PAH hotspot off Walsh Point comprises approximately 30,000 cubic metres of impacted material which would not be considered suitable for unconfined ocean disposal. However, this hot spot was not found during the pilot study despite sampling taking place at the same location. Further sampling and analysis will be required for the SDP process to determine the ocean disposal suitability.
Waste Classification	Sediment analytical results reported during the pilot study sediment sampling program were compared against the threshold concentrations reported in NSW DECC (2009) *Waste Classification Guidelines Part 1: Classifying Waste*. Concentrations of lead and nickel were reported in excess of the contaminant threshold for general solid waste. Selected samples reporting elevated concentrations were selected for toxicity characteristic leaching potential extraction and analysis for lead and nickel. The results were reported below the threshold concentrations for general solid waste. All other contaminants of potential concern reported concentrations below the threshold concentrations for general solid waste. In the event that portions of the material were not suitable for ocean disposal, the material would be classified and disposed of accordingly. Based on the available data, the results indicate that sediments would be suitable for on-shore disposal as General Solid Waste.

9.6 Recommended Mitigation Measures

9.6.1 Soil and Groundwater

Excavations for the construction of the Mayfield 1 and 2 berths will intercept contaminated material within the landside fill. The material would be tested for leachability during excavation and its classification under the *DECC Waste Classification Guidelines* (2008) confirmed.

The current standard method for managing contaminated material is cement stabilisation. Methods for stabilisation may improve in the future, and would be considered at the time of dredging. A soil and water management plan (SWMP) would be developed, and would detail measures equivalent to (or better than) the current methods to adequately manage contaminated materials.

The SWMP would consider the requirements of the management plan developed for the remediation of the former BHPB steelworks site. The SWMP would detail the management of contaminated soils and groundwater, and provide appropriate mitigation measures to be undertaken. This plan would include provisions for the classification and management of any surplus materials that are required to be disposed off-site. Where groundwater is to be intercepted, a licence would be obtained from the NSW Office of Water in accordance with the *Water Act 1912*.

9.6.2 Sediments

The findings of the pilot study sediment sampling program indicate that the majority of sediments in the proposed dredging areas would be suitable for unconfined ocean disposal. A SDP application is being investigated and developed concurrently to the planning approval process.

As part of the dredging works a soil and water management plan would be developed. The plan would outline appropriate sediment management and environmental controls to be followed. The plan would eliminate or minimise potential impacts to human health and the environment. Management actions to be considered include, but are not limited to the following:

- Implementation of appropriate OHS controls throughout the duration of the works.
- The use of silt curtains or appropriate technology during dredging operations.
- Validation sampling and analysis to identify or rule out the previously identified PAH hotspot identified off Walsh Point.
- Additional sediment sampling that may be required as part of the Sea Dumping Permit Application.
- Management of sediments if they are to be disposed of to landfill.

10. Hydrology

Hydrology is listed as a key issue in the DGRs. This chapter addresses the DGRs for the assessment of hydrological changes as a result of the Project. It is closely related to assessment of Chapter 8 (Sediment and Water Quality).

The DGRs for the Hydrology component of the EIS are provided in Table 10-1.

Table 10-1 Hydrology DGRs

Environmental Assessment Requirements	Where Addressed
Assess hydrodynamic changes to the Hunter River, including: flushing, tidal flow and velocity, wave dynamic, bank erosion and stability.	Section 10.3 (Potential Impacts on Hydrology), and Section 8.3.4 (Flushing Characteristics)
Identify the potential for the alteration of tidal range and water levels, saline intrusion to upstream water bodies, stratification and anoxia.	Section 10.3 (Potential Impacts on Hydrology)
Assess changes to flooding characteristics, including: velocity changes within and adjoining the works and the consideration of climate change.	Section 10.3 (Potential Impacts on Hydrology)
Consider the *Newcastle Floodplain Planning – Stage 1 Concept Planning Report* (Newcastle City Council).	Section 10.2 (Existing Environment for Hydrology)

10.1 Introduction

The hydrological assessment incorporated the results from the review of the extensive literature available for the Hunter estuary. As discussed in Section 8 the hydrodynamic model was refined and subsequently used to simulate changes to the estuary, and gauge potential impacts as a result of the Project.

10.1.1 Literature Review

The following documents were reviewed as part of the hydrological assessment:

- GHD 2003, *South Arm Dredging Project, Environmental Impact Statement.*
- Newcastle City Council 2009*, Newcastle Floodplain Planning – Stage 1 Concept Planning Report.*
- Public Works Department 1994, *Lower Hunter Flood Study.*
- Manly Hydraulics Laboratory 2002, *Hunter Estuary Processes Study.*
- Newcastle City Council 2009, *Hunter Estuary Coastal Zone Management Plan*.

- Sanderson, Dr Brian; Redden, Dr Anna and Matthew Smith 2002, *Salinity Structure in the Hunter River Estuary.*
- Patterson Britton & Partners (PBP, 1996) *Floodplain Management Study.*

10.1.2 Legislation and Guidelines

Appropriate guidelines and legislation considered in the assessment of hydrology included, but were not limited to, the following:

- ANZECC/ARMCANZ 2000, *Water Quality Guidelines for Fresh and Marine Waters.*
- CSIRO 2000, *Sediment Quality Guidelines.*
- Newcastle City Council 2009, *Newcastle Floodplain Planning – Stage 1 Concept Planning Report.*

10.1.3 Hydrodynamic Modelling

In order to quantify the existing hydrodynamic conditions and provide estimates of the likely conditions following completion of the proposed dredging activities, an existing RMA hydrodynamic model of the lower reaches of the Hunter River was revised and updated. This model had been previously developed for NPC on behalf of NSW Maritime by Patterson Britton and Partners (PBP) in association with GHD as part of the South Arm Dredging Project (GHD 2003).

The methodology used to upgrade and customise the existing model, and meet the DGRs in relation to hydrology, is detailed below:

- Reactivate the RMA model.
- Import the latest bathymetry, to reflect the recent works in the South Arm.
- Import the Project design.
- Undertake model runs using the RMA modelling software in order to simulate the following:
  - *River hydrodynamics under tidal conditions, enabling assessment of any alteration to tidal ranges and phasing throughout the estuary as a result of the proposed dredging works.*
  - *Salinity, in order to assess the potential alteration to the salinity structure of the estuary as a result of the proposed dredging.*
  - *An arbitrary conservative component, to provide a picture of any likely alteration to flushing and pollutant dispersion characteristics in the estuary due to the dredging.*
  - *Cohesive (muddy) and non-cohesive (sandy) sediment, to assist in prediction of the transport of suspended sediment generated during dredging and likely deposition zones. This was used to assess any potential impacts on fish, prawns, oysters and their habitats.*

The information generated by the model was then used to investigate the following issues:

- Bank erosion and stability, including consideration of natural flow events and the impacts of passing vessels and wave action.
- Saline intrusion impacts, such as mangrove/wetland community impacts, stratification and anoxia.
- Potential impacts on the findings and recommendations set out in the Newcastle Floodplain Planning Report.

The potential impacts associated with each of the issues were then evaluated and compared to existing conditions and background data where possible. The environmental risks related to each option were identified and assessed, and mitigation measures developed as appropriate.

10.2 Existing Environment

10.2.1 General

Water levels, tidal flows and water velocities vary within the Hunter River estuary due to a number of factors, including:

- Tidal action.
- Ocean storm surges.
- Coastal trapped waves.
- Freshwater flow, generally from rainfall run-off.
- Local wind setup within the estuary.
- Potential sea level rise transferring from the ocean to the estuary.

Generally, in periods of no rainfall, astronomical tides are the major factor affecting the hydrodynamics of the entrance channel, the North and South Arms, and fringing mangrove and saltmarsh areas of the Hunter River. In events of sufficient magnitude, freshwater flows from rainfall are the dominant process governing the movement of water within the estuary. Wetland areas, which are rarely or never inundated by tides, rely on flood flows to be submerged.

The annual water balance (change in volume) of the Hunter estuary is dominated by tidal inflow and outflow. Tidal movements account for 85 percent of inflows and 99.9 percent of outflows. Other contributions to estuary inflow comprise catchment run-off (8 percent), groundwater flow (7 percent) and direct rainfall (0.1 percent). Evaporation makes up the other, very small proportion of outflow (0.1 percent). The relative importance of tidal inflow and outflow diminishes with distance upstream in the estuary.

The mean river flow between 1975 and 2000 was 3,120 megalitres per day (ML/d), with a median of 720 ML/d (GHD, 2003). For most of the time, the freshwater flow is less than its mean value. The mean is therefore derived from the influence of large-scale rain events.

The existing environment of the Hunter estuary is described in more detail in subsequent sections. Specifics on the tidal hydrodynamics of the estuary are given in Section 10.2.2, while the flooding regime is described in Section 10.2.3. The salinity distribution of the Hunter estuary is affected by tidal and flooding processes as outlined in Section 10.2.4.

10.2.2 Tidal Hydrodynamics

The tides at the entrance of the Hunter River estuary are semi-diurnal with a strong spring-neap cycle. The tidal variation levels at Newcastle Harbour in the vicinity of the Project area are as follows:

Table 10-2 Tidal Level Variation at Newcastle Harbour

Highest recorded tide	2.37 m
Highest astronomical tide	2.10 m
Mean high water springs	1.62 m
Mean high water	1.49 m
Mean high water neaps	1.37 m
Mean sea level	0.99 m
Mean low water neaps	0.62 m
Mean low water	0.49 m
Mean low water springs	0.37 m

These figures are in relative terms to the Newcastle Harbour Tide Gauge (NHTG) Datum, operated by the Port of Newcastle. This is approximately the lowest astronomical tide level and is 1.01 metres below Australian Height Datum (AHD).

Tides in the Hunter estuary vary from the ocean entrance to the tidal limits, generally with a gradual reduction in the mean tidal range proceeding upstream. This excludes a slight amplification within the Williams and Paterson Rivers. The tidal limit in the Hunter River is approximately at Oakhampton (64 kilometres upstream from the ocean), with tides also intruding into major tributaries including the Paterson River as far as Gostwyck, about 73 kilometres from the ocean and the Williams River as far as the weir at Seaham, about 46 kilometres from the ocean.

The general reduction in tidal range moving upstream can be understood in terms of tidal excursion, the distance a water particle travels over a tidal cycle. In the lower estuary, the tidal excursion is about 10 kilometres, while at Morpeth it reduces to around three kilometres.

Numerous tributary creeks are also tidally influenced. These include Wallis, Fishery, Ironbark, Throsby, Styx and Cottage Creeks. However, floodgates at the entrance to the Wallis and Fishery Creek system, and also Ironbark Creek, significantly attenuate tidal intrusion upstream of the gates.

There is also a lag in the times of high and low water moving upstream. The peaks and troughs occur later upstream compared to the entrance, with the relative delay greater for low tides.

