15. MARINE ECOLOGY

This chapter describes the marine ecology study undertaken to address changes made to the project description, take account of additional information available, and respond to specific comments made in submissions on the Arrow LNG Plant EIS (Coffey Environments, 2012).

The chapter presents the findings of the marine ecology supplementary technical study conducted by Coffey Environments, which is included in Appendix 8, Technical Study of Marine Ecology (Port Curtis).

Impacts of project lighting and flaring on the behaviour of marine turtles are addressed in Chapter 16, Turtles and Lighting. Impacts associated with estuarine ecology – specifically in the Calliope River are addressed in Chapter 17, Estuarine Ecology (Calliope River). Impacts associated with dredging are addressed in Chapter 12, Sediment Characterisation; Chapter 13, Marine Water Quality and Chapter 14, Coastal Processes.

15.1 Studies and Assessments Completed for the EIS

This section provides an overview of the marine and estuarine ecology technical impact assessment completed for the EIS, and discusses the main conclusions from that assessment.

Coffey Environments was engaged to conduct the marine and estuarine ecology impact assessment with the assistance of Central Queensland University (CQU). The technical report, including the report of field investigations prepared by CQU, is included as Appendix 12 of the EIS. Chapter 19 of the EIS presents the findings of the assessment.

The impact assessment involved a desktop review of available literature to describe the existing characteristics and marine environmental values of Port Curtis and its coastline. Field investigations were carried out to supplement the desktop review. An assessment was then undertaken to identify and assess direct and indirect impacts on marine environmental values from construction and operation of the LNG plant and associated marine facilities. Mitigation and management measures were proposed to reduce potential impacts on the marine environment.

A range of physical environments and habitat types were identified within the Port Curtis region, which supports a range of significant biodiversity. These habitats, including benthic, reef and rocky substrates, intertidal mudflats, saltmarsh, mangroves and seagrass beds, provide important habitat for large macrobenthic, plankton and fish communities. Port Curtis and its surrounding waters are also known to support a large marine megafauna population, including a number of species that are listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the International Union for Conservation of Nature (IUCN) Red List. All marine plants in Port Curtis, including seagrass, mangrove and saltmarsh are protected under the *Fisheries Act 1994* (Qld).

Key impacts to the marine environment associated with construction and operation of the project were identified as:

- Loss and disturbance of marine and estuarine habitats from the construction and operation of project infrastructure including jetties, material offloading facilities (MOF) and dredging.
- Injury or mortality to dugongs, marine turtles and cetaceans from shipping activity and accidents, including boat strike.

- Displacement or mortality of dugongs, marine turtles, cetaceans and fish from the effects of underwater noise and project lighting.
- Loss of commercial and recreational fishing access through exclusion zones and removal of fish habitat.
- Competition from introduced species and pest species for foraging and breeding habitats.

With the adoption of appropriate mitigation and management measures, residual impacts on marine environmental values were largely assessed as negligible or minor. Two impacts were assessed as having a moderate significance. These were boat strike to dugongs, marine turtles and cetaceans, and underwater noise from pile driving to marine turtles.

Commitments to reduce the impacts on marine ecology from project activities were developed based on the assessment undertaken by Coffey Environments. The commitments presented in the EIS are shown in Table 15.1.

Table 15.1 Marine and estuarine ecology EIS commitments

No.	Commitment
C19.01	Develop a construction management plan, which contains specific mitigation measures, performance indicators and management actions required to reduce impacts to the marine and estuarine ecological values.
C19.02	Establish a marine offsets strategy for the project to compensate for the loss of marine and estuarine habitat as a result of the project.
	Implement measures to reduce the impacts of light from the LNG plant and ancillary facilities including:
C17.16	• Shield/direct the light source onto work areas where practical.
C17.17	• Use long-wavelength lights, where practical, including use of red, orange or yellow lights.
C17.18	• Lower the height of the light sources as far as practical.
C17.19	• Avoid routine planned maintenance flaring at night during sensitive turtle-reproductive periods (where practical).
C15.02	Develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g., current WBDD Project data) and will include:
C15.03	• Requirements for monitoring of water quality.
C15.04	• Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan.
C19.03	Comply with environmental and legal criteria of the Queensland Government environmental offsets policy as the overarching framework for a specific-issue offset policy.
C19.04	Contribute to the development of a Port of Gladstone shipping activity strategy and management plan. Comply with applicable speed limits for the Port of Gladstone-Rodds Bay Zone B dugong protection area, as detailed in the management plan.
C19.05	Install (where feasible) propeller guards (or equivalent) on high-speed vessels to reduce the impact of injury in the event of boat strike.
C19.06	Implement soft-start procedures where a sequential build-up of warning pulses will be carried out prior to commencement of full-power pile-driving activities.
C19.07	Undertake fauna observations prior to and during pile-driving and dredging activities to check for the presence of marine turtles, dugongs and cetaceans. Should fauna be spotted within the area of the works, implement procedures to minimise impact, such as reverting to soft-start piling or stopping temporarily to allow animals to move away from the area.
C19.08	Keep dredging activities within the identified dredge footprint area.

Table 15.1 Marine and estuarine ecology EIS commitments (cont'd)

No.	Commitment
C19.09	Maintain a fauna-spotting function (where practical) during dredging activities. Do not commence dredging if marine mammals, turtles or crocodiles are spotted within the area of dredging, and stop temporarily if fauna is spotted within the area of the dredge head. In both cases, resumption of dredging must wait until fauna has moved away.
C19.10	Project vessels servicing the LNG plant that originate from overseas ports must comply with Commonwealth and local government ballast water management systems and implement Australian Quarantine and Inspection Service hull hygiene measures.
C19.11	All project vessels must comply with all applicable maritime law, especially when passing through the GBRMP. Project vessels will traverse the marine park via designated navigation routes with pilotage as required within port boundaries.

15.2 Study Purpose

This supplementary marine ecology assessment addresses changes to the project description, considers additional information and responds to specific issues raised in the submissions on the EIS. These aspects are identified below.

15.2.1 Project Description Changes

Project description changes relevant to the supplementary marine ecology study are summarised below and include.

