17. ESTUARINE ECOLOGY (CALLIOPE RIVER)

This chapter describes the findings of the supplementary estuarine ecology (Calliope River) technical study undertaken to address changes made to the project description, to take account of additional information, and to respond to specific comments made in submissions on the Arrow LNG Plant EIS (Coffey Environments, 2012). It focuses on the impacts on estuarine ecology from the construction and operation of the mainland launch site (launch site 1), including impacts from the dredging of the bar at the mouth of the Calliope River.

The estuarine ecology (Calliope River) report was prepared by Coffey Environments (Appendix 10, Technical Study of Estuarine Ecology (Calliope River), to the Supplementary Report to the Arrow LNG Plant Environmental Impact Statement (SREIS)). The report includes information on coastal processes and hydrodynamics of the Calliope River contained in the supplementary report on coastal processes prepared by BMT WBM Pty Ltd (Appendix 7, Coastal Processes and Marine Water Quality Technical Study).

Information on other impacts to marine and estuarine ecology in Port Curtis and the Calliope River, including turbidity impacts from dredge plumes, are addressed in Chapter 15, Marine Ecology. Further information relating to sediment characterisation, marine water quality and coastal processes can be found in Chapter 12, Sediment Characterisation, Chapter 13, Marine Water Quality, and Chapter 14, Coastal Processes, respectively.

17.1 Studies and Assessments Completed for the EIS

This section provides an overview of the studies completed for the Arrow LNG Plant EIS and the relevant conclusions from those studies.

BMT WBM was engaged to conduct the coastal processes, marine water quality, hydrodynamics and legislation assessment for the EIS. Chapters 15 and 16 of the EIS outline the findings of this study; and the technical assessment is appended to the EIS as Appendix 8.

Coffey Environments prepared the marine and estuarine ecology assessment for the EIS, with input from Central Queensland University. The assessment is included as Appendix 12 of the EIS. Chapter 19 of the EIS presents the findings of this assessment.

17.1.1 Existing Environmental Values

The studies and assessments completed for the EIS described the marine and estuarine ecological values within and around Port Curtis and the Calliope River and assessed the potential impacts of the project using the significance method (sensitivity and magnitude).

The studies and assessments were informed by field sampling programs undertaken to gather information on the physical environment and habitats present within the Calliope River. Water, sediment and biological samples were collected during these field surveys. Five sites within the Calliope River were sampled, including in the vicinity of launch site 1 and within the proposed dredging footprint.

Hydrodynamic modelling was carried out to assess the impacts of the project on coastal processes and the Calliope River. This included model simulations for launch site 1 and the Calliope River after dredging.

Existing environmental values in the Calliope River encompass a diversity of physical environments and flora and fauna that reflect the high tidal range and the hydrodynamics of the area. Habitats include a benthic zone, reef and rock substrate and intertidal mudflats. Such flora as saltmarsh, mangroves and seagrass are present in the Calliope River, as well as such fauna as marine mammals (dugongs and cetaceans), marine reptiles (saltwater crocodiles, marine turtles and sea snakes), fish, plankton and nektonic and benthic macroinvertebrates. The area also supports significant commercial and recreational fishing activities, with the estuary acting as spawning habitat and nursery for commercially and recreationally important species.

17.1.2 Impact Assessment

The modelling studies concluded that project-related activities may result in impacts on coastal and estuarine processes of significance, including:

- Changes to the extreme low tide level in the Calliope River by up to 0.8 m during spring tides.
- Changes to currents in the Calliope River by up to 0.7 m/s during spring tides.
- Increased sediment transport and deposition at the mouth of the Calliope River.

The magnitude of the impact on water levels and currents in the Calliope River resulting from dredging was deemed to be very high, while the magnitude of the impact to sediment transport and shoreline processes was also deemed to be high, with both impacts being of moderate significance for the Calliope River.

Several direct impacts to the Calliope River ecology associated with the construction and operation of launch site 1 were identified in the EIS, including:

- Disturbance of 0.13 ha of reef habitat.
- Loss of 1.7 ha of wetlands identified as coastal or subcoastal floodplain tree swamps.
- Removal of up to 1.6 ha of estuarine salt flats and saltmarshes.
- Potential erosion and sediment generation from disturbed areas and boat wash or wave action.

The magnitude of all these impacts was deemed to be low to moderate with low significance.