The Hunter's North Arm dominates the tidal prism carrying about 80 percent of the tidal flow at Walsh Point, with the South Arm conveying around 20 percent. The upstream tributaries make relatively small contributions to the tidal prism, namely about seven percent in the Williams, four percent in the Paterson and two percent in the Hunter upstream of Morpeth.

Maximum tidal velocities are reduced to about half of the entrance values by Raymond Terrace, with the tidal prism having reduced to only about 15 percent of the entrance prism at this location. This includes the contributions of both the Hunter and Williams Rivers.

10.2.3 Flooding

Flooding behaviour in the Hunter estuary has changed substantially since European settlement due to estuary modifications. The construction of levees, spillways, canals, floodgates, and diversion banks has changed the river's behaviour. Much of these works were undertaken as part of the Lower Hunter Valley Flood Mitigation Scheme, in almost immediate response to the largest flood that had occurred since European settlement, which took place in 1955. In total, 160 kilometres of levees and spillways, 111 kilometres of flood canals, 175 floodgates, 14 kilometres of bank protection works and 40 kilometres of control and diversion banks were built as part of this scheme.

Most of the works were constructed between Morpeth and Hexham. There was also a levee created from Tomago to the eastern side of Fullerton Cove.

In case of flood events with higher annual exceedance probability (AEP), the flood flow is contained within the main channel of the river and surrounding levees. As the flood severity increases AEP reduces, floodwaters begin to overtop the natural and constructed levees and flow across the floodplain. For the 20 percent AEP and rarer events, the majority of flow is across the floodplain (GHD, 2003).

In high magnitude events (one percent AEP), only about 30 percent of the flood flow is carried in the main channel upstream of Purgatory Creek (near Hexham), with 70 percent carried by the Millers Forest and Woodberry Swamp floodplains. However, floodwaters are constricted at Purgatory Creek by the New England Highway and North Coast Railway, as well as high ground at Tarro. Some flow is able to pass through culverts under the highway and railway (in particular at the Tarro control on the Highway), or pass over these in floods larger (rarer, more severe) than the 10 percent AEP. About 30 percent of the flow enters Hexham Swamp in the 1 percent AEP event.

Therefore, much of the overbank flow is forced back into the main channel just upstream of Hexham. This flow tends to spill over Kooragang Island and Tomago Swamp, which are both completely inundated (excluding the southern part of Kooragang Island), during moderate to major floods (exceeding 10 percent AEP). The southern part of Kooragang Island is protected from floodwaters by a large railway embankment, forcing far more floodwaters into the North Arm compared to the South Arm. At Walsh Point, more than 75 percent of the flood flow is carried in the North Arm. Only about six percent of the flow goes overbank at Hexham and travels through Tomago Swamp to Fullerton Cove.

10.2.4 Salinity Structure

Sanderson *et al.* (2002) measured the vertical profiles of salinity (and temperature, turbidity and dissolved oxygen) at various locations in the Hunter estuary on 23 days between January and April in 2001. Measurements were taken at a total of 42 locations, from the entrance to as far upstream as Duckenfield (about 41 kilometres upstream from the entrance).

The measurements were generally made at high tide, covering a spring-neap tidal cycle coinciding with low rainfall, and immediately prior to, during and following a minor flood (peak flow about 200,000 ML/d) on 9 March 2001.

The spring-neap tidal cycle was observed to play only a minor role in modifying estuarine salinities, compared to river freshwater flows. Flows of sufficient magnitude (floods) were found to discharge most of the salinity from the estuary, excluding the areas where dredging to greater depths takes place.

After floods, the salinity was found to intrude slowly upstream. Turbulent mixing through the water column, as well as wind generated mixing, was found to mix the salinity concentrations in the water column. That is, water in the estuary was described as well mixed, with very little stratification during low freshwater flows.

Relationships for saline intrusion were derived for flows exceeding 200,000 ML/d. This enabled the position of the salinity isohalines (10, 15, 20 and 30 parts per thousand) to be determined as a function of river flow on the previous day.

These were then applied to the 1975–2000 flow record, and it was found that the 10 parts per thousand isohaline was most frequently found around 24 kilometres upstream. However, given that the freshwater flow is less than 200,000 ML/d for most of the time the salinity intrusion is likely to be overestimated during the most prevalent low flow conditions.

To provide a potentially improved estimate of historical salinity intrusion, a simple advection-diffusion relationship based on an idealised channel bathymetry was applied to the 1975–2000 flow record. This predicted that the average salinity varied from 35 parts per thousand at the ocean entrance to between about five parts per thousand and 25 parts per thousand at 20 kilometres upstream of the entrance. By about 30 kilometres upstream of the entrance, average salinities were less than five parts per thousand. According to MHL (2002), salinities upstream of Raymond Terrace in the Hunter River are typically about 0.2 to 0.5 parts per thousand.

External Sources

External sources of saline intrusion are also present in the Hunter estuary. Saline discharges from coal mines and electricity generators in the Hunter River are managed through the Hunter River Salinity Trading Scheme. Under this scheme, saline discharges are scheduled to occur during relatively high freshwater flows to minimise the salinity increases in the river, and thereby reduce impacts on the activities of irrigators and other water users, as well as on aquatic ecosystems.

10.3 Potential Impacts

10.3.1 Tidal Hydrodynamics

The alteration to water levels throughout the Hunter estuary as a result of the proposed dredging is given in Table 10-3. The reporting site locations are displayed in Figure 10.1.

Table 10-3 Predicted Changes in Water Level Due to Dredging of South Arm under Tidal Conditions

Site	Average Change (m)	Maximum Positive Change (m)	Maximum Negative Change (m)
Kooragang Berth No. 6	0.000	0.002	-0.002
Kooragang Berth No. 2	0.000	0.002	-0.002
Stockton Bridge	0.000	0.001	-0.001
North / South Arm Junction	0.000	0.002	-0.001
Walsh Point	0.000	0.002	-0.001
Tourle St Bridge	0.000	0.003	-0.003
Ironbark Creek	0.000	0.003	-0.002
Tomago	0.000	0.001	-0.001
Fullerton Cove	0.000	0.001	-0.001
Stockton Crossing	0.000	0.001	-0.001
Entrance	0.000	0.000	0.000
Hannell St	0.000	0.002	-0.002
Hexham Bridge	0.000	0.000	-0.001
Railway Bridge	0.000	0.003	-0.002

Changes in water levels from the proposed dredging in the estuary under tidal conditions are predicted to be negligible. The average change in simulated water levels at most sites is effectively zero. The maximum and minimum changes in water levels at Tourle Street Bridge, the Railway Bridge and the entrance to Ironbark Creek were three millimetres, two millimetres and two millimetres respectively.

Given the relatively small scale of the works, there would be virtually no effect on tidal planes in the estuary as a result of the proposed dredging.

LEGEND

Indicitive Reporting Site

Berth Locations

Watercourse

1:60,000 (at A4)

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

CLIENTS | PEOPLE | PERFORMANCE

Newcastle Port Corporation
Capital Strategic Dredging Project

Job Number	22-15683
Revision	0
Date	11 SEP 2012

Reporting Site Locations

Figure 10.1

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\22\15683\GIS\Maps\Deliverables\Environmental Assessment\Hydrology\2215683_H001_ReportingSites_Rev_0.mxd

Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay, mabarnier

10.3.2 Velocities

Based on the 29-day tidal simulation, the alteration to total velocities throughout the Hunter estuary due to the proposed dredging of South Arm is given in Table 10-4.

Table 10-4 Predicted Changes in Total Water Velocity Due to Dredging under Tidal Conditions

Site	Average Change (m/s)	Maximum Positive Change (m/s)	Maximum Negative Change (m/s)
Kooragang N6 Berth	0.000	0.002	-0.003
Kooragang N2 Berth	0.002	0.011	-0.005
Stockton Bridge	0.000	0.002	-0.002
North Arm and South Arm Junction	-0.002	0.005	-0.011
Walsh Point	0.001	0.034	-0.028
Tourle St Bridge	0.000	0.005	-0.006
Ironbark Creek	0.000	0.002	-0.002
Tomago	0.000	0.001	-0.001
Fullerton Cove	0.000	0.000	0.000
Stockton Crossing	0.000	0.006	-0.005
Entrance	0.000	0.002	-0.002
Hannell St	0.000	0.005	-0.005
Hexham Bridge	0.000	0.001	-0.001
Railway Bridge	0.000	0.004	-0.004

Under both spring and neap tidal conditions the proposed dredging would produce negligible changes to water velocities in the estuary. The average change in simulated velocities at most sites was negligible, with maximum average changes in velocities generally much less than 0.01 m/s (0.02 knots).

Velocities in the dredge area would reduce substantially after completion of the dredging. There would not be any significant alteration to tidal velocities (magnitude and direction) within the Port area that would affect navigation.

Given that the deepening and widening within each of the proposed berth areas would reduce water velocities at the site of the berths, the creation of the proposed berths would not result in any areas of scour or erosion which could affect the stability of banks, foreshores and structures adjacent the area to be dredged.

The potential scour and erosion associated with propeller wash generated by passing vessels and those utilising the berth has been considered in the conceptual design of foreshore protection measures. Details of foreshore treatments are provided in Chapter 2 (Description of the Project), Chapter 13 (Spoil Handling and Disposal) and Appendix E (Spoil Handling and Disposal Strategy). These measures would be further developed during detailed design.

Table 10-5 shows the average pre and post dredging flow rates throughout the Hunter estuary from the 29-day tidal simulation. Table 10-6 shows the maximum pre- and post-dredging flow rates throughout the Hunter estuary from the 29-day tidal simulation.

The flows are the averages across the channel cross-section at the locations shown. The maximums shown are for the 29-day simulation and are not necessarily the maximum possible tidal flow rates that could occur in the estuary.

Table 10-5 Predicted Pre and Post Dredging Average Flow Rates in the Hunter Estuary under Tidal Conditions

Site	Average Ebb Tide Flow (m^3/s)		Average Flood Tide Flow (m^3/s)	
	Existing	Dredged	Existing	Dredged
Ocean Entrance	1040	1038	1114	1115
Entrance to Throsby Creek	45	45	46	46
Main Channel at Confluence with Throsby Creek	955	954	1004	1004
Downstream entrance to South Arm	181	179	195	194
Downstream entrance to North Arm	728	728	744	744
Hexham St Bridge	245	245	255	255
North Arm Near Tomago	221	221	233	233
Ironbark Creek Entrance	57	57	51	51
Tourle Street Bridge	97	97	94	94

Table 10-6 Predicted Pre and Post Dredging Maximum Flow Rates in the Hunter Estuary under Tidal Conditions

Site	Maximum Ebb Tide Flow (m^3/s)		Maximum Flood Tide Flow (m^3/s)	
	Existing	Dredged	Existing	Dredged
Ocean Entrance	2692	2694	2850	2850
Entrance to Throsby Creek	164	165	161	161
Main Channel at Confluence with Throsby Creek	2487	2485	2555	2548
Downstream entrance to South Arm	551	542	619	614
Downstream entrance to North Arm	1870	1871	1885	1885
Hexham St Bridge	503	503	488	488
North Arm Near Tomago	429	429	451	451
Ironbark Creek Entrance	145	145	118	118
Tourle Street Bridge	271	271	251	250

The modelling shows that the proposed dredging works would not affect tidal flow rates in the estuary to any noticeable extent, and that the Project would have a negligible influence. Table 10-5 shows that the greatest potential change in average flow rates would be a reduction of two cubic metres per second at the harbour entrance and the downstream entrance to South Arm on the ebb tide.