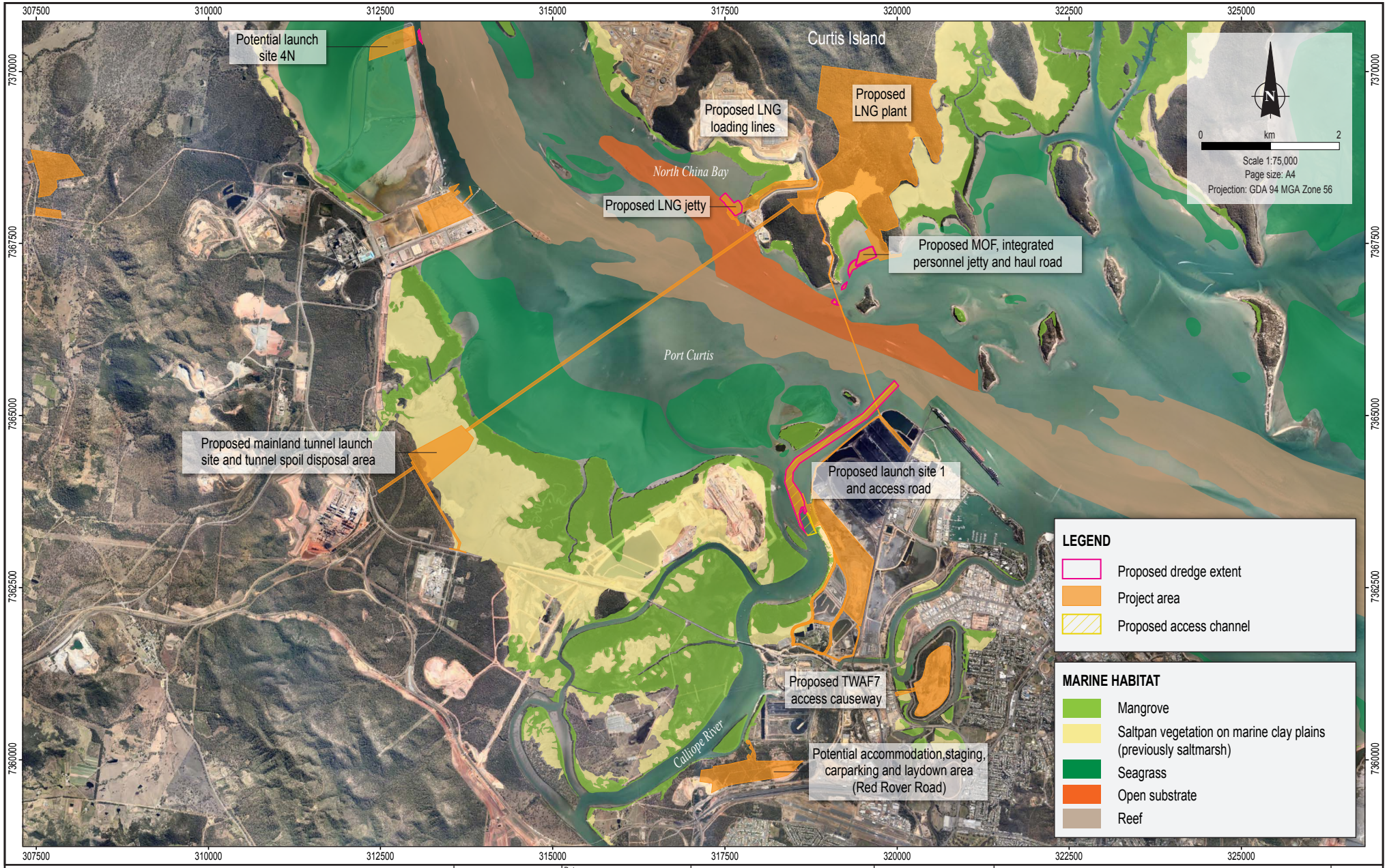
- Changes to dredge sites/footprints and related marine facilities, which could directly and indirectly impact marine habitat and marine fauna.
- Changes to marine logistics and transport and the potential for megafauna vessel strikes and interactions.

Additional information on these project description changes is detailed in Chapter 4 to Chapter 7.

Dredge Sites and Related Marine Facilities

Changes made to dredge sites and related marine facilities are outlined below. Hamilton Point South MOF 2 has been discontinued as a project option. Dredging is planned for the following sites: launch site 1 in the Calliope River, the Boatshed Point MOF and associated access channel and swing basin, and the LNG jetty. Minimal dredging is required at launch site 4N, the alternative mainland launch site.

Figure 15.1 shows the key areas of the project including laydown and staging areas, haul roads and TWAFs, and where habitat clearance will occur associated with dredging and marine infrastructure construction. Table 15.2 describes the areas of disturbance and associated dredging volumes for the construction and operation of project infrastructure. The amounts referenced in the table show the combined in situ volumes of dredging that are considered to be required at this point of time. These volumes will be further refined as a result of the detailed engineering, equipment selection and construction planning that will take place in the next phase of the project.



Source:
Proposed LNG plant layout, dredging, access channel extent and associated marine infrastructure from Arrow Energy.
Project area from Coffey Environments.
Marine Habitat: Seagrass from DEEDI (2002), Open substrate and reef from DPI QFS (2002). Mangroves and saltpan from Ecosure (groundtruthed where available, DERM RE v6.1 data otherwise).
Imagery from Nearmap (captured 7 August 2012).

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Arrow Energy

Arrow LNG Plant

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Main areas of the Arrow LNG Plant in Port Curtis

Figure No: 15.1

Table 15.2 Area of disturbance and dredge volumes

Component	Original EIS Layout		Revised layout	
	Area of disturbance (ha)	Dredge volume (m^3)	Area of disturbance (ha)	Dredge volume (m^3)
Boatshed Point MOF and integrated passenger jetty	1.3	50,000	4.5	148,000
Boatshed Point access channel and swing basin	N/A		2.5	165,000
Launch site 1 – Calliope River	36.7	900,000	30.2	900,000
LNG jetty – North China Bay	4.5	120,000	4.9	131,000
Launch site 4N	0.4	2,500	0.4	2,500
Total*	**42.5**	**1,070,000**	**42.1**	**1,344,000**

* Note that the maximum dredge volume for the EIS does not include the Hamilton Point South MOF or launch site 4N as these are project options. Similarly, the volumes for the SREIS do not include launch site 4N as this is an alternative to launch site 1.

Launch Site 1

The preferred mainland launch site is launch site 1 on the Calliope River, however launch site 4N at the Western Basin Reclamation Area is still being carried forward as an option.

The main changes to the design of launch site 1 from that presented in the EIS is the addition of a further linkspan berth (now four berths), enlargement of the material handling area at the berth to provide safe manoeuvrability of plant and equipment, and changes from the piled concrete deck structure to a sheet piled retaining structure.

The volume of material to be dredged in the Calliope River has not changed since the EIS was finalised, although the footprint of dredging has been refined (slightly decreased) (see Figure 4.5).

Boatshed Point MOF

The Boatshed Point MOF will comprise of five berths and associated facilities (including a ferry terminal area, passenger waiting terminal and laydown area).

The Boatshed Point MOF will involve a physical build-up of structures at the site to allow for the pioneer phase, early construction and peak phase of construction. The main changes of the design of the MOF from that presented in the EIS are the movement of facilities to the west, the provision of an additional linkspan berth, and the relocation of the passenger transfer facility to the northwest side of the facility, behind the Roll-on/Roll-off (RoRo) berth. The piled concrete deck structure has changed to a sheet piled, earth-filled structure, and the seabed lease has increased to include the extension of the MOF and the new location of the passenger terminal. Additional pile driving will also be required around Boatshed Point.

Dredging requirements (extent to be cleared and volumes to be removed) at the Boatshed Point MOF site have increased. Additional dredging is required to establish the passenger terminal and some dredging may be required in the footprint of the MOF structure to remove soft compressible materials to ensure a stable finished paving can be constructed (an increase in volume from 50,000m^3 to 148,000m^3) (see Figure 6.4).

A new dredge area is required near Boatshed Point to provide an access channel (and associated swing basin) from the Targinie Channel to the Boatshed Point MOF to allow access for large module carriers. The volume of dredged material at this site is expected to be approximately 165,000 m^3.

LNG Jetty

The design of the LNG jetty is unchanged. The anticipated volume of dredging of in-situ material required for construction of the LNG jetty has increased slightly and is now 131,000 m^3 (an increase from 120,000 m^3 in the EIS).

Intertidal Zone Activities

Some intertidal soft compressible materials may need to be removed along the Hamilton Point LNG loading corridor, at the Boatshed Point MOF, and at launch site 1, as well as along alignments of possible bunds to construct sedimentation settlement ponds. If required, this activity would be a land-based activity.

The construction of mainland facilities also has the potential to impact marine habitats and is discussed in more detail in Section 15.6.1.

Marine Logistics and Transport

The estimated number and frequency of marine vessel movements in Port Curtis and the Calliope River has been updated from that presented in the EIS. The revised numbers are presented in Table 15.3. The main changes to vessels are the reduced numbers of fast cat ferry movements. Vessel types (RoPax and high speed people movers), proposed speeds and passenger capacities are the same as those assessed in the EIS. No revisions have been made to the expected frequencies and number of other project related vessels such as LNG carriers, LPG vessels, barges, escort tugs, dredgers and support vessels.