Indirect impacts from increased levels of turbidity and sedimentation due to dredging of the Calliope River were identified for mangroves, benthic and intertidal mudflats, and reef and rock substrates. These impacts were classified as low magnitude with low significance to mangroves and to reef and rock substrates and as medium magnitude with moderate significance to benthic environments.

A number of commitments were developed to manage the impacts on coastal processes, marine water quality, sediments and marine and estuarine ecology relevant to the Calliope River. These commitments are listed in Table 17.1.

Table 17.1 Commitments: Marine and estuarine ecology (relevant to the Calliope River)

No.	Commitment
C11.11	Implement sediment and erosion control measures upslope of watercourses, wetlands and coastal areas or in areas with sodic soils to minimise increases in natural sediment discharge. Measures may include sediment traps, silt fencing, riprap, contour banks, detention dams, sediment ponds and vegetation and diversion berms.
C15.01	Stabilise the shoreline, where required, at the high tide level where marine infrastructure is installed.
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:

Table 17.1 Commitments: Marine and estuarine ecology (relevant to the Calliope River) (cont'd)

No.	Commitment
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.
C15.05	Implement management measures from the dredge management plan to address impacts from maintenance dredging.
C15.08	Only demolish the mainland launch site if another use is not identified.
C16.02	Obtain sediment samples from geotechnical drill cores to further characterise marine sediments disturbed during construction. Use the results to inform the development of the dredge management plan.
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.
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.
C19.08	Keep dredging activities within the identified dredge footprint area.

17.2 Study Purpose

The supplementary estuarine ecology (Calliope River) technical study addresses potential impacts on the ecology of the river from changes to the layout of launch site 1 and from the changes in extreme low-tide levels as a result of dredging the bar at the Calliope River mouth. The study takes into account additional information on the bathymetry and ecology of the river, and addresses issues raised in the submissions on the EIS.