Table 10-6 shows that the greatest change to the maximum flow rate over the tidal period would be a decrease of seven cubic metres per second at the main channel confluence with Throsby Creek on the incoming tide.

Overall, the modelling results indicate that tidal hydrodynamics would remain virtually unchanged after the proposed dredging. The magnitudes of these changes would be negligible and would not be expected to have any measurable effect on the estuary.

10.3.3 Wave Dynamics

The potential impacts of the proposed dredging activities on wave dynamics within the Hunter River have been considered using the results of previous studies and anecdotal evidence. Specifically, consideration has been given to swell waves (long period wave energy), locally generated sea (short period wave energy) and vessel wash.

Given that very little long period wave energy reaches the proposed dredging areas due to the geometry of the entrance to the Hunter River, no changes to long period wave energy are anticipated as a result of the proposed dredging works.

Locally generated sea within the South Arm of the Hunter River is fetch limited and as a result is generally less than 0.5 metres in height. These waves would not be affected by the proposed dredging activities due to the depth of water in both the existing and post dredge scenarios.

Finally, vessel wash has been considered in the design of the proposed dredging areas and associated batter slopes. Specifically, the concept designs include foreshore protection measures which have been designed to accommodate the vessel wash generated within an active commercial port such as the South Arm of the Hunter River. In particular, wave reflections are not expected to adversely affect activities or foreshore treatments along the more active portion of the South Arm of the Hunter River.

In summary, no significant impacts are expected with respect to wave dynamics within the South Arm of the Hunter River.

10.3.4 Flooding

In addition to potential changes to water velocities within the footprint of the works and the adjacent areas, consideration has been given to the potential changes to other flooding characteristics of the Hunter River, such as geomorphology, overland flood flows and peak flood levels.

Following completion of the proposed dredging activities, the dredged area itself would be deeper than under existing conditions. This would result in an increase to the cross section flow area of the South Arm. When considered in the context of the Hunter River as a whole, the proposed dredging works represent relatively small hydrodynamic changes that would not result in any significant change to the geomorphology of the estuary.

The concept design has avoided intrusive foreshore treatments and stabilisation measures that could restrict the flow of the South Arm.

Consequently, the alteration to the flood profile (peak water levels versus distance) would be negligible for both the North and South Arms of the Hunter River. No change would occur to either the duration or peak levels of flood events upstream or downstream of the proposed dredge areas.

As a result, no adverse flooding effects such as damage to property, or alteration of flood behaviour at environmentally sensitive sites would result from the Project.

Previous flood studies have noted that one of the most hydraulically effective management options for reducing flood levels associated with the Hunter Floodplain is dredging (PBP, 1996). The *Newcastle Floodplain Planning – Stage 1 Concept Planning Report* (NCC, 2009) specifies channel widening and deepening by dredging as a channel improvement measure to improve conveyance of floodwaters and reduce flood risk throughout the lower Hunter estuary.

Whilst the proposed dredging works could theoretically provide beneficial reductions in peak flood levels, the impact of these benefits is likely to be negligible. This is a result of the relatively small nature of hydrodynamic changes when considered in the context of the Hunter River as a whole.

Climate change, and its potential influence on flooding, has been considered. Sea level rise is the most likely aspect of climate change to affect the flooding characteristics of the Hunter River. Given that predictions of sea level rise are orders of magnitude greater than the predicted changes to water levels associated with the proposed dredging activities, there would be no significant contribution to the effects of sea level rise as a result of the proposed dredging activities.

10.3.5 Salinity Structure

Salinity is a factor that affects the health and distribution of a number of estuarine floral and faunal species. The potential impacts to flora and fauna as a result of the proposed works are considered in Chapter 15 (Flora and Fauna).

To investigate the potential alteration in salinity due to the proposed dredging, modelling were undertaken to investigate saline intrusion over a 29-day period. The modelling assumed an initially fresh estuary (0 parts per thousand) and saline oceanic waters of 35 parts per thousand, under tidal conditions. These are conservative conditions used to investigate any changes to salinity regime. Freshwater flows (particular floods) have a more significant influence on estuarine salinities than tides and would mask any variability in salinity intrusion. There would be little alteration to the high freshwater flow salinity regime under post-dredging conditions.

Salinity concentrations at the end of the 29-day simulations are tabulated in Table 10-7. This table also shows the average difference in pre- and post-dredging salinities over the 29 days of the simulation.

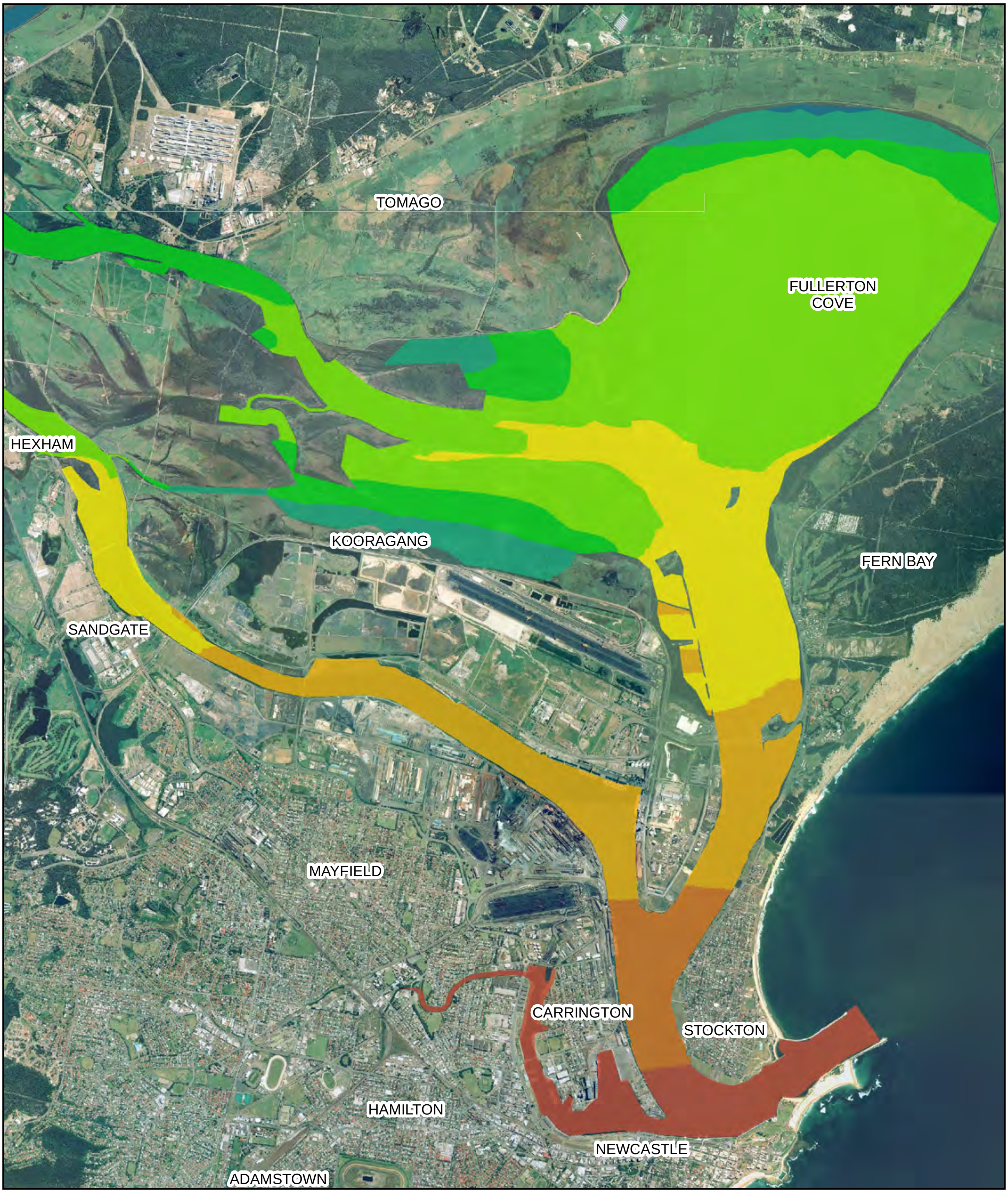
Table 10-7 Salinity Values after 29-day Simulation at Various locations in Estuary for Existing and Post-dredging Conditions

Location	Salinity (ppt) after 29 days		Average Difference in Salinity Pre and Post Dredging (ppt)
	Existing	Post-Dredging	
Kooragang N6 Berth	26.18	26.59	0.41
Kooragang N2 Berth	26.66	27.11	0.45
Stockton Bridge	24.76	25.03	0.08
North arm and South Arm Junction	29.20	29.28	0.34
Walsh Point	28.00	28.34	0.34
Tourle St Bridge	25.11	25.52	0.40
Ironbark Creek	19.33	19.62	0.29
Tomago	14.30	14.50	0.20

Location	Salinity (ppt) after 29 days		Average Difference in Salinity Pre and Post Dredging (ppt)
Fullerton Cove	17.97	18.20	0.23
Stockton Crossing	30.87	30.85	-0.02
Entrance	34.25	34.24	0.00
Hannell St	33.43	33.42	0.00
Hexham Bridge	9.89	10.04	0.15
Railway Bridge	23.63	24.01	0.37

From an examination of the modelling results presented in Table 10-7, there is slightly more saline intrusion under the dredged conditions, particularly in the South Arm. The alteration to the salinity intrusion regime was found to be concentrated around the dredge footprint, in the South Arm. In this reach, salinity values were (on average) less than 0.5 parts per thousand higher over the 29-day simulation after dredging. The results indicate that there are only negligible changes to the salinity regime, particularly outside of the Walsh Point to Ironbark Creek reach.

Figure 10.2 displays existing salinity conditions and Figure 10.3 shows salinity conditions post-dredging. Figure 10.4 displays the change in salinity concentrations above the concentration (0.3 parts per thousand) at which the model is able to graphically represent the changes in salinity.