Table 15.3 Proposed changes to ferry movements for mainland residents during construction and operation

Document	Number of mainland residents to be transported	No. of ferries (250 pax)	Total one way ferry movements (per day)	Total one way ferry movements (per month)
Movements reported in the EIS (construction)	1000 - 1500	3	56: approx. 40 (fast cat) 20 (RoPax)	1140 (fast cat) 540 (RoPax)
Revised Movements (construction)	1000 - 1500	4	34: 16 (fast cat) 18 (RoPax)	480 (fast cat) 540 (RoPax)
Movements reported in the EIS (operations)	Not reported in the EIS			
Movements (operation)*	375	2	20: 12 (fast cat) 8 (RoPax)	360 (fast cat) 240 (RoPax)

* During major maintenance works such as shutdown, workforce numbers and accordingly ferry movements will be approximately 50% more than ferry movements during operations.

15.2.2 Additional Information

The following additional information was compiled to inform the marine ecology technical study:

- The spatial and temporal use of the Calliope River and adjacent areas by marine megafauna (turtles, dugongs, and cetaceans).
- Potential impacts of noise from relocated pile driving activities at Boatshed Point.
- Potential impacts of maintenance dredging.

15.2.3 Submissions

Several submissions on the EIS raised issues relating to marine ecology. The full details of these submissions can be seen in the issues register table in Part B of the SREIS, together with responses to specific issues raised.

15.3 Legislative Update

Legislation, policies and guidelines related to the protection of the marine and estuarine environment are described in Chapter 19 of the EIS. No updates or changes of relevance to the assessment and management of marine ecology have been made since the EIS was finalised.

Attachment 1, Legislation Update, provides revisions to the legislative and approvals framework for the project since the EIS was finalised.

15.4 Study Method

This section describes the study method for the marine ecology supplementary technical report. The study involved a desktop component, which included database searches, a review of information provided by relevant agencies and impact assessment reports from other infrastructure projects in the Gladstone region, and an examination of updated aerial imagery and primary literature.

The results of various additional investigations and studies were also reviewed as follows:

- Updated bathymetric data for the Calliope River and Boatshed Point.
- Outputs of revised coastal processes and hydrodynamic modelling carried out by BMT WBM.
- Previous field survey results (based on a review of previous work completed for the EIS).
- Sightings of marine megafauna (turtles, dugong and dolphins) reported by Coffey Geotechnics (June to October, 2012) in Port Curtis and the Calliope River.
- Recent marine water quality and estuarine ecology surveys carried out by CQU in August 2012 (Appendix 5, Marine Water Quality – Part A: Marine Water Quality Report and Appendix 6, Marine Water Quality – Part B: Marine andEstuarine Ecology Report).

15.4.1 Revised Area of Disturbance

Area of disturbance (direct and indirect) calculations and the impacts of habitat disturbance on marine megafauna were reassessed in light of the project description changes, using the same approach applied in the EIS. Habitats to be removed were estimated using GIS mapping based on ground-truthed regional ecosystem 2012 datasets provided by Ecosure and 3D Environmental, regional ecosystem v6.1 2011 datasets provided by DERM and datasets provided by DEEDI and created in 2002 by the Department of Primary Industry and Fisheries (DPIF).

The marine and estuarine ecology impact assessment for the EIS calculated the amount of saltmarsh (saltflat and salt tolerant species) to be removed in the area by using a 2002 dataset sourced from DEEDI. The calculations made to support the studies and assessments carried out for the SREIS were based on 2011 DERM regional ecosystem (RE 12.1.2) and Ecosure and #D Environmental ground-truthed datasets, where RE vegetation 12.1.2 is described as saltpan vegetation including grassland and herbland on marine clay plains.

15.4.2 Marine Megafauna Sightings

The spatial and temporal use of the Calliope River and adjacent waterbodies by marine megafauna (dugongs, marine turtles, cetaceans) was investigated. This information informed the review of potential impacts of boat strikes and dredging on marine megafauna.

Between June and October 2012, Coffey Geotechnics (during unrelated survey work) recorded all sightings of marine turtles, dugongs and dolphins within the project area. Sightings were recorded from vessels moving within the Gladstone Marina, Port Curtis and the Calliope River, and from various stationary drilling platforms located throughout Port Curtis. All sightings were plotted on GIS maps; the total numbers recorded corresponded to type estimates only (e.g., dolphin) as accurate identification to genus or species level could not be achieved with confidence. These findings reflect opportunistic reports of sightings by the observers and were not part of a specifically-designed survey to study megafauna in the project area.

Information on the ecology, occurrence and habitat availability of megafauna (with a particular focus on cetaceans) in the project area was complemented with relevant primary literature, information recorded in databases from the Department of Environment and Heritage Protection (DEHP, 2012a), and observations made from February to April 2011 and in June 2011 by the Western Basin Dredging and Disposal Project using vessel and aerial surveys (GPC, 2011b). Information on the occurrence and distribution of the Australian snubfin dolphin (snubfin dolphin) and the Indo-Pacific humpback dolphins (humpback dolphins) in Port Curtis was also obtained from local surveys conducted between January 2006 and September 2008 (URS, 2009).

15.4.3 Vessel Interactions

The direct impact of boat strikes (vessel interactions) on marine megafauna (specifically dugong, marine turtles and cetaceans) was reviewed to take account of the change in vessel frequency, using the same method applied in the EIS. The assessment took into account vessel movement frequency during construction and operation, the likelihood of an animal being in the path of the vessel, and a species ability to detect and avoid vessels.

15.4.4 Underwater Noise

Additional pile driving is required at Boatshed Point to construct the MOF and integrated personnel jetty. The potential impacts of underwater noise generated during pile driving on marine fauna were reviewed following the same approach as described in the EIS.

15.4.5 Assessment Methodology

The study identified the existing environment in terms of marine ecology, focusing on the project description changes, submissions and additional information requirements identified from the EIS. The results of the desktop study and additional fieldwork were used to review the outcomes of the marine and estuarine ecology impact assessment. This specifically focussed on validating the impacts and mitigation measures that were committed to in the EIS and presenting any new impacts and mitigation measures that have resulted from the provision of new information. The significance assessment method remained the same as outlined in the EIS.

15.5 Study Findings

This section describes the results of the supplementary marine ecology technical report.

15.5.1 Marine Habitat Disturbance

The revised dredging extents and marine infrastructure locations will cause direct and indirect impacts to the five main marine habitats present in the project area. Revised disturbance areas, compared with the EIS, for mangrove, saltpan vegetation (previously saltmarsh), seagrass, reef and rock substrate, and benthic zone and intertidal mudflat habitats have been calculated.

Direct Impacts

Direct impacts on marine habitats through loss and disturbance involve clearing and removal works associated with the construction of project infrastructure and dredging activities. Direct impacts on mangroves, saltpan vegetation, seagrasses, benthic zone and intertidal mudflats, and reef and rock substrate were addressed in the EIS, and have been reviewed taking into account project description changes. The total area of disturbance for marine habitats as described in the EIS and the revised areas of disturbance are provided in Table 15.4. This table shows the base case and alternative cases for habitat clearance, as described in Appendix 11, Terrestrial Ecology Supplementary EIS Study. The base case clearance also takes into account areas that have already been cleared for other infrastructure (services lines for GAWB on Hamilton Point, areas around North China Bay).

Base case clearance comprises the Arrow Energy LNG plant site on Curtis Island, the mainland tunnel launch site, launch site 1 and TWAF 7. In the alternative case TWAF 7 is replaced by TWAF 8 and Red Rover Road, and launch site 4N (marine area) is also included.