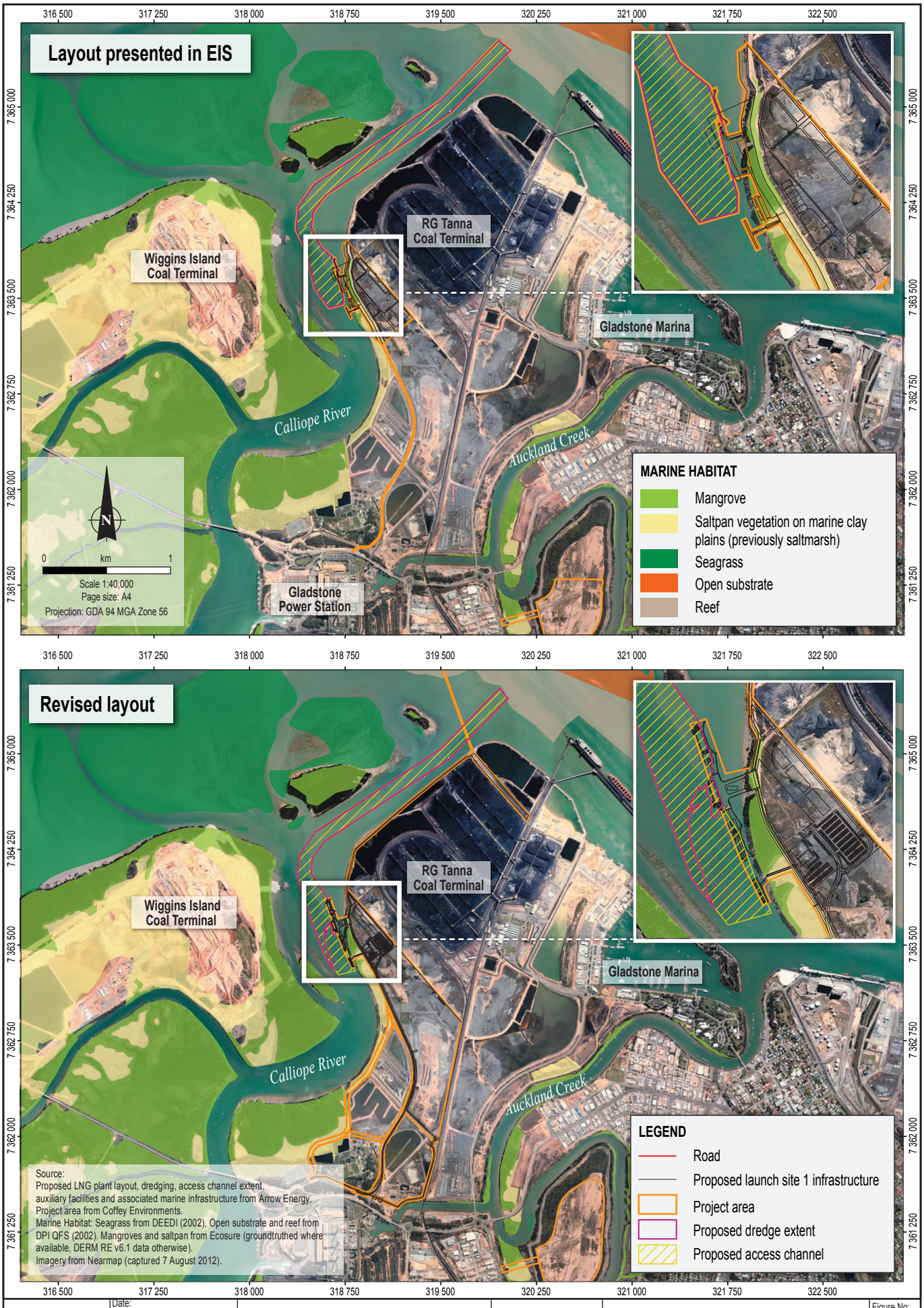
17.2.1 Project Description Changes

A number of changes have been made to the design of launch site 1 following the finalisation of the EIS. These changes include an additional linkspan berth, the enlargement of the material handling area, and the modification of the structure from a piled concrete deck to a sheet piled retaining structure (Figure 17.1). These changes will require the clearing of 2.01 ha of mangroves from alongside launch site 1 and an additional 0.03 ha of mangroves from the potential laydown and staging area. The impact of this clearance was not assessed in the studies completed for the EIS.

The dredging footprint in the Calliope River has reduced slightly although the maximum dredging volume has not changed (900,000 m^3).

17.2.2 Additional Information

The modelling presented in the EIS predicted a lowering in the extreme low tide levels in the river as a result of dredging the bar at the river mouth. The additional hydrodynamic modelling carried out by BMT WBM (Appendix 7) includes updated simulations of the overall reduction of the extreme low tide levels in the Calliope River as a result of the dredging. Additional bathymetric data obtained for the river was included in the model.



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Changes to mainland launch site (launch site 1)

Figure No: **17.1**

The updated model has provided more detailed information on changes in the frequency, duration and extent of exposure of the intertidal area following completion of dredging. The impacts of a reduction of extreme low tide levels and flow-on effects to the ecology of the river were not addressed in the EIS.

17.2.3 Submissions

Several submissions on the EIS raised issues relating to dredging in the Calliope River and impacts at launch site 1. The full details of these submissions can be seen in the issue register table in Part B, together with responses to specific issues raised.

17.3 Legislative Update

Legislation and policies relevant to estuarine ecology are described in the EIS and are unchanged. Since the EIS was finalised, the Queensland Government has released the Ecological Equivalence Methodology Guideline (DERM, 2011a), intended to inform requirements for ecological offsets under Queensland offsets policies.

17.4 Study Method

This section outlines the study method adopted by Coffey Environments for the supplementary estuarine ecology (Calliope River) technical study. The study method is described in detail in Appendix 10.

The method included a desktop component, a review of updated bathymetry, a review of hydrodynamic modelling information, a review of previous field survey results (included in Appendix 12 of the EIS) and a review of recent ecological survey results (Appendix 6, Marine Water Quality - Part B: Marine and Estuarine Ecology Report) to identify and assess potential impacts on the ecology of the river.

17.4.1 Desktop Review

The literature review focused on describing the current state of the Calliope River environment. Information was reviewed on the physiography, bathymetry, tidal regime, habitat types, and flora and fauna in the river.

17.4.2 Hydrodynamic Modelling

Information on predicted changes to the tidal regime in the Calliope River was provided by BMT WBM (Appendix 7). Model simulations were undertaken of pre and post-dredging conditions for a 12-month period at 10 survey sites along the Calliope River, covering a wide range of tidal conditions. Outputs from the simulations included changes in low tide levels at the 10 sites, predicted tidal amplitudes, number of low tides over the 12-month period, and percentage of time exposed of existing and additional intertidal river bed areas.

The additional exposed intertidal area was then estimated by subtracting the predicted intertidal area exposed at the extreme low tide level during pre-dredging conditions from the predicted intertidal area exposed at the extreme low tide level during post-dredging conditions. Model simulations and updated bathymetry data for the Calliope River were used to calculate this difference.