LEGEND

Salinity (parts per thousand)

0 - 4	16 - 20
4 - 8	20 - 24
8 - 12	24 - 28
12 - 16	28 - 32
	32 - 36

(29 day Tidal Simulations, Fresh Estuary)

1:60,000 (at A4)

0 220 440 880 1,320 1,760

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Revision 0
Date 11 Sep 2012

Existing Salinity Contours

Figure 10.2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au
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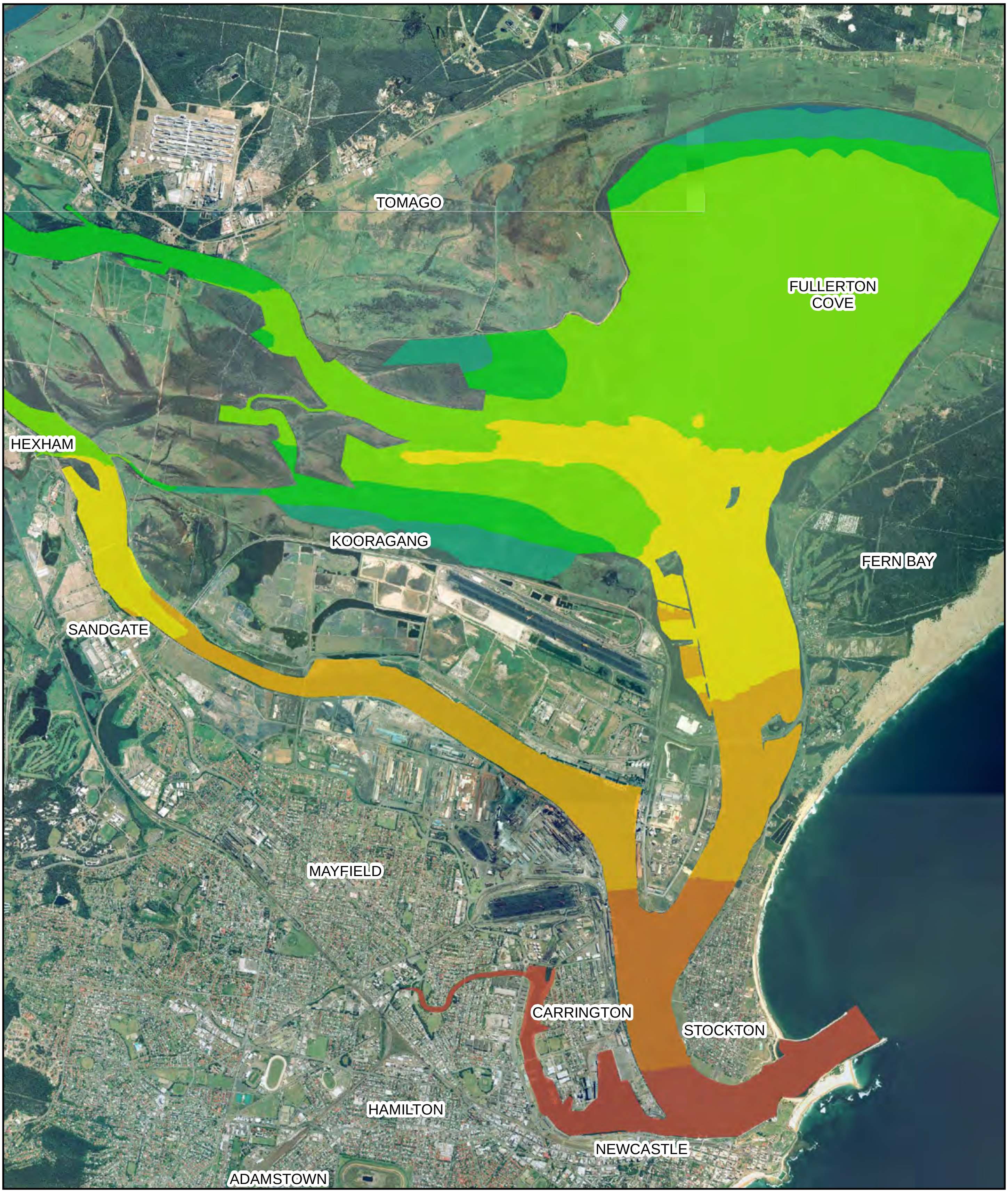
Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay



LEGEND

Salinity (parts per thousand)

0 - 4	16 - 20
4 - 8	20 - 24
8 - 12	24 - 28
12 - 16	28 - 32
	32 - 36

(29 day Tidal Simulations, Fresh Estuary)

1:60,000 (at A4)

0 220 440 880 1,320 1,760

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Post Dredging Salinity Contours

Figure 10.3

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

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Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay

LEGEND

Change in salinity (ppt)

- No change (transparent)
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1

(29 day Tidal Simulations, Fresh Estuary)

1:60,000 (at A4)

0 215 430 860 1,290 1,720

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Change in Salinity Concentrations (ppt)

Figure 10.4

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E ntlmail@ghd.com W www.ghd.com.au
G:\22\15683\GIS\Maps\Deliverables\Environmental Assessment\Hydrology\2215683_H004_ChangeInSalinity_ppt_0.mxd

Data Source: LPMA: DTDB - 2007, Imagery - 2007. Created by: gmcdiarmid, fmackay

10.4 Recommended Mitigation Measures

Simulation modelling identified that there would be no significant changes to the tidal hydrodynamics as a result of the Project. Reductions in water velocities were found to be negligible and as such, would have no significant effect on the estuary system.

Similarly, general flood flow distribution, volumes and duration would not be altered significantly. There would be a perceptible but insignificant reduction in flood risk throughout the lower Hunter estuary.

Saline intrusion was found to slightly increase. The changes to saline intrusion would not affect the likelihood of stratification or anoxia within the estuary.

Given the absence of any significant impacts on the hydrodynamics of the Hunter River, no specific mitigation measures are proposed other than the monitoring activities outlined in the remaining chapters of the EIS.

11. Noise and Vibration

11.1 Introduction

Noise and vibration were listed as key issues for the EIS in the DGRs. This chapter addresses the DGRs for noise and vibration. It assesses noise and vibration impacts potentially caused by the Project, and proposes mitigation measures to eliminate or reduce those impacts. This chapter closely relates to the assessment of Chapter 13 (Spoil Handling and Disposal) and Chapter 14 (Traffic and Transport). The DGRs for the Noise and Vibration component of the EIS are provided in Table 11-1.

Table 11-1 Noise and Vibration DGRs

Environmental Impact Statement Requirements	Where Addressed
Assess the impacts of noise and vibration on adjoining receivers from all activities on and offsite, taking into consideration the Project in isolation and the cumulative impact.	Section 11.4 (Potential Impacts from Noise and Vibration)
Take into account the *Interim Construction Noise Guideline* (DECC) and *Environmental Criteria for Road Traffic Noise* (EPA).	Section 11.3 (Methodology for Noise and Vibration)

Construction of the Project would predominantly involve water-based works in industrial areas. The area immediately surrounding the Project site consists of both vacant and occupied industrial land. This noise and vibration assessment has been based on the scenario that all berths are dredged during a single campaign.

The closest residential area to construction activities is located in north eastern Carrington. The closest residences are located on the eastern side of Scott Street, approximately 270 metres to the west of Dyke 3. Industrial warehouses and railway infrastructure are located between the construction site and these residences. The closest residence to the proposed Mayfield berths is located in Mayfield East, approximately 1.2 kilometres to the west. The Port Waratah Coal loader and the former BHP Steelworks site are located between the construction site and these residences.

The closest residential area to the proposed Kooragang and Walsh Point berths is located in Stockton, approximately 850 metres to the southeast. The North Arm of the Hunter River is located between the construction site and these residences. Figure 11.1 shows the location of sensitive receivers in relation to the Project area.

Barges would undertake the dredging works and the construction of sheet pile walls. Some landside plant and equipment would be used for the foreshore stabilisation works and for spoil handling and management. Spoil material that is not suitable for sea dumping or for alternative beneficial uses would be transported by road for disposal to landfill. The transportation of this material by road has the potential to produce noise impacts along the haul routes. However, the relatively low volumes of spoil to be disposed via landfill would not add significantly to traffic volumes. Refer to Chapter 14 (Traffic and Transport) for predicted traffic volumes from spoil haulage.

11.2 Existing Environment

11.2.1 Noise and Vibration Sensitive Receivers

Construction Sites

The proposed berths are located adjacent to past and present industrial land uses. Industrial land separates the Project site from the nearest sensitive receivers. The residential suburbs closest to the Project are Carrington, Stockton, Mayfield North and Mayfield East. Figure 11.1 shows the location of sensitive receivers in relation to the Project area.

Haul Routes

The material that is not suitable for sea dumping or beneficial reuse due to contamination would require disposal to landfill depending on the classification. Any contaminated material excavated from Mayfield 1 and 2 berths would also require disposal at landfill. Trucks would transport contaminated material to Kemps Creek in western Sydney for landfilling. Figure 11.2 shows the proposed haul route and Chapter 14 (Traffic and Transport) provides details on traffic associated with the Project.

The haulage route from Walsh Point would utilise designated heavy vehicle routes travelling west from Walsh Point along Cormorant Road, then across the Tourle Street Bridge. It would follow Industrial Drive and the Pacific Highway to the north, then west using the New England Highway and John Renshaw Drive to connect to the F3 Freeway to Sydney. The route would use the M2 and M7 motorways to travel to Kemps Creek in Sydney. From the Mayfield site, the route would join Industrial Drive in Mayfield East and follow the same route to Kemps Creek.

Cormorant Road is the main road transport route on Kooragang Island. It services industrial developments on Kooragang Island, as well as providing a link between Newcastle in the south, and Stockton, Port Stephens and Newcastle Airport to the north. There are no sensitive receivers located on Cormorant Road.

Industrial Drive is a major route through the city's port area that connects Newcastle with the Pacific and New England Highways. A small section of the route along Industrial Drive passes residential areas in Mayfield West and Warabrook after it joins the Pacific Highway. The Pacific Highway passes a small number of residences at Sandgate and Hexham. The New England Highway passes to the south of residential areas in Tarro and Beresfield. The remainder of the route is via John Renshaw Drive and the F3 Freeway.

11.2.2 Noise Environment

The noise environment in sensitive receiver areas surrounding the berths is largely influenced by road traffic noise on Industrial Drive and industrial noise from surrounding industry in Mayfield, Kooragang Island and Carrington. These industrial areas within the Newcastle Port have previously been subject to numerous noise impact studies. Background noise monitoring has therefore not been undertaken for this Project specifically. Noise monitoring data from relevant previous assessments has been referenced (see Section 11.3.2 for details on previous assessments).