Table 15.4 Extent of direct disturbance on marine habitats

Habitat	Total Area of Disturbance EIS (ha)	Revised Location of Disturbance	Breakdown of Areas of Disturbance (ha) (base case)	Breakdown of Areas of Disturbance (ha) (alternative case)	Revised Total Area of Disturbance (ha)
Mangroves*	5.80	Launch site 1 and haul road – Calliope River	2.01	2.01	Base case – 4.7 Alternative – 5.1
		Curtis Island infrastructure: Boatshed Point MOF, integrated personnel jetty / haul road and loading lines leading to LNG jetty and LNG jetty	2.48	2.48	
		Proposed TWAF 7 (laydown, carparking and staging area)	0.21	-	
		Red Rover Road (potential accommodation, staging, carparking and laydown area)	-	0.61	

Table 15.4 Extent of direct disturbance on marine habitats (cont'd)

Habitat	Total Area of Disturbance EIS (ha)	Revised Location of Disturbance	Breakdown of Areas of Disturbance (ha) (base case)	Breakdown of Areas of Disturbance (ha) (alternative case)	Revised Total Area of Disturbance (ha)
Saltpan vegetation on marine clay plains (previously saltmarsh)*	58.20	Mainland tunnel launch site	32.5	32.5	Base case – 55.01 Alternative – 54.49
		Curtis Island infrastructure: Boatshed Point MOF, integrated personnel jetty / haul road and loading lines leading to LNG jetty and LNG jetty	17.49	17.49	
		Launch site 1 and access road – Calliope River	4.50	4.50	
		Proposed TWAF 7 (laydown, carparking and staging area)	0.52	-	
Seagrass beds†	0.00	Potential launch site 4N	-	0.00	Alternative – 0.00
Benthic zone and intertidal mudflat°	5.31	LNG jetty	3.72	3.72	Both cases – 5.64
		Boatshed Point access channel and dredge footprint	1.92	1.92	
Reef and rock substrate°	0.40	Launch site 4N	-	0.14	Alternative – 0.14

*Areas calculated to inform studies completed for the SREIS are based on Ecosure ground-truthed regional ecosystem 2011 data set and DERM regional ecosystem v6.1 2011 data set.

†Areas calculated and presented in the EIS and SREIS are based on the full 2002 data set sourced from DEEDI.

°Areas calculated and presented in the EIS and SREIS are based on the full 2002 data set sourced from Department of Primary Industry and Fisheries (DPIF).

Mangroves

The maximum direct loss of mangroves has reduced by approximately 1.1 ha (base case) and 0.7 ha (alternative case and worst case scenario) from the estimated 5.80 ha specified in the EIS, with clearance mainly due to the construction of the LNG loading lines and LNG jetty in North China Bay as well as the launch site 1 and the associated haul road adjacent to the Calliope River.

Saltpan Vegetation

The maximum direct loss of saltpan vegetation has been recalculated to be 55.01 ha, corresponding to a reduction of 3.19 ha (base case and worst case scenario) and 3.71 ha (alternative case) from the estimated 58.2 ha quantified in the EIS. The habitat to be removed is largely associated with the construction of the mainland tunnel launch site and the Curtis Island marine infrastructure.

Benthic Zone and Intertidal Mudflats

The maximum direct loss of benthic zone and intertidal mudflats habitat has been reassessed to be 5.64 ha, an increase of 0.34 ha (both base and alternative case) from the estimated 5.3 ha indicated in the EIS. This area is to be removed during construction of the LNG loading lines and jetty in North China Bay and the access channel to Boatshed Point.

Reef and Rock Substrate

The maximum direct loss of reef and rock substrate following changes to the dredge extent around launch site 4N has been reassessed to be 0.14 ha (alternative case only), corresponding to a reduction in 0.16 ha from the estimated 0.3 ha specified in the EIS.

Seagrasses

No seagrass will be removed due to changes in the project description. No removal of seagrass habitat was proposed in the EIS.

Indirect Impacts

Indirect impacts to marine habitats are associated with increased sedimentation and turbidity plumes as a result of dredging activities. Indirect impacts of dredging on mangroves, seagrasses, reef and rock substrate, and intertidal zone were addressed in the EIS. Changes have been made to dredging activities, specifically the volume of material to be dredged and the areas to be dredged at some sites.

The volumes of material to be dredged have remained the same at launch site 1 and launch site 4N and have marginally increased at the LNG jetty. The major change is at Boatshed Point where the volume of material to be dredged has increased from 50,000 m^3 to a total volume of 313,000 m^3.

The dredge plume modelling results presented in the EIS were used to review the likely impacts of changes to dredging operations as the assumptions made in the modelling (principally the dredging method) have not changed. This includes the type of dredge equipment to be used (medium sized cutter suction dredge), the dredge production rates (500 m^3 per hour) and 24 hour operations. Recent sediment sampling, as described in Chapter 12, Sediment Characterisation, has also confirmed that the particle sizes used in the dredge plume modelling are consistent with the sediments found at Boatshed Point.

Dredging at Boatshed Point (in relation to effective dredging days) will be longer in schedule (completed in approximately 26 days) compared with approximately 4 days for a volume of 50,000 m^3. Lengthening the dredging schedule by 22 effective dredging days will increase the amount of total sediment disposition and the time of exposure of sensitive receptors to sediment plumes.

15.5.2 Changes to Marine Logistics and Transport

The number of marine vessels and the frequency of vessel movements within Port Curtis and the Calliope River have been updated from those reported in the EIS. Changes to marine logistics and transportation during construction and operations will change the potential for interaction between vessels and marine megafauna, i.e., boat strikes. These changes were reviewed to identify any changes to the worst-case scenario for residual and cumulative impacts as assessed in the EIS.

Fast cat ferry movements during construction will reduce to 480 per month compared with 1140 per month assessed in the EIS. Expected RoPax ferry movements during construction remain

unchanged at 540 per month (see Table 15.3), as have ferry vessel types, proposed speeds and passenger capacities.

During operations, the amount of people being transported to and from Curtis Island will reduce; therefore fast cat and RoPax ferry movements will be at a decreased rate of 360 and 240 single trips per month respectively. However, during major maintenance works such as shutdowns, workforce numbers and accordingly ferry movements will be approximately 50% more than the ferry movements during normal operations.

15.5.3 Marine Megafauna in Port Curtis

Further information on the spatial and temporal use of Port Curtis and the Calliope River was obtained through direct observations and a review of existing data. Ninety-three separate sightings of marine megafauna (marine turtles, dugongs and cetaceans) were recorded by Coffey Geotechnics between June and October 2012 around Boatshed Point (Figure 15.2) and in the Calliope River (Figure 15.3). Sightings were of either an individual or group (numbers of individuals in each group were not recorded in every instance).

Forty-nine separate sightings of marine turtles were recorded in Port Curtis and the Calliope River by Coffey Geotechnics during the five month period. Furthermore, information on marine turtles present in Port Curtis and adjacent areas can be gleaned from data on turtle strandings which were recorded in the Gladstone region (Rodds Bay Peninsula to Sandy Point, north of Yeppoon) between 1 January 2011 and 30 September 2012 (DEHP, 2012b). A total of 370 strandings were recorded, with 292 verified mortalities.

Sightings of dugongs are infrequent within Port Curtis. Thirteen separate sightings were recorded by Coffey Geotechnics between June and October 2012. Most dugongs were sighted close to the entrance channel to the Calliope River (see Figure 15.2). One deceased dugong was recorded near the Gladstone Power Station. There is also anecdotal evidence of dugong activity in waters near the power station. A total of 19 dugong strandings were recorded in the Gladstone region between 1 January 2011 and 30 September 2012 (DEHP, 2012b). Dolphins are frequently sighted in Port Curtis, particularly in the vicinity of the Gladstone Marina and along the entrance to Calliope River (see Figure 15.2). Thirty-one separate sightings of dolphins (individuals or pods) were recorded by Coffey Geotechnics around these areas between June and October 2012.

