Port of Gladstone
Gatcombe and Golding Cutting
Channel Duplication Project

Environmental Impact Statement

Gladstone Ports Corporation
Growth, Prosperity, Community.

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21

Cumulative impact assessment

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21 Cumulative impact assessment

21.1 Chapter purpose

This chapter describes the cumulative impacts that apply to the Project, considering reasonably foreseeable 'other projects' and exogenous factors such as episodic flood events and climate change. A detailed Cumulative Impact Assessment (CIA) Technical Report providing details of the method, approach and results of the CIA is provided in Appendix P.

The CIA involved the following tasks:

- Assessment the cumulative impacts of the Project on sensitive environmental values, considering the influence of previous, current and reasonably foreseeable projects in the region
- Determining the degree to which cumulative impacts on sensitive environmental values will approach thresholds for environmental protection
- Assessment the potential for Project impacts to act cumulatively with other environmental disturbances, such as flood events and climate change
- Conducting a CIA in accordance with contemporary impact assessment approaches and in a manner consistent with the EIS ToR and EIS Guidelines
- Assessment the economic impacts of the Project on other industries and commercial operations in the Gladstone region.

21.2 Legislative and policy context

CIA is part of the process of environmental impact assessment and is focussed on considering the actual and potential effects on the environment of multiple activities or impacts. It considers the impact of activities on a range of environmental values, including receptors, receivers, assets or valued resources. Environmental impacts may combine geographically (due to their close proximity) or over time (as projects are completed consecutively), to cause a different outcome than would otherwise have been the case had a project been developed in isolation.

There are a variety of definitions or approaches to CIA, which are described in published guidelines, scientific literature and in approval conditions. In Australia, cumulative impacts are generally assessed in a manner consistent with one of the circumstances summarised in Table 21.1.

Table 21.1 Summary of cumulative impact assessment approaches commonly used in Australia

Approach	Description
Single project	The cumulative impacts of a single project on the existing environmental baseline, accounting for previous activities. For example, assessment of the effects of clearing vegetation, taking into account all previous clearing that has occurred in the region.
Multiple projects, single environmental value	The cumulative impacts of multiple projects are assessed for a given environmental value or aspect of the environment. For example, development of a water quality strategy for a catchment, considering all sources of pollution.
Multiple projects, all environmental values	The cumulative impacts of multiple projects are assessed for all environmental values. For example, this may occur as part of a strategic assessment for a region, or assessment of a project where several 'other projects' are also being developed nearby.

The approach of considering multiple projects and all environmental values is the broadest definition of CIA, and generally aligns with the requirements of environmental impact assessment. Harriman and Noble (2008) noted that such CIAs are generally completed through either Project-related environmental impact assessments (by proponents), or through strategic or regional assessments by government agencies across a broader scale (e.g. Strategic Assessments under Part 10 of the EPBC Act).

It should be noted that there is no specific methodology for CIA that has gained wide acceptance nationally, or internationally. Indeed, a standardised methodology would need to have sufficient flexibility to be adapted to the location, scale and circumstances of a particular project. In this context, a tailored methodology which addresses some generic criteria applicable to CIA is likely to be most successful.

There is growing recognition of the importance of CIA in managing the GBRWHA, which is subject to a variety of pressures across a vast geographic scale (GBRMPA 2014) and is of relevance to the Project due to its location. Activities such as agriculture, fishing, port development and urban development are all likely to act cumulatively on the values of the GBRWHA. The influence of other factors such as climate change and extreme weather events are known to be important in shaping the condition and trend of environmental values. This situation presents a challenge for CIA on the Great Barrier Reef, to consider all relevant and realistic matters pertinent to the Project, without the unrealistic expectation of considering everything.

An independent review of the Port of Gladstone (SEWPaC 2013) highlighted the need for the assessment and consideration of cumulative impacts as one of three key findings in the future management of industrial expansions within the GBRWHA. An emphasis was placed on the importance of considering the impacts of ‘other projects’ in addition to the natural impacts of severe episodic weather events on environmental receptors. Such recommendations have been incorporated into the approach adopted for this CIA.

21.3 Methodology

The cumulative impacts of the Project and 'other projects' on environmental values that are site-attached (e.g. seagrass, mangroves) and mobile over an extended geographic range (e.g. dugongs and shorebirds) were assessed (refer Table 21.2).

Table 21.2 Environmental values considered in the cumulative impact assessment

Port Curtis	
Seagrass	Influenced by water quality, light levels, direct disturbance of the sea floor and events within Port Curtis and its catchment
Mangroves	Affected by local activities such as clearing, sediment processes and contamination
Saltmarsh	Affected by local activities such as clearing, sediment processes and contamination
Inshore reefs	Influenced by water quality, sedimentation, direct disturbance of the sea floor and events within Port Curtis and its catchment
Soft bottom benthic habitats	Influenced by water quality, direct disturbance of the sea floor and events within Port Curtis and its catchment
Commercial and recreational fishery	Impacts are manifested at a local (Port Curtis) scale in response to environmental conditions such as habitat quality, water quality and sediment quality. Ecology varies among species.
Water quality	Important aspect of the environment which affects the resilience of other values. Highly responsive to disturbances from multiple projects or natural events such as floods.