LEGEND

Sensitive Noise Receiver

Sensitive Noise Receiver Boundary

Berth Locations

1:30,000 (at A4)

0 112.5225 450 675 900

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Sensitive Noise Receivers

Figure 11.1

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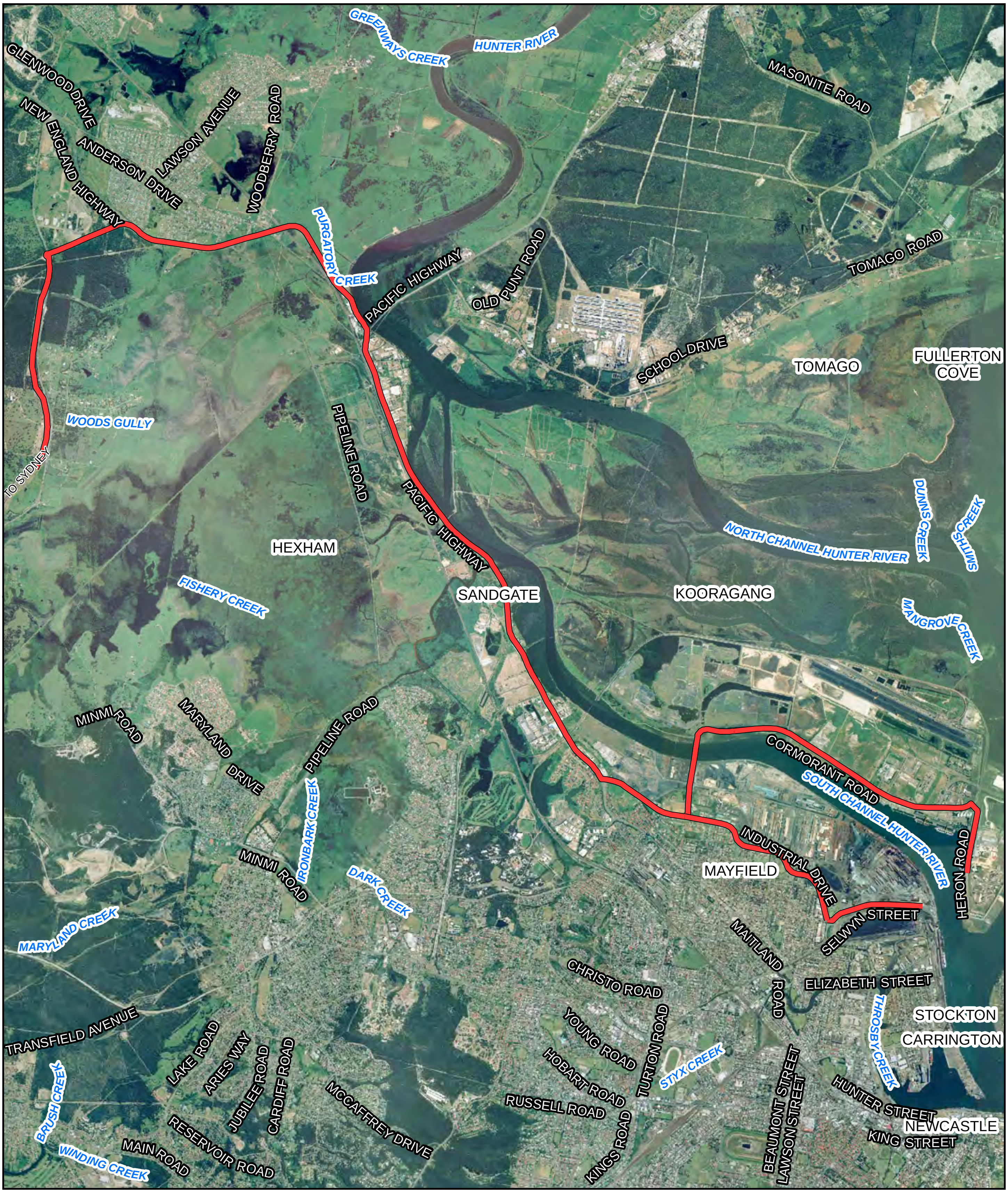
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: gmcdiarmid, fmackay



LEGEND

Proposed Spoil Haul Route

1:75,000 (at A4)

0 275 550 1,100 1,650 2,200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

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Job Number	22-15683
Revision	0
Date	10 Sep 2012

Proposed Spoil Haul Route

Figure 11.2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com.au **W** www.ghd.com.au

G:\22\15683\GIS\Maps\Deliverables\Environmental Assessment\Noise & Vibration\2215683_N002_ProposedHaulRoutes_20110901_A.mxd

Data Source: LPMA: Imagery - 2007; LPMA: DTDB - 2007. Created by: gmcdiarmid, fmackay, tmorton

11.3 Methodology

The assessment of potential noise and vibration impacts referenced applicable legislation and guidelines. Relevant existing literature was reviewed to establish the existing noise and vibration conditions. The methodology was then developed to assess the Project's potential impacts on surrounding land uses from proposed construction activities and operational requirements. Further details of the methodology used in the assessment of potential noise and vibration impacts are provided in Appendix H.

11.3.1 Legislation and Guidelines

Appropriate guidelines and legislation considered in the assessment of noise and vibration include, but are not limited to:

- Department of Environment and Climate Change (now Office of Environment and Heritage) Interim Construction Noise Guideline (ICNG) (2009).
- Department of Environment, Climate Change and Water (now Office of Environment and Heritage) NSW Road Noise Policy (2011).
- NSW Roads and Traffic Authority *Environmental Noise Management Manual* (2001).
- Department of Environment and Conservation (now Office of Environment and Heritage) Assessing Vibration: A Technical Guideline (2006).
- Environment Protection Authority (now Office of Environment and Heritage) NSW Industrial Noise Policy (2000).
- NSW Government Transport Construction Authority (TCA) Construction Noise Strategy (Rail Projects) August 2010.
- British Standard - BS 6472 – 1992, "Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)".
- British Standard 5228.2-2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 2 Vibration.*
- German Standard DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures.
- AS2436: 2010 Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites.

Interim Construction Noise Guideline DECCW 2009

The NSW Department of Environment and Climate Change (now Office of Environment and Heritage) *Interim Construction Noise Guideline* 2009 *(ICNG)* is the primary guideline used to assess noise impacts from construction activities. The standard hours for construction activity recommended in the ICNG are detailed in Table 11-2.

Table 11-2 ICNG Recommended Standard Hours for Construction Work

Work Type	Recommended Standard Hours of Work
Normal construction	◗ Monday to Friday: 7 am to 6 pm. ◗ Saturday: 8 am to 1 pm. ◗ No work on Sundays or Public Holidays.
Blasting	◗ Monday to Friday: 9 am to 5 pm. ◗ Saturday: 9 am to 1 pm. ◗ No work on Sundays or Public Holidays.

The ICNG provides noise management levels for construction noise at residential receivers. These management levels are calculated based on the Rating Background Level (RBL) at nearby residential locations, as shown in Table 11-3.

Table 11-3 ICNG Construction Noise Criteria at Residential Receivers, dB(A)

Time Period	Management Level $L_{Aeq(15\ min)}$
Recommended standard hours	Noise affected level: RBL + 10 dB(A) Highly noise affected level: 75 dB(A)
Outside recommended standard hours	Noise affected level: RBL + 5 dB(A)

The above levels apply at the boundary of the most affected residences or within 30 metres from the residence where the property boundary is more than 30 metres from the residence.

The *noise affected level* represents the point above which there may be some community reaction to noise. The *noise affected level* is the background noise level plus 10 dB(A) during recommended standard hours and the background noise level plus 5 dB(A) outside of recommended standard hours. The *highly noise affected level* represents the point above which there may be strong community reaction to noise and is set at 75 dB(A).

Table 11-8 in Section 11.3.2 shows the relevant noise levels for the Project based on the ICNG requirements, and ambient levels derived from the Wilkinson Murray and Heggies studies (see Section 11.3.2 for details on previous assessments).

Road Traffic Noise Criteria

The *Road Noise Policy* 2011 (RNP) DECCW (now Office of Environment and Heritage) provides traffic noise 'assessment criteria' for residential receivers in the vicinity of existing and new roadways. The applicable criteria for the Project's haulage routes are "*existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments*". The Project's potential impacts from construction related traffic noise are assessed in Section 11.4.8.

Vibration Criteria

Human Comfort Vibration Criteria

The NSW Department of Environment and Climate Change (now OEH) *Assessing Vibration: A Technical Guideline, 2006* was used to determine appropriate criteria for the assessment of vibration impacts from the Project.

The guideline is based on the British Standard BS 6472 – 1992, *Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz),* which sets out different types of sensitive receivers and activities.

Further guidance is obtained from British Standard 5228.2-2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 2 Vibration*.

Typically, construction activities generate ground vibration of an intermittent nature. Under BS 6472, intermittent vibration is assessed using the vibration dose value (VDV). Acceptable values of vibration dose are presented in Table 11-4.

Table 11-4 Acceptable Vibration Dose Values for Intermittent Vibration (m/s1.75)

Location	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
Residential buildings 16 hour day (0700 – 2300 hrs)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hour night (2300 to 0700 hrs)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Whilst the assessment of response to vibration in BS 6472-1:2008 is based on Vibration Dose Value (VDV) and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of Peak Particle Velocity (PPV). PPV is likely to be more routinely measured based on the more usual concern over potential building damage.

Humans are capable of detecting vibration at levels which are well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in British Standard BS 5228-2:2009 *Code of Practice for Noise and Vibration on Construction and Open Sites – Part 2: Vibration* as shown in Table 11-5.

Table 11-5 Guidance on the Effects of Vibration Levels

Approximate Vibration Level	Degree of Perception
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.30 mm/s	Vibration might be just perceptible in residential environments.

Approximate Vibration Level	Degree of Perception
0.30 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

The potential vibration impacts from the Project in relation to goals derived from BS 6472 and BS 5228-2:2009 are provided in Table 11-13 in Section 11.4.7.

Structural Vibration Criteria

Currently, no Australian Standard sets criteria for the assessment of building damage caused by vibration. Applicable vibration values are obtained from the German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures (DIN 4150)*.

Section 11.4.7 describes the Project's potential vibration impacts on structures near the construction sites.

11.3.2 Literature Review

A number of previous studies were reviewed for this EIS. The previous studies provided information on the noise and vibration impacts associated with previous dredging and foreshore improvement projects undertaken in the South Arm of the Hunter River.

Previous studies were also referenced to assess existing road and traffic conditions in the area surrounding the Port of Newcastle. In particular, the road linkages with the regional arterial road network, including Industrial Drive, Maitland Road/Pacific Highway, and the Sydney-Newcastle Freeway were examined to determine potential noise impacts from hauling spoil material by road.

Preliminary Environmental Assessment

The Preliminary Environmental Assessment (PEA) for the Project - *Capital Strategic Dredging Project (MP10_0203) – South Arm, Hunter River, Preliminary Environmental Assessment* (Worley Parsons, February 2011) assessed the potential noise and vibration impacts as a high significance level. This was based on the assumption at the time that blasting would be required for the dredging and foreshore improvement works.

The PEA referenced previous noise and vibration studies from similar projects in the area. These previous assessments were used to determine the preliminary potential noise and vibration impacts from the Project. The PEA assessed that the potential impacts were high if blasting was to be used. Given that blasting works would not be undertaken for the Project, the significance level of noise and vibration for sensitive receptors would reduce significantly.