Surveys undertaken between February to April and in June 2011 as part of the Western Basin Dredging and Disposal Project (GPC, 2011a) recorded 124 and 57 dolphins, respectively, comprising humpback, snubfin and inshore bottlenose dolphins. Humpback dolphins were the most frequently observed species, with 85 sightings (GPC, 2011a). Larger dolphin numbers were reported around Port Alma and Port Curtis during summer, with most pods sighted in Port Curtis. Visual and photo-identification surveys of snubfin and humpback dolphins in Port Curtis were conducted between January 2006 and September 2008 as part of a PhD research project (URS, 2009). Over the two year period, 156 humpback dolphin pods were sighted, with pods averaging less than 4 individuals and a maximum of up to 15. No snubfin dolphins were observed during that period. The study suggests that approximately 65 humpback dolphins live in Port Curtis (URS, 2009).

Source:
Marine life sighting from Coffey Geotechnics (indicative observations from field work locations only).
Proposed dredging and access channel extent from Arrow Energy.
Project area from Coffey Environments.
Imagery from Nearmap (captured 7 August 2012).

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File Name: 7033_16_F15.02_GIS_GL

Arrow Energy

Arrow LNG Plant

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Sightings of marine megafauna around Boatshed Point and Hamilton Point

Figure No: 15.2

Source:
Marine life sighting from Coffey Geotechnics (indicative observations from field work locations only).
Proposed dredging and access channel extent from Arrow Energy.
Project area from Coffey Environments.
Imagery from Nearmap (captured 7 August 2012).

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MXD: 7033CC_16_GIS065_v1_2
File Name: 7033_07_F15.03_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Sightings of marine megafauna in Gladstone Marina and Calliope River

Figure No: 15.3

15.5.4 Pile Driving

The revised sound exposure level (SEL) contours for pile driving at Hamilton Point, Boatshed Point and launch site 1 in the Calliope River are shown in Figure 15.4, Figure 15.5 and Figure 15.6, respectively. The 350 m noise contour represents the distance where sound levels drop below 150 dB re 1µPa and beyond which injury is unlikely to occur. Outside the 350 m noise contour, behavioural responses may still be expected.

Information available on dugongs, turtles and dolphins indicates that these animals could be present in most parts of Port Curtis (see Figure 15.2) and the Calliope River (see Figure 15.3). These species could potentially pass within 350 m of pile driving at the three project sites.

Dugongs and turtles are likely to focus feeding activities at seagrass beds. Two seagrass patches are present to the east of Boatshed Point at a range of approximately 20 m to 500 m to the east of the 350 m SEL contour. There is no intersection with seagrass beds for any of the SEL contours within which risks of injury to marine fauna would be expected to occur.

15.5.5 Maintenance Dredging

The EIS verified the need for additional work to further assess the potential impacts of maintenance dredging. Maintenance dredging will be required to maintain the shipping access channel to the swing basin adjacent to the LNG jetty, launch site 1 in the Calliope River, and at the Boatshed Point MOF.

Modelling conducted by BMT WBM (2012) examined the potential accumulation of fine sediments, following construction at the harbour on the western side of Boatshed Point and near launch site 1 in the Calliope River. During operations, the modelling indicates that fine sediment will deposit at these sites and dredging will be required to maintain shipping access. Limited deposition (up to 0.06 m/month) is expected in the Calliope River in navigable areas. Based on the modelled deposition rates, more frequent dredging is likely to be required at Boatshed Point. The actual dredging frequency required to manage this material will be determined on an as needs basis once capital dredging and construction is completed.

15.6 Potential Impacts and Management Measures

This section describes changes to the impacts, including cumulative impacts, described in the EIS and presents any new impacts or impacts that represent a new worst-case scenario. New management measures and any changes to measures described in the EIS are also discussed.

15.6.1 Loss and Disturbance of Marine and Estuarine Habitat

This section describes the direct and indirect impacts related to the construction and operation of the project on marine and estuarine habitats.

Direct Impacts

The direct impacts from the removal of mangroves, saltpan vegetation, seagrasses, benthic zone and intertidal mudflats, and reef and rock substrate habitats are unchanged from those presented in the EIS. Mitigation measures are also unchanged.

Source:
Proposed LNG plant layout, dredging, access channel extent and associated marine infrastructure from Arrow Energy.
Project area from Coffey Environments. Underwater noise projection contour from Katestone.
Marine Habitat: Seagrass from DEEDI (2002), Open substrate and reef from DPI QFS (2002). Mangroves and saltpan from Ecosure (groundtruthed where available, DERM RE v6.1 data otherwise).
Imagery from Nearmap (captured 7 August 2012).