Port Curtis	
Sediment quality	Important aspect of the environment which affects the resilience of other values. Highly responsive to disturbances from multiple projects or natural events such as floods.
Port Curtis, The Narrows and Port Alma, and extended geographic range	
Dugong	Individuals within the population are likely to move throughout the Port Curtis, The Narrows and Port Alma region
Australian humpback dolphin and Australian snub-fin dolphin	Australian humpback dolphins are likely to move throughout the Port Curtis, The Narrows and Port Alma region. The Australian snub-fin dolphin predominately utilises the Port Alma region.
Humpback whale	While Port Curtis does not provide essential habitat for whale species, individuals may move throughout the Port Curtis, The Narrows and Port Alma region in association with migrations. The waters off Port Curtis are known to support calving activities for the Humpback whale.
Water mouse	While individuals are relatively site attached, habitat occurs throughout the intertidal areas of Port Curtis, The Narrows and Port Alma region, and fragmentation or disturbance of habitat should be considered at this scale
Marine turtles (primarily Green turtles, Flatback turtles)	Flatback turtles will use the Port Curtis region for nesting and during the inter-nesting period. Green turtles will forage and occasionally nest in the region. Foraging Green turtles within Port Curtis will be relatively site-attached but will undergo breeding migrations outside of the region. Inter-nesting Flatback turtles may utilise Port Curtis. Loggerheads also nest occasionally in the region.
Conservation significant and migratory fish species (shark and ray species)	Individuals within the population are likely to move throughout the Port Curtis, The Narrows and Port Alma region
Shorebirds (resident and migratory)	Subject to significant pressures (hunting, habitat destruction, and disturbance from a range of sources, including feral or domestic animals) along their international migratory pathway, which should be considered in the context of Project-related impacts
OUV of the GBRWHA	Occurs at a larger scale than Port Curtis. Important that OUV is considered at a variety of scales and not just locally, particularly when assessing integrity. Values that contribute to the local expression of OUV are summarised in the Master Plan for the priority Port of Gladstone (DTMR 2018). They include marine water quality, marine turtles, seagrass, shorebirds and continental islands.

The reasonably foreseeable 'other projects' potentially contributing additional environmental risk to the Project were identified by reviewing proposed projects known publicly or advised by the Coordinator-General. The relevance of such projects for incorporation into the assessment was further assessed, using accepted practices for CIA. Speculative projects were excluded from further analysis, as were projects where insufficient information was available to make informed judgements on impacts, or where impacts were unlikely to be material.

The 'other projects' determined for inclusion in the CIA which are reasonably foreseeable to be under construction and/or have operational impacts that are not presently influencing the existing environment were:

- Arrow Bowen Pipeline – Bowen Basin to Gladstone pipeline
- Clinton Vessel Interaction project
- Pacificus Tourism Project
- Toolooa PDA
- Maintenance dredging within the Port of Gladstone (note that an additional 7% of maintenance dredging required for the Project's duplicated channels is assessed in this EIS). This 'other project' therefore comprises the remaining 93% of maintenance dredging activities which do not form part of the Project impact assessment in this EIS.

The location of these projects is shown in Figure 21.1.

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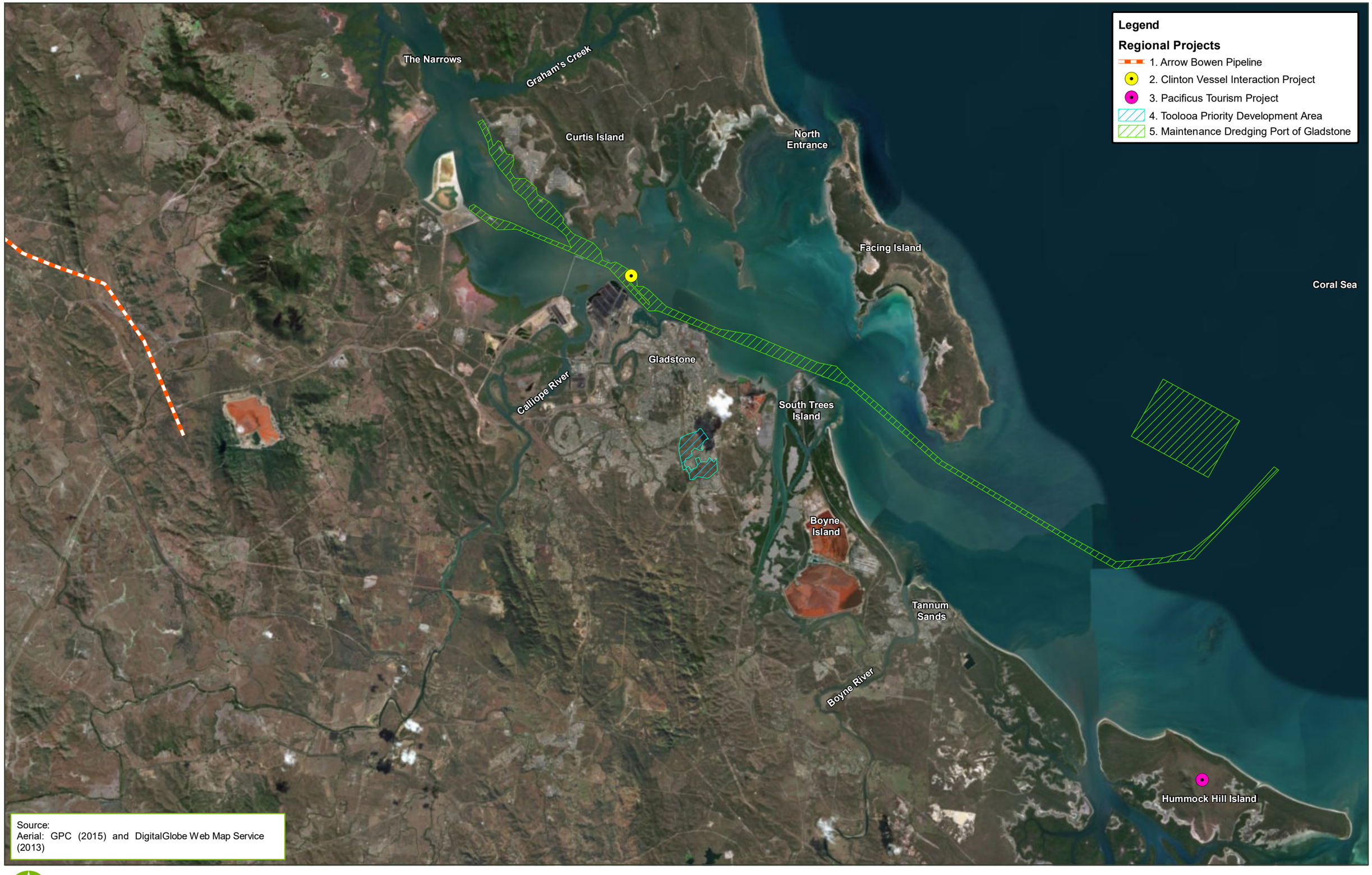

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Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 21.1: Other projects included in the CIA

Cumulative impacts were assessed through the consideration of environmental risk of multiple projects over varying spatial and temporal scales. Using a quantitative scoring methodology, the environmental risks from the Project alone and the additive effects of the 'other projects' were analysed. A qualitative assessment of the potential influence of exogenous factors such as severe weather events and climate change were also completed for each environmental value.