17.4.3 Impact Identification

Potential impacts were identified on the ecology of the Calliope River, including mangrove communities, fish and macroinvertebrate communities.

Pre- and post-dredging low tide levels derived from model simulations were examined to assess the impacts of dredging and the resulting modification of low tide levels to mangrove communities. The assessment included:

- Review of information on bed elevations that remain exposed for 70% of the time.
- Analysis of existing mangrove distribution from remote-sensing imagery.
- Review of relevant literature on mangrove and macroinvertebrate community resilience to exposure or inundation.

The assessment tested three hypotheses: the potential for an increase, a decrease or no change in the mangrove area.

Further information on fish assemblages in the river was collected during a field survey carried out in August 2012 by Central Queensland University (see Appendix 6). This survey supplemented information presented in the EIS (see Appendix 12 of the EIS).

Changes to estuarine habitats in the river may occur due to the lowering of extreme low tide levels. The fish and macroinvertebrate communities and species that are dependent on or associated with mangrove habitats and thus are likely to be affected were identified.

17.4.4 Significance Assessment

Assessment of the impact of changes in extreme low tide levels due to dredging in the Calliope River, as well as the impacts due to changes to the project description, was undertaken using the significance method (sensitivity and magnitude). This method is outlined in Chapter 19, Marine and Estuarine Ecology of the EIS.

17.5 Existing Environment

The Calliope River is located west of Gladstone in central Queensland and flows into the central area of Port Curtis. The river is 100 km long with a catchment area of approximately 2,255 km^2 and an estimated annual discharge of 153,000 megalitres. Bathymetry varies dramatically along the main channel of the Calliope River, with depths ranging from 2.5 to 17.5 m. There are three bars that are almost fully exposed at low tides along the river: one at the mouth, a second at 6.3 km upstream from the mouth, and a third at 7 km upstream from the mouth. Similarly, four deeper areas of between 10.5 and 17.5 m are located at 1.5 km, 3 km, 4.3km and 5.2 km upstream from the river mouth (see Figure 14.2). The estuary is tide-dominated, with large semidiurnal tides that extend up to 25 km upstream, although the tidal prism is significantly reduced by the presence of the bars. Tidal velocities in the main channel range from 0.4 m/s (upstream) to 1.6 m/s (mouth).

The natural landscape of the river has been modified, with approximately two-thirds native vegetation cleared in the river basin. The coastal plain around the Calliope River is characterised by wide stretches of marine muds and mangrove swamps, with the wetlands between Fishermans Landing and the Calliope River relatively undisturbed. Saltmarsh habitat occurs in the upper intertidal zone, with mangroves in the mid-intertidal zone and seagrass in the lower intertidal zone (see Figure 17.1). A wide diversity of marine- and estuarine-dependent species live in or use these habitats. A total of 124 species of benthic macroinvertebrates and 35 species of fish and nektonic macroinvertebrates have been recorded in the area around the Calliope River and Port Curtis. Marine megafauna, including marine turtles, dugongs, and cetaceans, have been observed around the Calliope River, feeding in and around the seagrass beds.

A more detailed description of the existing environment of the Calliope River is included in Appendix 10.

17.6 Study Findings

The effects of changes in tide levels were identified at 10 locations in the Calliope River, starting from the river mouth (point 1) to approximately 12.8 km upstream (point 10). The post-dredging effects predicted from model simulations are shown in Figure 14.5 and described below.

- An increase of 0.4 m in the overall tidal amplitude post-dredging near site 3, with the increase diminishing to approximately 0.1 m near site 9.
- A maximum drop of 0.5 m in the extreme low tide level (from site 3 to site 7) with the magnitude of the drop decreasing to 0.14 m near site 9 (7.8 km upstream). This represents a change from the 0.8 m drop in extreme low tide level estimated in modelling carried out for the EIS.
- Permanent inundation will occur at elevations 0.51 m below the current bed elevations near the river mouth (points 3 and 6) and at 0.15 m below the current bed elevations near point 9.
- A twelvefold increase in the frequency of exposure and a 1- to 1.5-hour increase in duration of exposure for bed elevations below -1.5 m AHD (equivalent to a less than 4% increase in exposure time on average).
- An increase of 30 ha of exposed intertidal area between points 1 and 10.

These changes will have flow-on effects on the intertidal zone ecology of the river.