coffey environments

Date: 06.12.2012
MXD: 7033CC_16_GIS069_v1_1
File Name: 7033_16_F15.04_GIS_VS

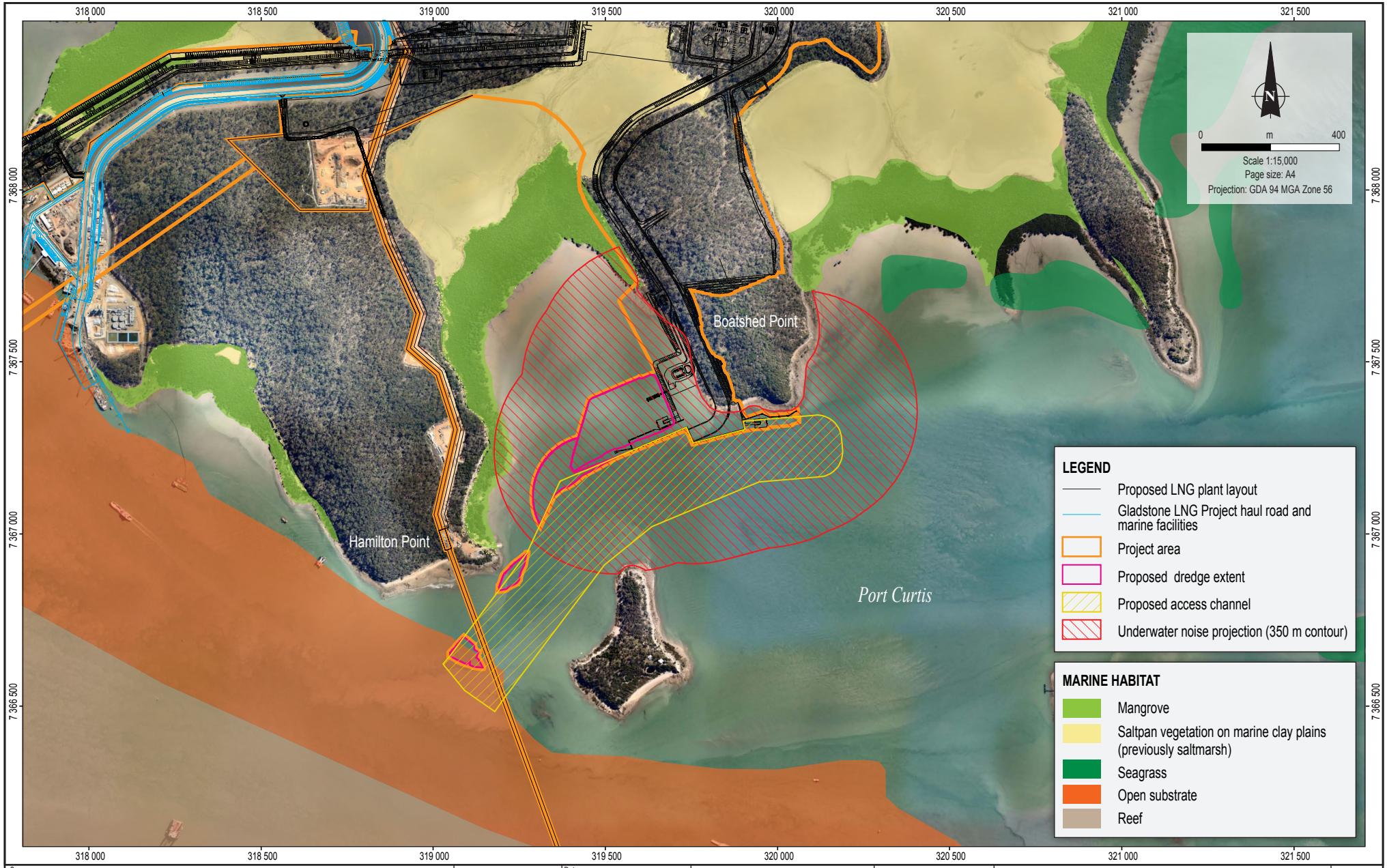
Arrow Energy

Arrow LNG Plant

arrow energy go further

Underwater noise projection from pile driving in North China Bay

Figure No: **15.4**



Source:
Proposed LNG plant layout, dredging, access channel extent, auxiliary facilities and associated marine infrastructure from Arrow Energy. Project area and underwater noise projection contour from Coffey Environments.
Marine Habitat: Seagrass from DEEDI (2002), Open substrate and reef from DPI QFS (2002). Mangroves and saltpan from Ecosure (groundtruthed where available, DERM RE v6.1 data otherwise).
Imagery from Nearmap (captured 7 August 2012).

coffey environments

Date: 10.12.2012
MXD: 7033CC_16_GIS070_v1_1
File Name: 7033_16_F15.05_GIS_VS

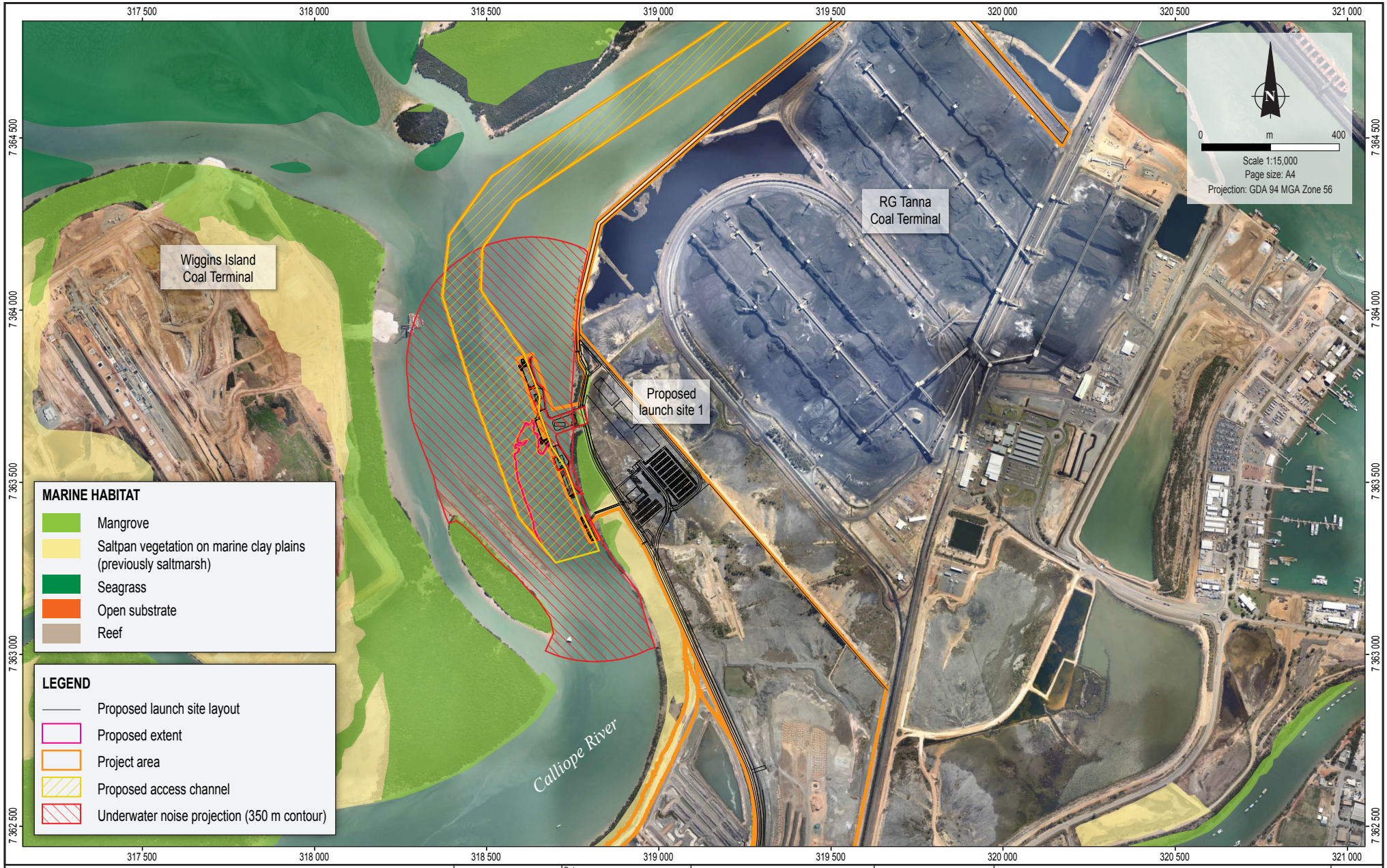
Arrow Energy

Arrow LNG Plant

arrow energy go further

Underwater noise projection from pile driving at Boatshed Point

Figure No: 15.5



Source:
Proposed LNG plant layout, dredging, access channel extent, auxiliary facilities and associated marine infrastructure from Arrow Energy. Project area and underwater noise projection contour from Coffey Environments.
Marine Habitat: Seagrass from DEEDI (2002), Open substrate and reef from DPI QFS (2002). Mangroves and saltpan from Ecosure (groundtruthed where available, DERM RE v6.1 data otherwise).
Imagery from Nearmap (captured 7 August 2012).

coffey environments

Date: 10.12.2012
MXD: 7033CC_16_GIS067_v1_1
File Name: 7033_16_F15.06_GIS_VS

Arrow Energy

Arrow LNG Plant

arrow energy go further

Underwater noise projection from pile driving at launch site 1

Figure No: 15.6

Indirect Impacts

Indirect impacts on marine habitats associated with dredging were based on the predicted spatial extent of plume formation, as determined through modelling conducted by BMT WBM. The indirect impacts associated with dredging at launch site 1, launch site 4N and the LNG jetty remain as assessed in the EIS as the volume of dredged material to be removed has either remained the same or only marginally increased.

The increases in dredging volumes and extent associated with the construction of the Boatshed Point MOF, access channel and swing basin has the potential to impact on nearby seagrass beds. At least two large areas of seagrass are known to exist to the east of Boatshed Point. These beds could be feeding grounds for dugongs and several species of marine turtles. The locations of these two beds are shown on Figure 15.5.

The seagrass beds could be impacted by plumes of suspended sediment from dredging at Boatshed Point. Seagrass is light and sediment-sensitive and plumes extending over the beds could reduce light reaching the seagrass. Sediment may also settle out and deposit over the beds.