All potential environmental impacts predicted to result from the Project alone were collated using the results of the technical impact assessments and associated environmental risk assessments presented in this EIS. To establish a consistent and simplified framework for the comparative risk analysis, a suite of potential modes of impact was established (refer Table 21.3).

Table 21.3 Potential modes of impact used in cumulative impact assessment risk analysis

Potential mode of impact included in CIA	Types of potential impacts in included in the environmental impact assessment for the Project
Direct removal of habitat	■ Loss of seagrass habitat from smothering or being cut off from the marine environment ■ Loss of foraging habitat for shorebirds associated with the loss of soft sediments in intertidal environments
Secondary and indirect impacts	■ Loss of seedbanks for seagrass ■ Loss of foraging resources for Water mouse or shorebirds that are supported by benthic communities indirectly impacted by the Project (e.g. from sediment plumes), or from fragmentation and degradation of terrestrial habitat
Injury and mortality	■ Injury and death caused by contact with increased levels of waste and marine debris ■ Injury and death caused by entrapment and direct contact with construction machinery and/or vessel strike
Turbidity and sedimentation	■ Increased light attenuation reducing photosynthesis and growth rates of seagrass ■ Siltation of the foreshore and intertidal environments during the placement of core and armour material leading to loss or weakening of the intertidal marine plants and initiating local erosion ■ Burial of sessile benthic species and stress in filter feeding species. Change in community structure ■ Impairment of species' ability to detect predators/prey in favoured habitats (e.g. seagrass)
Mobilisation of contaminants	■ Degradation of soft sediment habitats and toxicity to benthic macroinvertebrates. Transfer of contamination to other aquatic ecosystem components. ■ Illness, injury and death to fish species ■ Adverse health effects through algal blooms as a result of eutrophication in waters through increased nutrient supply
Hydrodynamic and hydrological changes	■ Altered erosion and deposition rates impacting growth rates, causing mortality to seagrass ■ Changes to stormwater flooding associated with the placement of core and armour material altering water quality and causing damage to adjacent mangrove communities
Introduction of artificial reef habitat	■ Changes to fauna assemblages from introduction of additional rock habitat – 3D artificial habitat in intertidal and subtidal areas, in replacement of natural habitat

Potential mode of impact included in CIA	Types of potential impacts in included in the environmental impact assessment for the Project
Underwater or above ground noise	■ Mortality of marine fauna from injury associated with being located too close to piling activities ■ Alteration of behaviour, impairment to communication, trauma to hearing and to non-hearing tissue ■ Disruption to foraging and roosting behaviour of shorebirds leading to displacement
Additional light	■ Phototaxis responses in marine fish and invertebrates: alteration of susceptibility to predation or access to food resources ■ Alteration of foraging behaviour in turtles, disorientation of hatchlings, impact on nesting of female turtles
Spread pests or weeds	■ Displacement of benthic macroinvertebrates through competition with invasive species for resources ■ Displacement of shorebirds and Water mouse by predation, reduction in food resources and reduction in habitat quality from introduction of invasive species
Environmental incident	■ Loss of containment of oil, hazardous waste or other contaminants, smothering mangrove roots and suffocating trees
Bund wall seepage	■ Reduction and/or loss of marine fauna habitat values from changes to water quality

Once the environmental risk of the Project alone was evaluated for all potential modes of impact on all environmental values, the risk assessment was repeated considering the reasonably foreseeable 'other projects'. Residual risk ratings for 'other projects' were obtained and/or interpreted from the respective project's environmental assessment and EMP documentation and assigned against the standard suite of potential modes of impact for the CIA using a scoring methodology. Criteria were then used to determine whether and how the risk rating for the Project would change in light of the potential for cumulative risks from 'other projects'. Once the environmental risk of all projects was evaluated, the additional risk of exogenous factors, such as climate change and severe weather events were considered qualitatively.

This staged environmental risk assessment process provided an initial indication of the modes of impact that are most relevant for the Project and the environmental values that are the highest risk of being affected by Project-related activities. The environmental values for which cumulative impacts are most likely were also identified (those for which the environmental risk increases with the scale of the assessment). The purpose of both analyses was to provide insight into relative cumulative risks rather than to come to an absolute measure. The analyses also reflect the unlikely scenario that all risks from the 'other projects' would occur at the same time.

To provide insight into how the risks from 'other projects' may act cumulatively over time, their scheduling was mapped over the project's anticipated implementation period. The broad analysis undertaken does not distinguish where in the Port or wider Gladstone region, cumulative risks are likely to be significant. Additional analysis examined how these cumulative risks may be spatially distributed. Further details on the methodology applied to the assessment of cumulative impact is provided in Appendix P.

21.4 Assessment of cumulative environmental risk

21.4.1 Influence of 'other projects'

Risk scores for all environmental values from 'other projects' are shown in Table 21.4. The Clinton Vessel Interaction project, and maintenance dredging within the Port of Gladstone contribute most of the cumulative environmental risk to the values under consideration.

Table 21.4 Risk scores to all values from 'other projects'

'Other project'	Additional cumulative risk score across all values
Arrow Bowen Pipeline Project	5
Clinton Vessel Interaction project	**35**
Pacificus Tourism Facility	24
Toolooa Priority Development Area	10
Maintenance dredging within the Port	**58**

Risk scores for 'other projects' were not sufficient to cause a Project risk to increase for any mode of impact to an environmental value, when assessed against the criteria established (provided in Appendix P). Risk scores that came closest to increasing cumulative risks, compared with the Project alone, are:

- Mobilisation of contaminants on soft bottom benthic and seagrass habitats
- Turbidity and sedimentation on seagrass habitats
- Underwater noise impacting on marine turtles, dugong and/or dolphins.