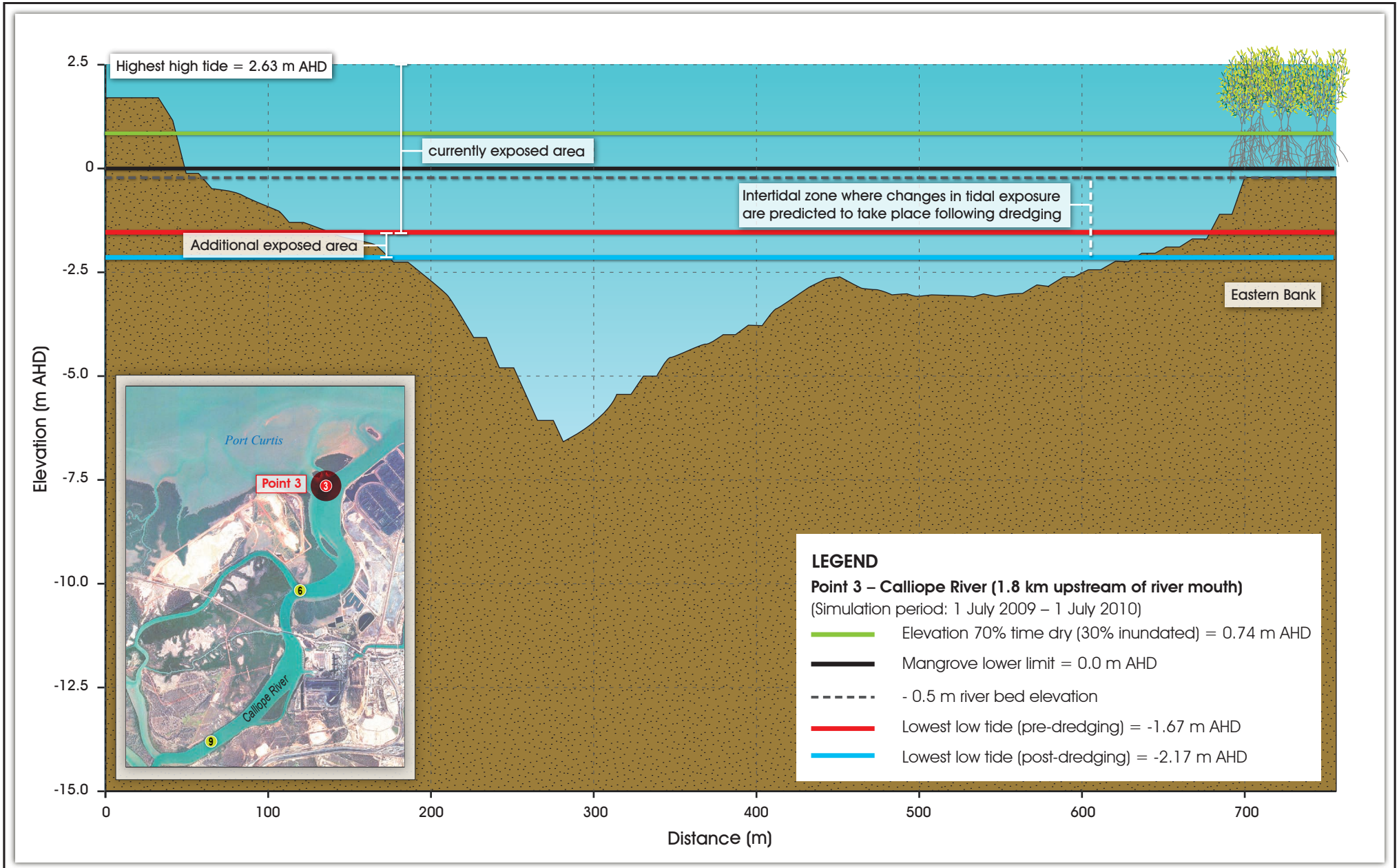
17.7 Validation and Assessment of Impacts

Direct and indirect impacts to the ecology of the Calliope River derived from dredging of the bar near the mouth and from changes to the layout of launch site 1 are described below.