Previous Studies

Relevant noise and vibration studies reviewed as part of this assessment include the following:

- EMGA | Mitchell McLennan, 2010, The Terminal 4 Project – Preliminary Environmental Assessment Report.
- Worley Parsons, 2010, Capital Strategic Dredging Project (MP10_0203) – South Arm, Hunter River, Preliminary Environmental Assessment.
- Heggies Australia Pty Ltd, July 2006, Newcastle Coal Export Terminal Construction, Operation and Road Transport Noise Impact Assessment Report Number 10-4515-R.
- Wilkinson Murray, July 2010, Prepared for AECOM Australia Pty Ltd Noise Assessment Mayfield Site Port-Related Activities Concept Plan EA, Report No. 09077 Version F.
- Wilkinson Murray, January 2009, Intermodal Good Facility Kooragang Island Report 08222 Version A.
- Wilkinson Murray, January 2009, Report 08222 Version A, Intermodal Good Facility Kooragang Island.
- Heggies Australia Pty Ltd, July 2006, Report Number 10-4515-R, Newcastle Coal Export Terminal Construction, Operation and Road Transport Noise Impact Assessment.

Mayfield Site Port-Related Activities Concept Plan EA

Noise monitoring was conducted by Wilkinson Murray on behalf of AECOM Australia Pty Limited in 2009 for the Mayfield Site Port-Related Activities Concept Plan EA. This site lies adjacent to the proposed Mayfield and Dyke Point berth areas.

Table 11-6 summarises the background noise monitoring results for three locations in the Mayfield and Carrington areas during March and September 2009. L_{90}, relates to the Rating Background Level (RBL). Existing ambient noise levels are described as energy average equivalent sound pressure level for the period ($L_{Aeq\ (day/evening/night)}$).

Table 11-6 Summary of Measured Noise Levels – Wilkinson Murray 2009

Logging Location	L_{A90} Rating Background Level dB(A)			Ambient L_{Aeq} dB(A)		
	Day (7 am – 6 pm)	Evening (6 pm – 10 pm)	Night (10 pm – 7 am)	Day (7 am – 6 pm)	Evening (6 pm – 10 pm)	Night (10 pm – 7 am)
A – 1 Arthur Street, Mayfield	46	47	46	53	53	50
B – 2 Crebert Street, Mayfield	49	42	40	69	65	60
C – 32 Elizabeth Street, Carrington	44	43	39	57	54	46

Newcastle Coal Export Terminal Construction, Operation and Road Transport Noise Impact Assessment (Heggies, 2006) and Intermodal Good Facility Kooragang Island (Wilkinson Murray, 2009)

Noise monitoring has been conducted in the Stockton area by Wilkinson Murray and Heggies Australia Pty Ltd (Heggies) in 2006 and 2009. Table 11-7 summarises these background noise results.

Table 11-7 Measured Background Noise Levels – Stockton – 2006 and 2009

Location	L_{A90} Rating Background Level dB(A)		
	Day (7 am – 6 pm)	Evening (6 pm – 10 pm)	Night (10 pm – 7 am)
Stockton East (Wilkinson Murray)	41	43	43
Stockton East (Heggies)	41	43	43
Stockton West (Heggies)	42	44	44

These studies included noise monitoring in the Mayfield, Carrington and Stockton areas. The findings of these reports have been adopted and used to establish the appropriate noise criteria for this assessment. The noise monitoring conducted by Wilkinson Murray and Heggies is assumed to have been undertaken in accordance with the DECCW *Industrial Noise Policy* and is suitable for use in this assessment.

The findings of the studies undertaken by Wilkinson Murray and Heggies show that background noise levels are typical of the residential/industrial interface, dominated by port activities, industry and road traffic.

11.4 Potential Impacts

The dredging of all berths simultaneously is possible. Accordingly, this noise and vibration assessment is based on construction activities occurring at all of the proposed berths at once together with the haulage of spoil by road. In the event that all sites are not dredged simultaneously, potential noise and vibration impacts and cumulative impacts would diminish.

The magnitude of noise impacts associated with construction would be dependent upon a number of factors including:

- The location, intensity and duration of construction activities.
- The type of equipment used.
- Existing local noise sources.
- Intervening terrain between noise source and receiver.
- The prevailing weather conditions.

The proposed construction sites are located in industrial areas along the Hunter River. The existing noise environment adjoining the berths is characterised by industrial and port related transportation activities. The nearest sensitive receivers are separated from the berths by industrial land and water (refer to Figure 11.1). The predicted construction noise levels have been calculated considering distance attenuation.

Mobile machinery would move about on site, variously altering the directivity of the noise source with respect to individual receivers. During any given period the machinery items to be used on site would operate at maximum sound power levels for only brief stages. At other times the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at maximum sound power levels at any one time. Furthermore, certain types of construction machinery would be present on site for only brief periods during construction. Chapter 2 (Description of the Project) provides indicative timeframes for construction activities.

The relatively minor scale of construction activities and the distance to sensitive receivers would limit potential impacts from construction. Generally, construction activities would be conducted in standard work hours. Dredging may be undertaken 24 hours per day, and would be the only activity to occur during night time hours. Sheet pile wall construction would not occur during night time works, and would be restricted to standard construction hours.

Proposed haul routes for truck movements all follow designated heavy vehicle routes which do not use residential roads (refer to Figure 11.2).

Summary of Predicted Noise and Vibration Impacts

The predicted noise and vibration impacts associated with construction and dredging activities are:

- Dredging works would not exceed the noise affected level at nearby noise sensitive receivers during standard construction hours.
- Dredging may exceed the noise affected level at Carrington where night time dredging is undertaken.
- Sheet piling has the potential to exceed the noise affected level during standard construction hours at Carrington and Stockton.
- Sheet piling is not predicted to exceed the highly noise affected level for standard hours.
- Excavation and spoil handling would be undertaken during standard construction hours. This activity would not exceed the noise affected level at sensitive receivers.
- Spoil haulage using the proposed route via freeways, arterial and sub-arterial roads would not produce significant noise impacts on sensitive receivers.
- Noise impacts from any stockpiling and transfer site established at Walsh Point are not predicted to exceed the noise affected level at nearby noise sensitive receivers during standard construction hours. However, if the compound is operated outside of standard hours are the noise affected level at Stockton and Carrington may be exceeded.

11.4.1 Noise Goals

Table 11-8 shows the relevant noise goals for the Project based on the *Interim Construction Noise Guideline* 2009 *(ICNG)* requirements. Details on the sound power levels from typical construction equipment are provided in Appendix H.

Table 11-8 Construction Noise Goals for Residential Receivers $L_{Aeq(15min)}$ dB(A)

Receiver Area	Outside Recommended Standard Hours	Within Recommended Standard Hours	
	Noise Management Level – Noise Affected Level dB(A) $L_{Aeq(15min)}$	Noise Management Level – Noise Affected Level dB(A) $L_{Aeq(15min)}$	Noise Management Level – Highly Noise Affected Level dB(A) $L_{Aeq(15min)}$
1 Arthur Street, Mayfield	51	56	75
2 Crebert Street, Mayfield	45	59	75
32 Elizabeth Street, Carrington	44	54	75
Stockton Township	48	51	75

11.4.2 Dredging Noise Impacts

Dredging may be undertaken 24 hours a day for the course of the construction period. Noise associated with dredging barges would be similar to existing night-time harbour traffic. The closest residential area to dredging works is in the north eastern section of Carrington.

The noise and vibration assessment used modelling software that does not account for intervening buildings or climatic influences. Port-side warehouses at Carrington, located between Dyke 3 and residential areas, have to potential to reduce noise measurements by up to 10dB(A) depending on climatic conditions. Conversely, prevailing winds directed towards residential areas have the potential to increase noise if buildings or other structures do not block some of the noise. Therefore, the modelling used for this assessment is considered appropriate.

The use of backhoe excavators on barges to dredge Dyke 3 has the potential to produce noise impacts in Carrington at night. The standard procedures for the backhoe dredging at night would reduce potential impacts. Procedures to reduce noise impacts include not shaking the bucket or striking the bucket to loosen dredged sediment. Considering the relatively low levels of noise when these procedures are used, the short construction duration at any berth, the distance to sensitive receivers and intervening industrial warehouses, potential dredging noise impacts on sensitive receivers would not be significant.

11.4.3 Noise Impacts from Foreshore Works

Construction plant and equipment, and the operation of the barge, would generate construction noise and vibration impacts during foreshore treatment works. Foreshore treatment and spoil handling would be undertaken in standard construction hours.

The standard construction hours are 7 am until 6 pm Monday to Friday and 8 am until 1 pm Saturday, with no work on Sunday or Public Holidays. If works are required outside of these hours, appropriate measures to mitigate potential impacts on nearby residences would be implemented. Measures would include scheduling significant noise generating construction activities outside of the evening and night time periods (6 pm to 7 am).

Night time works would be restricted to dredging, while sheet pile wall construction would only occur during standard construction hours.

To assess the highest potential for construction noise impacts, the assessment was based on all berths being constructed simultaneously. If works are not undertaken at all berths simultaneously, noise impacts would diminish. Table 11-9 presents predicted noise levels for foreshore works at all berths together with predicted cumulative impacts from simultaneous construction.

Table 11-9 Predicted Construction Noise Levels – Berth Excavation, dB(A)

Construction at Berth	Berth Excavation Predicted Noise Levels, dB L_{Aeq}			
	Mayfield (Arthur Street)	Mayfield (Crebert Street)	Carrington Township	Stockton Township
Excavation At Individual Berths				
Dyke 3	30	32	51	41
Mayfield 1	32	34	41	37
Mayfield 2	32	35	38	36
Mayfield 3	33	36	36	34
Mayfield 4	34	37	35	33
Mayfield 5	35	37	34	32
Mayfield 6	37	38	33	31
Mayfield 7	38	38	32	30
Kooragang 1	31	33	37	37
Walsh Point 1	31	33	41	41
Walsh Point 2	31	33	39	39
Walsh Point 3	31	33	37	38

Construction at Berth	Berth Excavation Predicted Noise Levels, dB L_{Aeq}			
	Mayfield (Arthur Street)	Mayfield (Crebert Street)	Carrington Township	Stockton Township
Simultaneous Excavation At All Berths				
Cumulative impact	44	46	53	48
Criteria				
Noise affected level (standard hours)	56	59	54	51
Highly noise affected level	75	75	75	75
Noise affected level (outside standard hours)	51	45	44	48

Comparison of worst-case predicted noise from foreshore works (excavation at all berths simultaneously) presented in Table 11-9 indicates these activities would not exceed the noise affected level during standard hours.

11.4.4Noise Impacts from Sheet Piling

Table 11-10 presents predicted noise levels from vibratory piling at each berth. Sheet piling works would only be undertaken during standard construction hours, and would not occur during night time works. Highlighted values represent the highest predicted noise impacts for each noise sensitive receiver area.