Risk scores for 'other projects' that add some additional risk for a mode of impact to an environmental value (but remaining well below the criteria to alter the Project risk rating) include:

- Injury and mortality to marine turtles, dugong and/or dolphins
- Mobilisation of contaminants to marine turtles, dugong, dolphins, inshore reef, saltmarsh and/or mangrove habitat
- Direct removal of soft bottom benthic habitat
- Secondary or indirect impacts to shorebirds
- Underwater noise impacting on humpback whales and conservation significant fish
- Turbidity and sedimentation on soft bottom benthic, inshore reef, saltmarsh and/or mangrove habitat
- Spread of pests to soft bottom benthic habitat or change in habitat type to rock
- Additional light on habitat for marine turtles.

There was nil to negligible difference between the Project's environmental risk alone and cumulative environmental risk for the following key values and modes of impact:

- Direct removal of habitat for marine turtle, shorebirds, Water mouse, dugong, dolphins, Humpback whale, conservation significant fish, seagrass and fisheries
- Secondary or indirect impacts to Water mouse and seagrass
- Injury and mortality on shorebirds, Water mouse, Humpback whale, conservation significant fish, fisheries
- Turbidity and sedimentation on the habitat for marine turtles, shorebirds, Water mouse, dugong, dolphins, Humpback whales and conservation significant fish
- Mobilisation of contaminants on the habitat for shorebirds, Water mouse, Humpback whale, conservation significant fish and/or fisheries
- Hydrodynamic and hydrological changes on habitat for shorebirds, Water mouse, seagrass, saltmarsh and mangroves
- Change of habitat type to rock for shorebirds, Water mouse, saltmarsh and mangroves
- Addition noise on habitat for shorebirds, Water mouse, fish and/or fisheries
- Additional light on habitat for Water mouse

- Spread of pests or weeds on habitat for shorebirds, Water mouse saltmarsh and mangroves
- Bund wall incident releasing turbid water on the habitat of Water mouse.

In summary, the 'other projects' do not act cumulatively to increase the risk for any mode of impact for any of the environmental values, when assessed against the criteria. Water quality modes of impact to seagrass and soft bottom benthic habitats, and general disturbance of habitat for dugongs, dolphins and turtles were those impacts closest to increasing risks from the Project alone.

21.4.2 Environmental values

The impact assessment identified variable levels of risk for environmental values (refer Chapter 9 (nature conservation)). The Project alone presents the highest risks to values that are site-attached and dependent on water quality (e.g. seagrass) and mobile species that are vulnerable to disturbance (e.g. shorebirds, marine turtles, dugongs and dolphins). Values for which environmental risk is low are those that will be subject to minimal disturbance or are widespread throughout the region and/or are known to be resilient to change (e.g. mangroves, saltmarsh and benthic habitats).

The cumulative risk scores for 'other projects' in respect of the key values are summarised in Table 21.5 and where relevant, the potential influence of exogenous factors is noted. Raw scores are provided in Appendix P. Scores were highest for seagrass, inshore reefs, soft bottom benthic habitats, dugong, dolphin and marine turtles, primarily resulting from sensitivity to reduced water quality and sedimentation. This indicates that these environmental values are those at greatest risk from the cumulative impacts of ‘other projects’.

Table 21.5 Cumulative risk scores from 'other projects' for environmental values

Environmental value	Additional cumulative risk score from 'other projects'	Key contributors to cumulative environmental risk
Seagrass	12	Decreased water quality and increased sedimentation. Exogenous factors such as floods.
Mangroves	6	Decreased water quality, increased sedimentation and hydrological changes. Exogenous factors such as floods and climate change.
Saltmarsh	6	Decreased water quality, increased sedimentation and hydrological changes
Inshore reefs	12	Decreased water quality, increased sedimentation and introduction of pests. Exogenous factors such as floods and climate change.
Soft bottom benthic habitats	15	Direct removal of habitat, decreased water quality, increased sedimentation and introduction of pests
Fisheries (recreational and commercial)	3	Direct removal of fisheries habitat and decrease in habitat suitability as a result of decreased water quality
Dugongs	16	Decreased water quality (dependence on seagrass), injury and mortality, and underwater noise. Exogenous factors such as floods
Dolphins	16	Loss of inshore foraging habitat, decreased water quality, injury and mortality, and underwater noise
Humpback whales	6	Underwater noise
Water mouse	7	Direct loss and fragmentation of habitat
Marine turtles	18	Decreased water quality (dependence on seagrass), injury and mortality, underwater noise, lighting, interaction with vessels and increased disturbance to nesting and hatching success. Exogenous factors such as floods and climate change.
Conservation significant fish	8	Loss of inshore habitat and underwater noise

Environmental value	Additional cumulative risk score from 'other projects'	Key contributors to cumulative environmental risk
Shorebirds	7	Sensitivity to increased disturbance (noise and light), injury and mortality and reduction in food resources. Sensitivity to exogenous factors such as climate change and disruption to ecological requirements in migratory 'fly ways'.

When the cumulative risk scores from 'other projects' are considered in addition to those from the Project alone, the distribution of risk across the environmental values remains broadly similar to that from the Project alone (refer Table 21.6). The highest cumulative risks scores from 'other projects' (refer Table 21.6) largely fall on environmental values subject to moderate risk from the Project alone. Shorebirds, which incur the highest Project risk score, and marine turtles are subject to varying degrees of additional cumulative risk from 'other projects', but remain as the environmental value with the highest risk score when all risks are considered.

The overall effect is that while the risks to shorebirds are significantly higher compared with other values for the Project alone, when the additive risks of 'other projects' are considered, the risks to seagrass, dugongs, dolphins, and marine turtles are similar (although lower than the risk to shorebirds). Most of this additional risk comes from the Clinton Vessel Interaction project and maintenance dredging for the Port (refer Table 21.4), the 'other projects' with activities located within the marine environment. There is also potential for indirect impacts from the Pacificus Tourism Facility (e.g. lighting and recreational use of beaches) to affect turtles and shorebirds in a manner that is cumulative with impacts from the Project.