17.7.1 Impacts to Mangrove and Associated Fauna from Dredging-derived Changes

Mangroves occur at the intertidal area between the highest astronomical tides and mean sea level and are incapable of surviving in areas that become inundated for more than 30% of the time (Hutchings & Saenger 1987; Mann, 2000). According to model simulations of the Calliope River, the mangroves' lowest boundary is located at an elevation of approximately 0.75 m AHD, i.e., the bed elevation that becomes inundated for 30% of the time, while the bed elevations affected by the drop in tide levels are below -0.5 m AHD (Figure 17.2). Consequently, changes in the duration of exposure and frequency of low tides per year are not expected to affect the mangroves in any way after dredging the bar near the mouth of the Calliope River.

The increase in time exposed at the lower bed elevations has the potential to affect the benthic habitats at those locations. No noticeable differences between intertidal and subtidal benthic communities were observed in studies carried out for the EIS (see Appendix 12 of the EIS) and the increase in frequency and duration of exposure was relatively small (equivalent to a less than 4% increase in exposure time on average). This change is not expected to have any measureable impacts on these communities in the river. Fish and other crustaceans may experience a small decrease in foraging opportunities that is unlikely to be measurable. However, this slight decrease in foraging opportunities for fish and crustaceans will be balanced by a slight increase in foraging opportunities for shorebirds.



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Cross-section at point 3 along the Calliope River showing the lowest low-tide levels and mangrove intertidal habitat riverward limits

Figure No: **17.2**

17.7.2 Impacts from Changes to Launch Site 1

Direct and indirect impacts to environmental values of the Calliope River derived from changes to the design and layout of launch site 1 are described below.

Mangroves

The direct impact from the overall removal of 5.78 ha of mangrove for the entire project was assessed in the EIS as a low magnitude impact with **minor** significance based on the small area of impact in absolute and percentage terms (less than 1% of the total mangrove area present in Port Curtis). Therefore, the removal of a smaller area of mangrove (2.03 ha) in the Calliope River was assessed as a low magnitude impact with no changes in the worst-case scenario. The magnitude and significance of this impact remains as assessed in the EIS.

Reef Habitats

The direct impact of the loss of approximately 0.14 ha of reef habitat outside the river mouth was assessed in the EIS as low with **minor** significance due to the small area of the impact in absolute and percentage terms. This area has been decreased to less than 0.01 ha and the magnitude and significance of the impact remain as assessed in the EIS.

17.8 Additional Management Measures

No additional management measures to those presented in the EIS are proposed to mitigate the expected changes in exposure times due to dredging the bar at the mouth of the Calliope River. Measures to mitigate the loss of 2.03 ha of mangrove from the construction of launch site 1, including any offsets required, are discussed in the marine ecology technical study (Appendix 8, Technical Study of Marine Ecology (Port Curtis) for the SRIES) and Chapter 15, Marine Ecology.

17.9 Conclusion

The EIS concluded that the direct impact to the Calliope River's ecology resulting from the project development was of low magnitude with minor significance for mangroves, the benthic zone and rock and reef substrates. Indirect impacts were deemed of low magnitude with minor significance for mangroves and for reef and rock substrate and of medium magnitude with moderate significance for the benthic zone. This original assessment was based on information on habitat loss through clearing and the indirect impacts of sediment plumes created from dredging. The clearing of an additional 2.03 ha of mangroves for the construction of launch site 1 does not change the worst-case scenario as presented in the EIS and the impacts remain as assessed in the EIS.

The potential impacts to estuarine ecology from the reduction in low tide levels from the dredging of the bar at the mouth of the river was not specifically assessed in the EIS. The updated hydrodynamic model considered changes in extreme low tide levels due to dredging, and subsequent review of previous and recent field survey results informed the assessment of potential impacts.

The intertidal area that mangroves inhabit is well above the region affected by the drop in the extreme low tide levels and will not be affected. The increase in the area and time of exposure will be small, and changes to intertidal communities are unlikely to be detectable.

17.10 Commitments Update

One measure to manage potential estuarine ecology impacts presented in the EIS has been revised and one deleted. One new commitment (relevant to estuarine ecology) has been added

as set out in Table 17.2. All other measures are unchanged and are included in Attachment 7, Commitments Update.

Table 17.2 Commitments update: estuarine ecology (Calliope River)

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 updated C17.02A
C17.02A	Develop an Environmental Offsets Operational Management Plan that addresses terrestrial and marine offset requirements, and provides details on offset options and opportunities, in consultation with relevant government stakeholders prior to commencement of construction that addresses terrestrial and marine offset requirements, and provides details on offset options and opportunities.	New to Marine and Estuarine Ecology. Commitment from terrestrial ecology updated to include marine offsets, government stakeholders and align with confirmed approach.