Table 11-10 Predicted Construction Noise Levels – Sheet Piling, dB(A

Berth	Sheet Piling Predicted Noise Levels, dB L_{Aeq}			
	Mayfield (Arthur Street) Daytime noise goal 56 dB(A)	Mayfield (Crebert Street) Daytime noise goal 59 dB(A)	Carrington Township Daytime noise goal 54 dB(A)	Stockton Township Daytime noise goal 51 dB(A)
Piling At Individual Berths				
Dyke 3	41	43	**62**	**52**
Mayfield 1	43	45	52	48
Mayfield 2	44	46	49	47
Mayfield 3	44	47	47	45
Mayfield 4	45	48	46	44
Mayfield 5	46	48	45	43

Berth	Sheet Piling Predicted Noise Levels, dB L_{Aeq}			
	Mayfield (Arthur Street) Daytime noise goal 56 dB(A)	Mayfield (Crebert Street) Daytime noise goal 59 dB(A)	Carrington Township Daytime noise goal 54 dB(A)	Stockton Township Daytime noise goal 51 dB(A)
Mayfield 6	48	49	44	42
Mayfield 7	49	49	43	41
Kooragang 1	42	44	48	48
Walsh Point 1	42	44	52	**52**
Walsh Point 2	42	44	50	50
Walsh Point 3	42	44	48	49
Criteria				
Noise affected level (standard hours)	56	59	54	51
Highly noise affected level	75	75	75	75
Noise affected level (outside standard hours)	51	45	44	48

Table 11-10 shows exceedances of the daytime noise goals from sheet piling at Carrington during the construction of the proposed Dyke 3 berth. These predictions do not account for the possible reduction in noise from the port side warehouses located between the site and the nearest residences.

A minor exceedance is possible at Stockton as a result of the construction of Dyke 3 and the Walsh Point berth pocket. Piling impacts would not exceed the highly noise affected level at any of the identified noise sensitive receivers. In order to reduce noise impacts from sheet piling, mitigation measures detailed in Section 11.5 would be implemented for affected noise sensitive receivers in Carrington and Stockton where feasible and reasonable. If piling is to be undertaken outside of standard hours, additional mitigation measures will be required.

11.4.5 Noise Impacts from Spoil Stockpiling and Transfer

Table 11-11 presents predicted noise levels at each receiver area generated by any spoil stockpiling and transfer compound at located Walsh Point. Walsh Point was selected as a potential spoil stockpiling and transfer location due to the potential presence of contaminated material in the previously identified ‘Walsh Point hotspot’. If contaminated sediment is not removed from Walsh Point and the sediment is suitable for sea dumping or beneficial reuse, the spoil stockpiling and transfer would not be required at this site.

Table 11-11 Predicted Construction Noise Levels – Walsh Point Transfer Compound, dB(A)

Noise Source Location	Walsh Point Site Compound Predicted Noise Levels, dB L_{Aeq}			
	Mayfield (Arthur Street)	Mayfield (Crebert Street)	Carrington Township	Stockton Township
Walsh Point compound	36	39	46	49
Criteria				
Noise affected level (standard hours)	56	59	54	51
Highly noise affected level	75	75	75	75
Noise affected level (outside standard hours)	51	45	44	48

Spoil handling and stockpiling would only take place during standard construction hours. Table 11-11 shows that there would be no exceedances of applicable noise goals as a result of spoil handling and stockpiling during standard construction hours. Works may exceed the noise affected level at Stockton and Carrington if the compound is operated outside of standard hours.

11.4.6 Construction Impacts at other Sensitive Land Uses

Potential construction noise impacts at sensitive land uses other than residences were assessed. Table 11-12 provides the relevant noise goals for sensitive receivers, together with predicted noise levels.

Table 11-12 Construction Noise Criteria and Predicted Impacts at other Sensitive Land Uses dB(A)

Sensitive Receiver (when in use)	Management Level $L_{Aeq\ (15\ min)}$	Location and Approximate Distance from the closest berth	Greatest Predicted Impact $L_{Aeq\ (15\ min)}$
Classrooms at schools and other educational facilities	Internal noise level: 50 dB(A)	Carrington Public School, 500 metres	46 dB(A) internal
		Mayfield East Public School, 1100 metres	39 dB(A) internal
		Hunter Christian School, 1600 metres	46 dB(A) internal
Places of worship	Internal noise level: 45 dB(A)	Carrington Catholic Church, 450 metres	47 dB(A) internal

Sensitive Receiver (when in use)	Management Level $L_{Aeq\ (15\ min)}$	Location and Approximate Distance from the closest berth	Greatest Predicted Impact $L_{Aeq\ (15\ min)}$
Active recreational areas (such as sports grounds or playgrounds)	External noise level: 65 dB(A)	Grahame Park, Carrington, 400 metres	58 dB(A) External
		Mayfield Sporting Ovals, 1100 m	49 dB(A) External

Table 11-12 shows that construction works would not exceed any applicable noise goal at other sensitive land uses, with the exception of a minor exceedance of 2 dB(A) at the Carrington Catholic Church.

11.4.7 Vibration Impacts

Vibration impacts would be produced from the sheet piling activities required to construct sheet pile walls adjacent to the Mayfield, Walsh Point and Dyke Point berths. Vibration impacts from the Project would be intermittent in nature and would take place in standard daytime construction hours. Therefore, no night time vibration impacts would result from the construction of the Project.

The assessment of vibration impacts references British Standard 5228:2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 2 Vibration* (BS 5228) and the NSW Roads and Traffic Authority *Environmental Noise Management Manual* (2001) (ENMM).

BS 5228 and the ENMM provide prediction methods to assess vibration impacts from piling. Vibration levels decrease significantly with distance from the source. At 10 metres from the source, the highest vibration levels would be 12 millimetres per second (mm/s). At distances of greater than 500 metres, the highest predicted vibration levels would be 0.02 to 0.5 mm/s. Further details on BS 5228 and the ENMM are provided in Appendix H. Figure 11.3 shows BS 5228 vibratory predictions.

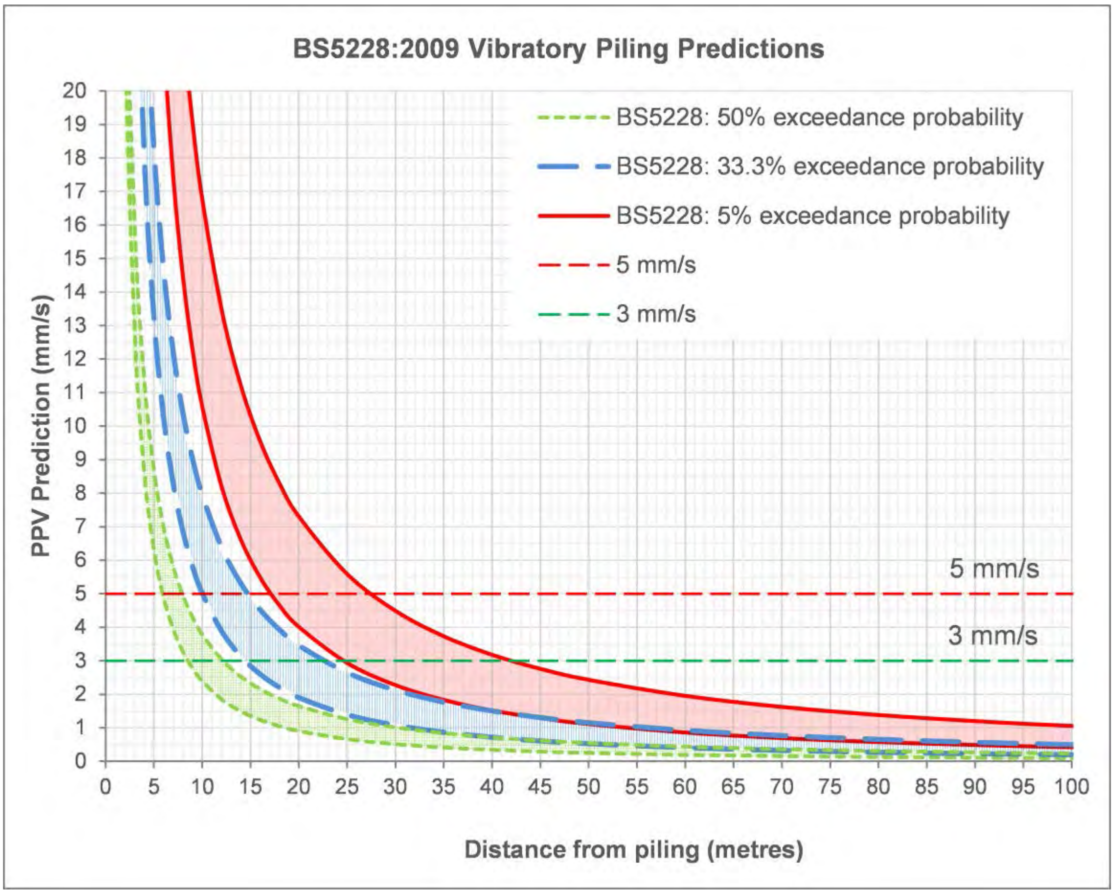

Figure 11.3 British Standard 5228:2009 Vibratory Piling Predictions

Table 11-13 shows predicted vibration levels from sheet piling activities at various distances from the source using the RTA's (now RMS) *Environmental Noise Management Manual* Method (ENMM) and the British Standard 5228:2009 (BS 5228). Further details on the ENMM and BS 5228 are provided in Appendix H.

Table 11-13 Piling Vibration Impact Predictions

Item	Distance to Source (m) / Peak Particle Velocity, PPV (mm/s)					
	10	30	60	100	250	500
Sheet Piling	12	2.1 to 5.0	0.7 to 2.9	0.3 to 1.9	0.1 to 0.9	0.02 to 0.5

These predicted vibration levels were used to assess the Project's potential impacts on residential areas (human comfort vibration) and on buildings adjoining the site.

Human Comfort Vibration

British Standard 6472 sets target vibration levels for construction activities. Table 11-14 shows the appropriate target maximum derived from BS 6472, and the maximum vibration levels predicted to occur at residential areas.

Table 11-14 Human Comfort Vibration Limits from BS 6472 in the 1 Hz to 80 Hz range

Approximate Vibration Level	Degree of Perception
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.30 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

Predictions for construction show that the maximum vibration levels predicted at residential areas would be 0.1 to 0.9 mm/s at Carrington. This level would be barely perceptible and is significantly lower than the level where vibration levels are likely to cause complaint. Therefore no significant vibration impacts would be produced by construction activities in residential areas.

Building Vibration Impacts

Appropriate vibration target levels for the assessment of vibration impacts on buildings were derived from German Standard DIN 4150-3. DIN 4150 sets guideline values in millimetres per second (mm/s). The predicted vibration levels from the Project in relation to DIN 4150 are provided in Table 11-15. Construction activities from the Project would operate in the 1 Hz to 80 Hz range.

Table 11-15 shows that vibration levels from sheet piling are predicted to be lower than the DIN4150-3 guideline limits at:

- Distances greater than 60 metres from sensitive structures.
- Thirty metres from dwellings. The closest residence is located approximately 270 metres from the site, and therefore no residences would be impacted.
- Ten metres for buildings of industrial/commercial type construction.