Table 21.6 Effect of cumulative environmental risk scores from 'other projects' on Project risks for key environmental values

Cumulative risk[3]	Seagrass	Mangroves	Saltmarsh	Inshore reefs	Benthic habitats	Fish (recreation and commercial)	Dugongs	Dolphins	Humpback whales	Water mouse	Marine turtles	Conservation significant fish	Shorebirds
Project alone[1]	16		6	1	7	7	12	12	9	18	14	8	25
Project plus 'other projects'[2]	28	204	12	13	22	10	28	28	15	25	32	16	32

Table notes:

1 Project alone: <11 Low (green), 11-20 Medium (orange) and 21+ High (red)
2 Project plus 'other projects': <20 Low (green), 20-29 Medium (orange), 30+ High (red)< 20 Low, 20 to 29 Medium, 30+ High
3 The risk rating criteria in this table are derived to assist in categorising and distinguishing the difference between raw scores, and are not linked to the risk categories in Appendix B of Appendix P

21.4.3 Cumulative risk over time

The Project has the potential to occur over a period of approximately 10 years, however not continuous during this period. The 'other projects' acting cumulatively over this period will occur at different timeframes within this period. The indicative timing of 'other projects' is shown in Figure 21.2, with regard to the anticipated Project period.

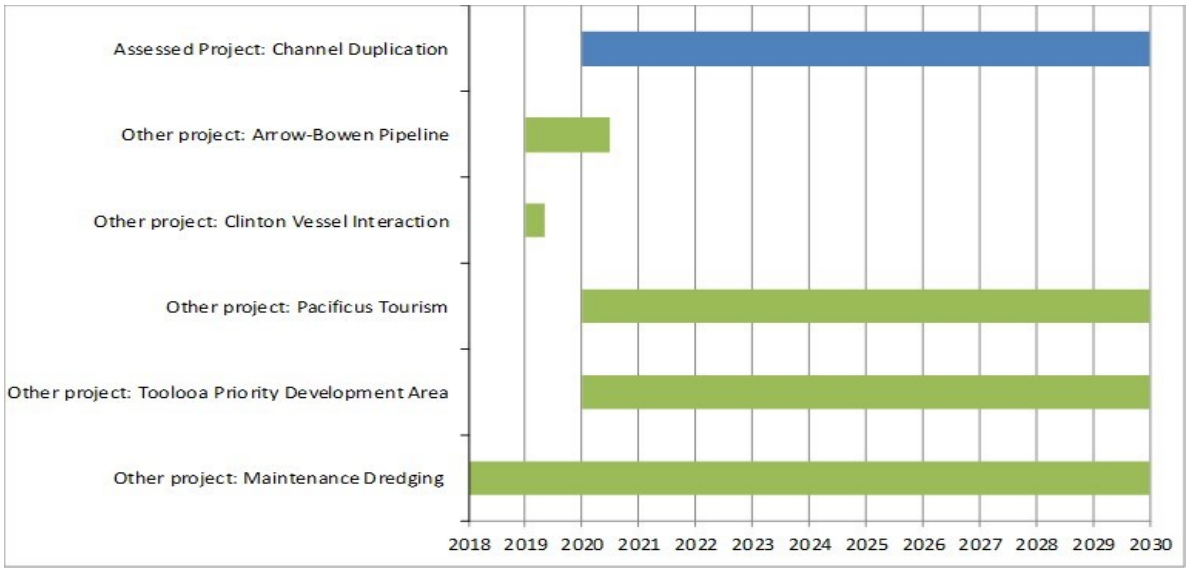

Figure 21.2 Timing of the 'assessed' and 'other projects'

The Clinton Vessel Interaction project and maintenance dredging for the Port of Gladstone contribute the most cumulative risk, due to their presence within the marine environment. However, the former is likely to be completed in 2019, before commencement of the Project. Maintenance dredging, while scheduled over the 10 year period of Project implementation, will occur intermittently. GPC usually completes a maintenance dredging campaign annually between November and February, with a dredger potentially returning mid-year to complete a minor campaign, subject to requirements and scheduling (GPC 2012).

21.4.4 Spatial distribution of impacts from multiple projects

Aspects of the Project are located across an area of approximately 80km^2, from the southern entrance to The Narrows (in the north) to the southern entrance channel to the Port (in the south). Activities in the western third of the Project area include the establishment of the WBE reclamation area and BUF, initial dredging for the barge access channel and the placement and beneficial reuse of dredged material in the WB and WBE reclamation areas. In the central part of Port Curtis, works are limited to barges transporting dredged material to the BUF and the removal of navigation aids. In the eastern third of the Project area, the installation of navigational aids and dredging of the Gatcombe and Golding Cutting bypass channels will occur.

The distribution of the five 'other projects' under consideration is summarised in Table 21.7.

Table 21.7 Location of 'other projects' in relation to the Project

Project	Distance from Project	Areas with potential to be affected
Arrow Bowen Pipeline	~10km from the WBE reclamation area	Negligible effects on coastal areas. Potential indirect impacts from water and sediment runoff.
Clinton Vessel Interaction	~4km from initial dredging for the barge access channel	Temporary increase in suspended sediment and disturbance in central part of Port Curtis
Pacificus Tourism	~6km from the channel duplication dredging, located to the southeast on Hummock Hill Island	Eastern sections of Port Curtis and areas further south. Increased disturbance from recreational visitation, minor changes to water quality and habitat fragmentation.
Toolooa PDA	~8km west of the channel duplication dredging, located away from the coast in a suburb of Gladstone	Central and eastern sections of Port Curtis. Incremental decline in water quality from urbanisation of the catchment
Maintenance dredging of the Port	Dredging and material placement activities to occur in similar areas of Port Curtis as Project activities	All parts of Port Curtis. Periodic decline in water quality and seagrass health from the suspension of sediments. Some disturbance to marine fauna.

The Clinton Vessel Interaction project and the annual maintenance dredging of the Port are the two projects with the greatest potential for spatial overlap in the areas to be impacted by the Project. Both are dredging projects with similar potential modes of impact to the Project. The Clinton Vessel Interaction project is likely to be completed several years before the commencement of dredging for the Project. However, the annual maintenance dredging is likely to be completed at a similar time as the Project, as this activity occurs each year.