The modelling of sediment plumes carried out by for the EIS was reviewed by BMT WBM in light of the changes to dredging at Boatshed Point. The revised dredging extent at Boatshed Point does not extend further eastwards towards the beds and the main change will be the longer period of dredging. The review assumed that the dredge method remains as assessed in the EIS and under these conditions, the rate of sediment entering the water column will not change from that assessed in the EIS for both the MOF and LNG jetty dredging works.

More sediment will enter the water column over time at these two locations although the concentrations of suspended sediment will not increase as the modelling carried out for the EIS showed that concentrations will build up over the first two weeks of dredging and will then reach dynamic equilibrium. Dredged sediment is also expected to settle out and mix with natural suspended sediment during the neap tide periods. The depth of sediment accumulation will be proportionally larger, although is not expected to extend significantly further than predicted in the EIS. Based on the modelling conducted for the EIS, very little, if any, sediment accumulation will occur at the two seagrass beds east of Boatshed Point.

The impacts of maintenance dredging during operations are expected to be the same as capital dredging. Although the volumes of material to be dredged during maintenance dredging will be significantly lower, capital dredging will be a single event, as opposed to a repetitive activity during operations. Maintenance dredging will occur at a minimum annually, with the majority of maintenance dredging occurring at Boatshed Point.

Any impacts on the seagrass beds at Boatshed Point will be short term and localised. Should smothering occur, seagrasses possess a number of adaptations, including horizontal rhizome growth and sediment trapping functions, to tolerate smothering and survive burial for short periods (de Boer, 2007). The combined area of the Boatshed Point beds is 7.4 ha accounting for 2.2% of the total area of seagrasses estimated to be present in Port Curtis (3,403.8 ha). The magnitude and significance of indirect impacts will therefore remain as the assessment in the EIS (i.e., low in magnitude and of minor significance).

Arrow Energy will develop a dredge management plan that will consider relevant water and sediment monitoring data to address potential impacts associated with dredging. The plan will require the development of a water quality monitoring program and an action plan to minimise impacts of dredging on sensitive areas (including seagrass beds) if project water quality criteria

are exceeded (see Chapter 13, Marine Water Quality). The dredge management plan will consider the locations and timing of all dredging activities in Port Curtis (project and non-project related).

15.6.2 Impacts on Marine and Estuarine Fauna

The main direct impacts on marine fauna in Port Curtis and the Calliope River include habitat disturbance from clearing, vessel interactions and underwater noise. The key indirect impact on marine fauna relates to sedimentation and turbidity plumes from dredging works, which can impact on water quality and cause smothering of food sources and habitat. These impacts were reviewed following changes to dredging activities and marine infrastructure. Table 15.5 summarises the impacts to marine fauna from project related activities and any changes to the significance of the impact as described in the EIS.

Table 15.5 Revised impacts on marine fauna values

Value	Sensitivity	Impact	Magnitude/ Significance EIS (residual)	Magnitude/ Significance Revised (residual)	Change to Worst-case Scenario?
Dugong	Medium	Direct: Vessel interaction	High/Moderate	Low/Minor	Yes (improved)
		Direct: Underwater noise (pile driving)	Medium/Minor	Low/Minor	Yes (improved)
		Direct: Habitat loss	Not assessed	Low/Negligible	N/A*
		Indirect: Turbidity plumes from dredging	Not assessed	Medium/Minor	N/A*
Marine turtles	Medium to High	Direct: Vessel interaction	High/Moderate	Low/Minor	Yes (improved)
		Direct: Habitat loss	Not assessed	Low/Negligible	N/A*
		Indirect: Turbidity plumes from dredging	Not assessed	Medium/Minor-Moderate	N/A*
Cetaceans	Medium	Direct: Vessel interaction	High/Moderate	Low/Minor	Yes (improved)
		Direct: Underwater noise (pile driving)	Not assessed	Low/Minor	N/A*
		Direct: Habitat loss	Not assessed	Low/Negligible	N/A*
		Indirect: Turbidity plumes from dredging	Not assessed	Medium/Minor	N/A*

Table 15.5 Revised impacts on marine fauna values (cont'd)

Value	Sensitivity	Impact	Magnitude/ Significance EIS (residual)	Magnitude/ Significance Revised (residual)	Change to Worst-case Scenario?
Invertebrates/ macrobenthos	Low	Direct: Underwater noise (pile driving)	Medium/Negligible	Low/Negligible	No
		Direct: Habitat loss	Not assessed	Low/Minor	N/A*
		Indirect: Turbidity plumes from dredging	Not assessed	Medium/Negligible	N/A*
Plankton	Very low	Direct: Underwater noise (pile driving)	Medium/Negligible	Low/Negligible	No
		Indirect: Turbidity plumes from dredging	Not assessed	Medium/Negligible	N/A*
Fish and shellfish	Medium	Direct: Underwater noise (pile driving)	Medium/Minor	Low/Minor	No
		Direct: Habitat loss	Not assessed	Low/Minor	N/A*
		Indirect: Turbidity plumes from dredging	Not assessed	Medium/Minor	N/A*

*N/A – Not applicable.

Habitat Disturbance

The direct and indirect impacts of habitat loss or disturbance on key marine fauna values was assessed following changes to the project description, the provision of additional information and the results of survey conducted after the EIS was published. Due to the extent of habitat clearance being very small and all habitats being well represented in Port Curtis and surrounding areas, the significance of impact to all marine fauna has been assessed as minor.

The results from benthic surveys undertaken by CQU during the August 2012 fieldwork suggests that dredging of the access channel and swing basin at Boatshed Point is likely to result in the localised loss of individuals of at least 220 species of macroinvertebrates from 9 different phyla (Wilson, 2012). The most common organisms recorded included brittle stars, gastropods and polychaete worms.

Sediment plumes generated during dredging at Boatshed Point could impact on seagrass beds to the east of the area, thereby indirectly affecting the main feeding areas of dugong and turtles. These seagrass beds will only be impacted temporarily, and the significance of indirect impacts to all marine fauna has been assessed as minor (or moderate in the case of some marine turtle species with high sensitivity values).

Although considered generally difficult to quantify, turbidity and sediment plumes can also indirectly impact benthic (flora and fauna associated with the seabed), pelagic (free swimming fauna in the water column) and planktonic (microscopic and/or macroscopic flora and fauna drifting in the water column with water currents) communities in a number of ways. The impact from increased turbidity and sediment plumes on habitats as well as marine flora and fauna is

expected to be both localised and largely short-lived, as a result of local high-velocity tidal currents causing rapid plume dispersion from the point source (Appendix 7, Coastal Processes and Marine Water Quality Technical Study).

Marine offset strategies (C17.02A and C19.03) will be implemented to compensate for direct impacts to marine habitats. Water quality monitoring (C15.04) will be undertaken (and specified in the dredge management plan) to inform the timing, location and method of the dredging operations, especially in the event that water quality exceeds regulated limits due to turbidity.

Underwater Noise

Pile driving impacts to marine fauna include physical injury and behavioural disturbance. The anecdotal observational data indicates that marine megafauna are present around Curtis Island (see Figure 15.2) and the Calliope River (see Figure 15.3), and it is possible that marine fauna could pass within the 350 m radius of pile driving during the construction of marine infrastructure.

As discussed in the marine and estuarine ecology impact assessment (Coffey Environments, 2011), there are major uncertainties around threshold response distances for dugongs, marine turtles and cetaceans due to a lack of empirical data. The literature describes a relatively narrow zone of potential injury risk (if suddenly exposed) but a much wider sound range that would be severe enough to cause disturbance or influence behaviour. The characteristics of underwater pile driving indicate that sound levels may exceed thresholds associated with physiological damage to marine fauna that are located very close to the source, or cause behavioural changes to marine fauna located at distances several hundred metres away. Most pile driving for the project will be nearshore and within shallow water but could potentially be in deeper waters and could affect most of the water column.