Table 11-15 Guideline Values for Short Term Vibration Velocity on Structures

Guideline Values for Velocity, vi(t) [mm/s]					The Project
Line	Type of Structure	Vibration at the Foundation at a Frequency of			Highest vibration level from construction
		1Hz to 10 Hz	10Hz to 50Hz	50Hz to 100Hz	
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	12
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	0.1 to 0.9
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (eg listed buildings under preservation order)	3	3 to 8	8 to 10	2.1 to 5

11.4.8 Transportation Noise Impacts

The Project may temporarily increase truck movements during construction. The haulage routes discussed in 11.2.1 are classified as principal haulage routes, using freeways, motorways or arterial roads. As the highest percentage increase in vehicles is less than 1 percent of existing traffic volumes, construction is not predicted to cause any appreciable increase in traffic noise levels.

Chapter 14 (Traffic and Transport) discusses the potential increases in traffic from haulage and site vehicles. The DECCW (now Office of Environment and Heritage) *Road Noise Policy* 2011 (RNP) establishes criteria to assess noise impacts from construction traffic.

The RNP target levels for construction related traffic noise for existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments is 60 dB(A) for the daytime, and 55 dB(A) for night time. The RNP's target criteria for these residential areas is no greater than an additional 12 dB(A) during both daytime and night time hours. These target levels apply at the buildings façades of the sensitive receivers (externally). No construction traffic for the Project would operate during night time hours, so the appropriate noise level for construction traffic is 60 dB(A) with no greater than a 12 dB(A) increase above existing levels.

Table 11-16 presents the predicted traffic noise increase, considers the increase of total vehicles as well as the increase in heavy vehicle percentage.

Table 11-16 Predicted Traffic Noise Level Increases from the Project

Road - Haulage Route	Total Traffic Increase Percentage During Construction	Heavy Vehicle Percentage Increase During Construction	Predicted Noise Increase - dB(A)
Cormorant Road / Tourle Street	0.39%	0.31%	0.08
Industrial Drive	0.30%	0.24%	0.06
Maitland Road / Pacific Hwy	0.18%	0.18%	0.04
New England Highway	0.11%	0.11%	0.03
John Renshaw Drive	0.38%	0.38%	0.08
Sydney- Newcastle Fwy	0.22%	0.22%	0.04
Pennant Hills Road	0.21%	0.21%	0.06
M2 Motorway	0.09%	0.09%	0.02
M7 Motorway	0.05%	0.05%	0.01

Table 11-16 shows that the highest predicted noise increases are on Cormorant Road and Tourle Street, and on John Renshaw Drive. The increase is predicted to be 0.08 dB(A), considerably lower than the 12 dB(A) goal set by the RNP. Therefore, construction traffic would not produce and appreciable increase in traffic noise.

11.4.9 Cumulative Impacts of other Projects

The potential for the Project to produce cumulative impacts with adjoining projects would depend on the timing of construction. Other projects in the adjoining area have been identified, but the timing of construction is uncertain.

The Port Waratah Coal Services application for the construction of the port's fourth coal terminal (known as the T4 Project) is the most likely project to be under construction at the time the Project is to be constructed. However, the Environmental Assessment for the T4 Project is not on public exhibition and no approval has been granted. Determining potential cumulative construction noise impacts is therefore difficult to predict.

The Project's construction noise impacts would be minor. A minor exceedance is possible at Carrington for night time dredging works at Dyke 3. Where backhoe dredges are used for night time works, appropriate protocols such as not shaking or hammering buckets to dislodge sediment, would reduce potential noise impacts significantly. The Project is therefore unlikely to contribute cumulatively with other adjoining construction projects. However, NPC would liaise with proponents of known construction site to determine the potential for cumulative construction noise and vibration impacts.

Construction traffic noise would be minor and well below noise target levels set in appropriate guidelines and legislation. It is possible but unlikely that construction traffic noise from the Project would contribute cumulatively with construction traffic noise from adjoining projects. NPC would liaise with proponents of known construction sites in the area and determine the potential for cumulative construction traffic noise.

11.4.10 Operational Noise Impacts

As the Project seeks approval to dredge river sediment and undertake foreshore treatment works, no direct operational noise impacts would result from the Project. The use of the berths would depend on the nature of the landside development, which would be the subject of further environmental assessments. Operational noise from the movement of vessels to and from the berths would not increase significantly above existing noise levels.

The future landside developments that would utilise the berths created by the approval of this Project are likely to produce operational impacts. These impacts would be assessed in future environmental assessments for these proposed developments.

11.4.11 Operational Vibration Impacts

As the Project seeks approval to dredge river sediment and undertake foreshore treatment works, no ongoing operational vibration impacts would result from the Project. Any future landside developments that have the potential to create operational vibration impacts would have to assess these potential impacts in future environmental impact assessments.

11.4.12 Summary of Potential Noise and Vibration Impacts

The expected noise and vibration impacts during construction of the Project are as follows:

- Construction noise impacts from dredging works are not expected to exceed the noise affected level at nearby noise sensitive receivers during standard construction hours. There is potential to exceed the noise affected level at Carrington where night time backhoe dredging is undertaken and appropriate protocols are not used.
- Sheet piling has the potential to exceed the noise affected level during standard construction hours at sensitive receivers in Carrington and Stockton. However, these levels would not exceed the highly noise affected level for standard hours.
- Construction noise impacts at non-residential sensitive receptors such as schools, churches and outdoor recreation areas are predicted to comply with the respective ICNG criteria. However, impacts may occur at the Carrington Catholic Church if it is in use during piling at berth Dyke 3.
- Construction noise impacts from the potential Walsh Point stockpiling and transfer compound are not expected to exceed the noise affected level at nearby noise sensitive receivers during standard construction hours. However, if the compound is used outside of standard construction hours, the noise affected level at Stockton may be exceeded.
- Excavation and spoil handling would be undertaken during standard construction hours. This activity would not exceed the noise affected level at sensitive receivers.

- Spoil haulage using the proposed route via freeways, arterial and sub-arterial roads would not produce significant noise impacts on sensitive receivers.
- Construction of the Project is predicted to cause no appreciable increase in the resulting traffic noise levels.

Vibration levels from sheet piling are predicted to be lower than the DIN 4150-3 (1999) guideline limits at distances greater than 60 metres for sensitive structures, 30 metres for dwellings, and 10 metres for buildings of industrial/commercial type construction.

11.5 Recommended Mitigation Measures

There is the potential that construction activities could exceed the noise and vibration management levels for the Project, particularly if some activities are scheduled outside the standard construction hours. Every practical and reasonable measure would be implemented to minimise the noise impacts of construction activities on local residences. A summary of the construction noise mitigation measures is provided below.

11.5.1 Noise Mitigation Measures

The following construction noise mitigation measures would implemented to reduce the impact on the surrounding residents during construction:

- Where feasible and reasonable, construction activities would be scheduled during the standard construction hours. Approval would be sought for noise generating activities outside of standard construction hours if required.
- All equipment would be selected to minimise noise emissions. Equipment would be fitted with appropriate silencers and be in good working order. Machines found to produce excessive noise compared to normal industry expectations would be removed from the site or stood down until repairs or modifications can be made.
- To reduce the annoyance associated with reversing alarms, broadband reversing alarms (audible movement alarms) would be used as a preference to tonal alarms for all site equipment. Satisfactory compliance with occupational health and safety requirements would need to be achieved and a safety risk assessment would be undertaken to determine that safety is not compromised. Refer to Appendix C of the ICNG for more information.
- Appropriate consultation would be undertaken with affected sensitive receivers as per Section 11.5.2. A noise and vibration management plan (NVMP) would be developed as part of the CEMP.

11.5.2 Community Consultation and Monitoring

The NSW Government TCA *Construction Noise Strategy* (Rail Projects August 2010) provides further guidance for dealing with exceedances of construction noise criteria after all feasible and reasonable mitigation measures have been implemented. The TCA has developed an Additional Mitigation Measures Matrix (AMMM) to rank the additional community consultation measures that could be implemented. The community consultation procedures in Table 11-17 and Table 11-18 have been developed for this project based on the AMMM.

Table 11-17 Proposed Community Consultation for Construction during Standard Hours

		Receiver Location			
		1 Arthur Street, Mayfield	2 Crebert Street, Mayfield	32 Elizabeth Street, Carrington	Stockton Township
Moderately intrusive	Controlling level $L_{Aeq\ (15\ minute)}$	66	69	64	61
	Actions	Letterbox Drop, Monitoring			
Highly intrusive	Controlling level $L_{Aeq\ (15\ minute)}$	75	75	74	71
	Actions	Letterbox Drop, Monitoring			

A community liaison phone number and site contact during works would be established. Details would be provided as part of the letterbox drop so that noise and vibration complaints can be received and addressed in a timely manner. Table 11-18 details the recommended community consultation procedure for works outside standard hours.

Table 11-18 Proposed Community Consultation for Construction outside Standard Hours

		Receiver Location			
		1 Arthur Street, Mayfield	2 Crebert Street, Mayfield	32 Elizabeth Street, Carrington	Stockton Township
Noticeable	Controlling level $L_{Aeq\ (15\ minute)}$	46	40	39	43
	Actions	Letterbox drop			
Clearly audible	Controlling level $L_{Aeq\ (15\ minute)}$	56	50	49	53
	Actions	Letterbox drop, monitoring			
Moderately intrusive	Controlling level $L_{Aeq\ (15\ minute)}$	66	60	59	63
	Actions	Letterbox drop, monitoring (night only: individual briefings, phone calls, specific notifications)			
Highly intrusive	Controlling level $L_{Aeq\ (15\ minute)}$	75	70	69	73
	Actions	Letterbox drop, monitoring, individual briefings, phone calls, specific notifications, respite offers (night only: alternative accommodation)			

Where there are complaints about noise or vibration from an identified work activity, works would be reviewed, and where reasonable and feasible, additional actions implemented to minimise the noise or vibration issue.

11.5.3 Work Ethics

All site workers should be sensitised to the potential for noise impacts on local residents and encouraged to take practical and reasonable measures to minimise the impact during the course of their activities. This should include:

- Avoid shouting and slamming doors.
- Where practical, machines should be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods.
- Minimise reversing.
- Avoid dropping materials from height and avoid metal to metal contact on material.

11.5.4 Structure Condition Inspections (Vibration)

Condition inspections are recommended for any utility, structure or building when vibratory piling is planned within 60 metres. Any utility, structure or building requiring a building inspection would be determined prior to construction works commencement. This would include existing pile walls at or near the berth locations.

11.5.5 Vibration Human Comfort Impacts

The construction works are considered short term by the NSW Office of Environment and Heritage *Assessing Vibration A Technical Guideline* (AVTG). Where alternative construction methods that do not produce vibrations are impractical, the following principles from the AVTG can be utilised to minimise adverse impacts on the community.

- Confining vibration-generating operations to the least vibration-sensitive part of the day—when the background disturbance is highest.
- Determining an upper level for vibration impact also considering what is achievable using feasible and reasonable mitigation.
- Consulting with the community regarding the proposed events.