The remaining four projects are located on land and have the potential for indirect or facilitated cumulative impacts. This may occur through fragmentation of wildlife habitat at a regional scale, increased disturbance to a population and/or its habitat (e.g. marine turtles or shorebirds), or through declines in water quality from runoff. Of these, the Pacificus Tourism project occurs in closest proximity to the Project activities and has the greatest potential for disturbance of sensitive receptors during construction. The Arrow Bowen Pipeline is located more than 10km from the coast and is unlikely to contribute cumulative risks. Increased visitation arising from the Pacificus Tourism project after construction, and increased urbanisation from the Toolooa Priority Development Area following the completion of construction are also relevant.

21.4.5 Exogenous factors

21.4.5.1 Flood events

A major flood event occurred in the Calliope and Boyne Rivers of the Gladstone region in December 2010 and January 2011, with a range of impacts on the estuarine environment of Port Curtis. The Awoonga Dam overflowed on 12 December 2010 for the first time in 14 years, with water continuing to flow over its spillway for a period of seven months. The event resulted in decreased water quality within Port Curtis, with high turbidity and suspended sediment concentrations.

In the months that followed, a temporary reduction of seagrass habitats and an increase in strandings of marine wildlife occurred, including turtles and dugong.

The flood event of 2011 illustrates the potential vulnerability of estuarine ecosystems such as Port Curtis during times of stress caused by climatic events. During such times, there is a heightened potential for cumulative impacts as the ecosystem is likely to be less resilient to the influence of anthropogenic activities such as dredging. In the years that followed the 2010-11 flood event, a recovery of the ecosystem was observed, with seagrass returning to areas previously impacted, marine animal strandings returning to normal (low) levels and the health status of marine turtles recovering. Such processes are part of the natural cycle of impact and recovery from severe weather events such as cyclone and flood.

Additional impacts from the Project, if carried out during a time of exogenous stress such as a flood, are difficult to predict in advance. However, they are likely to include a reduced tolerance of sensitive habitats such as seagrass and coral communities to respond to Project-related changes in environmental conditions such as increased suspended sediment concentrations and deposition. This in turn may affect marine fauna that depend on such habitats, such as turtles, dugong and fish. Such factors will be considered in the development of management plans for the Project dredging, with the timing and nature of Project activities reviewed, should a major flood or significant exogenous event occur at the same time as the Project.

21.4.5.2 Climate change

One of the most significant risks to the GBRWHA is climate change. Increasing sea surface temperatures and acidification of the ocean are expected to have impacts on coral reef ecosystems. In recent years, severe bleaching events have been recorded in response to warming sea surface temperatures. Such events have the potential to kill corals and their associated reef communities or leave them vulnerable to stresses from other factors, such as anthropogenic activities. The inshore coral reefs of the Great Barrier Reef, have been noted to be in significant decline over the past few decades, due to activities primarily within the Great Barrier Reef catchment and declines in water quality along the Great Barrier Reef coast.

Climate change is recognised as a key system-wide threat to the Great Barrier Reef, and widespread coral bleaching is known to be a major consequence of increased sea surface temperatures. Additional levels of environmental risk have the potential to occur, when bleaching events coincide with dredging programs. Numerous dredging campaigns have been undertaken across the world during coral bleaching events, with varying consequences (e.g. Miami Harbour Phase III Federal Channel Expansion; Barrow Island, Pluto and Wheatstone projects in Western Australia and the Nelly Bay Harbour Development on the Great Barrier Reef). Recent experimental research has also indicated that bleached corals have more difficulty clearing themselves of sediments (Bessell-Browne et al. 2017), thereby providing a clear evidence pathway for cumulative impacts of combined bleaching and dredging events.

Based on the above, there is clearly increased risk for inshore coral communities within and around the Project area if a coral bleaching event coincides with the Project. Additional impacts are most likely to be associated with a decreased tolerance from corals of smothering by sediments, and therefore risks are highest to corals inhabiting areas where deposition rates are the highest.

Coral bleaching events can be predicted with some certainty at a regional scale, by monitoring sea surface temperatures. Whether and how events may manifest at a local level is less clear. However, having mechanisms to identify coral bleaching events (predictive and in situ) along with adaptive management mechanism to address potential risks, will be a component of dredging management plans to address the potential for cumulative effects. If such an event occurs within the Port of Gladstone, the Project will assess the need to amend the turbidity trigger values contained in the Environmental Monitoring Procedure.

21.5 Cumulative impact to key environmental values

This section provides a summary outcome on the cumulative impact of multiple projects on key environmental values of Port Curtis, noting that the effect of 'other projects' in combination with the Project is not sufficient to increase the rated risks for the Project alone for any mode of impact. Additional detail is provided in Appendix P. Values that were identified as medium or high in Table 21.6 are discussed in further detail in the sections below, ordered from highest to lowest risk.

21.5.1 Shorebirds

Migratory shorebirds show fidelity to their roosting and foraging sites and prefer to roost close to foraging areas. This fidelity may adversely impact upon survival rates when the habitat is permanently lost or altered. Roosting sites have been identified near the WBE reclamation area, and establishment of Project infrastructure may alter roosting behaviour, due to the loss of foraging habitat. Approximately 1.18% of the total area of potential shorebird habitat within the Port Curtis region is expected to be lost due to the establishment of the WBE reclamation area. The environmental risk associate with this is assessed as very high in the Project EIS.

Direct injury or mortality caused by the establishment of the WBE reclamation area is unlikely to affect migratory shorebirds to the extent that numbers or species populations decline or are significantly impacted. The generation of noise, vibration and dust during the Project has the potential to cause disturbance to foraging, roosting and migratory behaviour. The risk to critically endangered or endangered shorebird species under the EPBC Act was assessed as high to very high, and medium to high for vulnerable and/or migratory species.

Of the 'other projects' under consideration for cumulative impacts, there will be minimal direct disturbance of shorebird habitat. The Toolooa PDA is located approximately 2km from wetland habitats at the entrance to the Boyne River, which are likely to be utilised by shorebirds as foraging and roosting areas. The Pacificus Tourism project will result in disturbance of a small coastal area for construction of a bridge. There will also be increased visitation to the region, which may in turn cause increased disturbance to shorebirds along coastal foreshores. However, the additional affects from these projects are considered to be minor. All of the remaining 'other projects', are located a significant distance from shorebird habitat to avoid impacts and are in keeping with the current environmental setting of the Gladstone region.