The EIS included a commitment to implement soft-start procedures prior to commencement of full-power pile-driving activities (C19.06). Bubble curtains can also assist in the management of underwater noise during pile driving activities and can reduce the impacts on marine megafauna. Arrow Energy will evaluate the use of bubble curtains for each method of piling, and deploy where they are demonstrated to be effective in aiding the rapid attenuation of underwater noise and deterring marine fauna from approaching, or remaining at, pile driving sites (C19.13). The implementation of existing and new management measures will reduce the impact from moderate to low, resulting in an improvement to the worst-case scenario described in the EIS.

The three areas of pile driving are well separated so there will be no overlap of the 350 m underwater noise contours. Furthermore, as there are no seagrasses within the 350 m zone at the three sites, there will be limited risk of disturbance to dugong and marine turtles feeding in these areas.

Boat Strike

The assessed direct impact on marine megafauna (dugongs, marine turtles and cetaceans) from vessels strikes has been reduced from a significance of moderate to low, resulting in an improvement to the worst-case scenario described in the EIS. All mitigation measures proposed in the EIS, including complying with vessel speed limits (C19.04) and vigilance to the presence of marine turtles, dugongs and cetaceans (C19.09) will remain effective.

In addition, Arrow Energy will establish a system for recording of opportunistic observations of marine megafauna (turtles, saltwater crocodiles, dugong and cetaceans) spotted during marine operations such as dredging, pile driving and marine transport including where these activities occur within the Calliope River (C19.12). The system will support development of greater understanding of the spatial and temporal use of Port Curtis and the Calliope River by

megafauna, in particular the area between the mouth of the Calliope River and the Gladstone Power Station. Managing vessel speeds through speed limit restrictions remains the foremost mitigation measure.

15.6.3 Changes to Cumulative Impacts

Cumulative impacts to the marine environment were reviewed for:

- Direct and indirect habitat loss.
- Vessel strike frequency.
- Underwater noise.

Direct and Indirect Habitat Loss

Cumulative impacts relating to direct and indirect marine habitat loss have not changed from those presented in the EIS.

Marine Logistics, Transport and Vessel Interactions

Data provided in other proponents impact assessments, and the revised project vessel data, indicate that the contribution of the project to vessel movements in Port Curtis reduces by approximately 10% for construction and increases during operations when compared to the contribution predicted in the EIS.

Although there has been an increase in ferry movements during operations, there has been a decrease in ferry movements during the construction phase. Implementation of the management measures identified in the EIS during both construction and operation of the project will mean the significance of residual impacts associated with vessel strike remains low.

Underwater Noise

The cumulative impact of underwater noise from vessel movements and pile driving activities will be highly dependent on the detailed construction schedules for all relevant projects and the proximity of these activities to each other. Construction schedules are not currently predicted to overlap. Mitigation measures will be reviewed in the event that scheduling does overlap.

15.7 Marine Offsets

A Draft Environmental Offset Strategic Management Plan (Attachment 6) has been developed by Arrow Energy, and is consistent with the Environmental Offset Strategy. The plan:

- Describes measures taken to avoid and minimise impacts.
- Identifies Arrow Energy's likely offset requirements.
- Presents evidence that there are opportunities to achieve the required offsets.
- Sets out Arrow Energy's preferred approach to the provision of environmental offsets.

The Draft Environmental Offsets Strategic Management Plan presents the results of GIS analysis involving the sequential application of filters to identify suitable patches/tracts of target regional ecosystems, to facilitate identification of potential offset sites.

15.8 Conclusion

This chapter summarises the findings of the marine ecology technical study which was conducted to validate impacts and assess any changes to the worst-case scenario (both positive and negative changes) associated to changes to the project description, the provision of new information, and comments made in submissions on the EIS.

There are no changes to the nature and significance of direct impacts associated with the removal of mangroves, saltpan vegetation, seagrasses, benthic zone and intertidal mudflats, and reef and rock substrate habitats from the findings reported in the EIS. As such, no new mitigation measures are proposed.

The nature and significance of indirect impacts on mangroves, benthic zone and intertidal mudflats, and reef and rock substrate habitats associated with dredging activities at launch site 1, the LNG jetty and launch site 4N did not change from those presented in the EIS. An increase in the volume of material to be dredged during the construction of the MOF could have a temporary, localised impact on the seagrasses located to the east of Boatshed Point. The management measures outlined in the EIS, including the development and implementation of a dredge management plan (and associated water quality monitoring program, are considered to be adequate to mitigate the potential impacts to these seagrass beds.

Direct and indirect loss of habitat impacts to marine fauna values will be mitigated by management measures relating to marine offset strategies (direct) and water quality monitoring (indirect) that were committed to in the EIS.

Assessed direct impacts from vessel strikes on marine megafauna (dugong, cetaceans and marine turtles) were all reduced from a significance of moderate to minor due to the commitment of existing and additional management measures. Managing vessel speeds through speed restrictions remains the foremost mitigation measure.

The worst case scenario for pile driving impacts on marine megafauna (dugong and marine turtles) were all reduced from moderate to minor. These improvements are due to the establishment of bubble curtains as appropriate for various types of piling, as a management measure to attenuate noise in the water column, coupled with the existing management measures outlined in the EIS.

Overall, the mitigation measures detailed in Table 15.6, including new measures to further protect the marine and estuarine ecological values of Port Curtis, are considered to be adequate in managing the impacts associated with the construction and operation of the Arrow LNG Plant.

15.9 Commitments Update

Two new commitments have been added in response to the marine ecology technical study (commitments C19.12 and C19.13). Commitment C19.01A has been revised to provide further clarity and Commitment C19.02 has been removed and replaced by Commitment C17.02A which has been revised to include marine offsets. Commitment C17.16A has been revised to expand the intent of the commitment.

The new and revised commitments relevant to terrestrial ecology are set out in Table 15.6. Other measures are unchanged and are included in Attachment 7, Commitments Update.

Table 15.6 Commitments update: marine ecology

No.	Commitment	Comment
C19.01A	Develop a construction environmental management plan, which contains specific mitigation measures, performance indicators and management actions required to reduce impacts to the marine and estuarine ecological values.	Changed for improved definition
~~C19.02~~	~~Establish a marine offsets strategy for the project to compensate for the loss of marine and estuarine habitat as a result of the project.~~	Deleted and replaced with enhanced commitment 17.02A
C17.02A	Develop an Environmental Offsets Operational Management Plan that addresses terrestrial and marine offset requirements in consultation with relevant government stakeholders prior to commencement of construction. The plan will provide details on offset options and opportunities, and details on how the offset meets relevant policies and how it will be managed over the life of the offset.	New to marine and estuarine ecology. Terrestrial ecology commitment changed to include marine offsets.
	Implement measures to reduce the impacts of light from the LNG plant and ancillary facilities including:	No change
C17.16A	• Shield/direct the light source onto work areas where practical and avoid light spill onto habitat areas (such as mangroves and Clinton ash ponds) where practical.	Changed to expand on intent of commitment
C19.12	Establish a system for recording of opportunistic observation of marine megafauna (turtles, saltwater crocodiles, dugong and cetaceans) spotted during marine operations such as dredging, pile driving and marine transport including where these activities occur within the Calliope River.	New commitment
C19.13	Evaluate the use of bubble curtains for each method of piling, and deploy where they are demonstrated to be effective in aiding the rapid attenuation of underwater noise and deterring marine fauna from approaching, or remaining at, pile driving sites.	New commitment