Shorebirds are relatively tolerant of exogenous factors that may impact on the local environment of Port Curtis, due to the types of habitats they utilise and ability to move to alternative areas. While they may be vulnerable to significant events such as cyclones, their ability to migrate vast distances in the event of a temporary declines in habitat values makes them more resilient than other species, particularly those dependent on seagrass for food (e.g. turtles and dugong). However, movements based on temporary impacts from projects also have the potential to reduce the migration and breeding success of shorebirds, through the expenditure of additional energy reserves.

The significant residual adverse impact assessment concluded that the establishment of the WBE reclamation area has the potential to result in a significant residual adverse impact on shorebirds in the area.

While shorebirds will be subject to the highest environmental risks of any value in the Port Curtis region from the Project alone, there will be negligible increase in this risk from 'other projects' and exogenous factors. Therefore, the potential for cumulative impacts is low.

The highest rated cumulative risk for a mode of impact to shorebirds (direct disturbance of habitat) is assessed to be very high, the same as for the Project alone.

21.5.2 Marine turtles

Of the six species of marine turtle with the potential to occur within the Port Curtis region, the Green turtle and Flatback turtle are most common. Foraging Green turtles live within the sheltered environments of Port Curtis, feeding on a range of food sources, including seagrasses, algae and mangrove fruits. Flatback turtles nest on the beaches of Curtis Island and Facing Island. Flatback turtles move into Port Curtis during the inter-nesting period, the approximate two week period between laying successive clutches of eggs. Once they complete nesting, Flatback turtles return to their foraging grounds, which may be up to 1,000km away.

Hawksbill turtles, Olive ridley turtles and Loggerhead turtles have a lower abundance in Port Curtis, but may be present in small numbers from time to time. The Leatherback turtle has a low likelihood of occurrence within the Project area but may occur very occasionally.

The assessment of potential impacts of the Project on marine turtles is therefore focussed primarily on foraging Green turtles, and Flatback turtles during the inter-nesting period (which occurs from October to January each year).

The impact assessment found that the Project will not have a significant residual adverse impact on marine turtle species. The area of seagrass and inshore habitat to be disturbed during the Project is relatively small, with indirect impacts likely to be short term. Potential indirect Project impacts will not have a significant impact on the marine turtle life cycle.

Marine turtles have a higher vulnerability to cumulative impacts than some other environmental values, due to their exposure to a multitude of pressures and stressors across their life cycle within the Great Barrier Reef region and beyond. Most marine turtles utilising Port Curtis will be at risk of anthropogenic impacts across various aspects of their life cycle. This makes the assessment of cumulative impacts difficult.

Of the 'other projects' under consideration for cumulative impacts, the Pacificus Tourism project, Clinton Vessel Interaction project, and annual maintenance dredging of the Port are most relevant for impacts on marine turtles. These projects can be expected to result in:

- Disturbance from increased visitation and recreational boat use in the area
- An increase in artificial lighting and the night time sky glow of the Gladstone region
- Short term declines in water quality and impacts to seagrass from dredging plumes
- Disturbance from the temporary use of dredging plant, increasing the risk of boat strike, and disturbance to habitat.

Dredging techniques generally result in a low interaction rate between marine turtles and dredging plant. The noise and vibration and general disturbance to habitat is temporary. Each 'other project' will have its own environmental management and monitoring regime to mitigate the risk of impacts to key habitat values such as seagrass. Common approaches for dredging projects include the application of turbidity or light trigger values, which if exceeded, result in a change to the dredging activities. The timing of the 'other projects' will most likely reduce the potential for cumulative impacts. The Clinton Vessel Interaction project is due to be completed in 2019, prior to the commencement of the Project. This dredging project and the annual maintenance dredging will be undertaken by GPC (the same proponent as the Project), providing opportunity to manage cumulative impacts.

Marine turtles are also vulnerable to the influence of exogenous factors that affect the health of their habitat. In particular, major flood events, such as occurred in 2011 can be expected to result in a reduction of seagrass and potentially result in an increase in strandings. Studies have shown that the recovery of health indicators in Green turtles following the flood conditions generally takes years (e.g. Flint 2015). There is a medium to high potential for cumulative impacts, should the Project be completed at a similar time to natural events such as floods. If a similar event was to occur during the dredging campaign, there will be careful monitoring of the environmental conditions and new mitigation measures will be introduced, if necessary, to reduce environmental risk.

The highest rated cumulative environmental risk for a mode of impact to marine turtles is assessed to be very high, the same as for the Project alone.

21.5.3 Dugong

Dugongs are protected as a migratory species under the EPBC Act and listed as vulnerable under the NC Act. A small population of dugongs considered to be regionally-significant to southern Queensland is known to utilise the Port, and areas immediately adjacent, to forage on seagrass which forms a key part of their diet. Isolated patches of seagrass have been identified within the WBE reclamation area, accounting for approximately 3.8% of coastal seagrass mapped in Port Curtis. The removal of these seagrass meadows as part of the establishment of the WBE reclamation area will result in the permanent and irreversible loss of dugong habitat and may disrupt foraging ability.

Noise and vibration caused by the removal and installation of navigational aids are also likely to disrupt foraging temporarily, with a risk rating assessed as medium. Dugongs use sensitive bristles on their upper lip to detect seagrass rather than relying on their poor eyesight. Therefore, it is unlikely that an increase in sedimentation caused by dredging will directly affect foraging ability. However, seagrass meadows are particularly susceptible to changes in water quality, and may decline as a result of increased turbidity, leading to an indirect impact on dugongs.

A medium risk rating is associated with an increase in waste materials entering the marine environment (i.e. ingestion or entanglement in marine debris), while vessel strike, direct contact with construction plant or entrapment in reclamation areas has been assessed as low to medium. The significant residual adverse impact assessment concluded that the establishment of the WBE reclamation area has the potential to result in a significant residual adverse impact on dugong habitat in the area.

Of the 'other projects' under consideration for cumulative impacts, the Pacificus Tourism project, Clinton Vessel Interaction project, and annual maintenance dredging of the Port are most relevant for impacts on dugong. These projects can be expected to result in:

- Disturbance from increased visitation and recreational boat use in the area
- Short term declines in water quality and impacts to seagrass from dredging plumes
- Disturbance from the temporary use of dredging plant, increasing the risk of boat strike, and disturbance to habitat.

Like marine turtles, dugongs are vulnerable to the influence of exogenous factors that affect the health of their habitat. Major flood events, such as that which occurred in 2011, can be expected to result in a reduction of seagrass and facilitate in a potential temporary increase in dugong strandings. There is a medium potential for cumulative impacts, should the Project be completed at a similar time as natural episodic events such as a flood.

The highest rated cumulative environmental risk for a mode of impact to dugongs is assessed to be very high, the same as for the Project alone.

21.5.4 Dolphins

The Australian humpback dolphin is known to utilise waters surrounding the channel duplication area to forage for food (a range of fish species and crustaceans). The permanent loss of benthic substrate at the channel duplication area through dredging activities has a high risk rating and the potential to directly impact an important area of habitat for this species. Establishment of the WBE reclamation area, and associated loss of habitat is almost certain to impact these the species, with a very high risk rating. The Australian snubfin dolphin occurs at Port Alma, further away from Project activities.

Dolphins may be affected by indirect impacts of the Project through changes in water quality, underwater noise and vibration, and the introduction of invasive species and disease. An increase in waste materials entering the marine environment (i.e. ingestion or entanglement in marine debris), while vessel strike, direct contact with construction plant or entrapment in reclamation areas are also potential impacts, assessed as low to medium risk in the Project EIS.

The significant residual adverse impact assessment concludes that the Project activities at the WBE reclamation area are unlikely to have a significant residual adverse impact on inshore dolphin species in the area.

Of the 'other projects' under consideration for cumulative impacts, the Pacificus Tourism project, Clinton Vessel Interaction project, and annual maintenance dredging of the Port are most relevant for impacts on inshore dolphins. These projects can be expected to result in:

- Disturbance from increased visitation and recreational boat use in the area
- Short term declines in water quality and impacts to habitat from dredging plumes
- Disturbance from the temporary use of dredging plant, increasing the risk of boat strike, and disturbance to habitat.

Exogenous factors such as flooding and cyclones may affect inshore dolphins, although they are likely to have lower sensitivity to such events than marine turtles and dugong. Overall, the potential for cumulative impacts is assessed to be low to medium.

The highest rated cumulative environmental risk for a mode of impact to dolphins (direct loss of habitat) is assessed to be very high, the same as for the Project alone.

21.5.5 Seagrass

Seagrass is a key ecological value within Port Curtis, providing habitat, shelter and food resources for a variety of ecologically-significant marine species (i.e. dugong, dolphins and fish). During construction of the WBE reclamation area, suspended sediment will smother seagrass, resulting in the direct loss of coastal seagrass habitat, irreversibly impacting on seagrass meadows within the WBE reclamation area. Approximately 3.8% of coastal seagrass mapped in Port Curtis is almost certain to be impacted by Project activities.

Secondary impacts caused by the construction of the WBE reclamation area are of medium risk. Permanent loss of viable seagrass seeds in the WBE reclamation area may impact on the capacity for surrounding seagrass meadows in Port Curtis to recover from future losses. A short term reduction in water quality during the establishment of the WBE reclamation area, affecting seagrass through the release of sediment laden runoff and/or contaminants will be generally restricted to a contained area.

Dredging activities leading to the permanent loss or alteration of benthic substrate at the areas to be dredged are of low risk to coastal seagrass meadows and medium risk to deep water seagrass meadows. A reduction in benthic light due to elevated turbidity caused by dredging will reduce the ability of seagrass to photosynthesise, resulting in a medium risk to both coastal and deep water seagrass habitats.

The significant residual adverse impact assessment concluded that the establishment of the WBE reclamation area will result in a significant residual adverse impact on seagrass.

Of the ‘other projects’ under consideration for cumulative impacts, the Clinton Vessel Interaction project and annual maintenance dredging of the Port are most relevant for impacts on seagrass, causing short term declines in water quality and impacts from dredging plumes. There is potential for cumulative impacts, depending on the timing of dredging activities and the ability of seagrass to recover from impacts caused by the Project.

Seagrass is vulnerable to exogenous factors such as major floods or cyclones due to sediment laden runoff and/or contaminants from upstream, and turbidity causing the reduction in benthic light and smothering. The potential for cumulative impacts from ‘other projects’ and exogenous factors will be carefully considered in management plans developed for the Project. There is a medium to high potential for cumulative impacts, should the Project be completed at a similar time to such activities or natural events.

The highest rated cumulative environmental risk for a mode of impact to seagrass (direct loss) is assessed to be very high, the same as for the Project alone.

21.5.6 Water mouse

The Water mouse is a Vulnerable species under the EPBC Act and the NC Act. The Project EIS assessment concluded that the Project will not have a significant residual adverse impact on the Water mouse. There are no areas of potential water mouse habitat within the proposed WBE reclamation area.

Potential Water mouse habitat is mapped within the area that may be influenced by indirect impacts of the Project (e.g. influenced by Project noise, lighting, or changes to hydrology). These habitat areas meet the definition of critical habitat for the species.

The removal and degradation of habitat as a result of development actions is the principal threat to the survival of the Water mouse. The species is vulnerable to cumulative impacts if a series of projects establish along a section of coastal foreshore habitat, fragmenting habitat. Permanent loss of habitat areas may impact on the species ability to disperse and persist within the landscape. Indirect impacts from noise, lighting and changes in hydrology may also impact the species.

The Landscape Fragmentation and Connectivity Tool analysis undertaken during the Project EIS concluded that the loss of vegetation within the WBE reclamation area would not have a significant impact on connectivity areas for terrestrial species.

There are no significant impacts on Water mouse anticipated from the five 'other projects' being considered in the CIA. The Pacificus Tourism project is the only project that will result the clearing of Water mouse habitat, with < 0.1ha of disturbed mangrove areas to be disturbed. Some minor indirect impacts may occur from urbanisation of the Toolooa PDA, but these are considered to be negligible in scale.

The Water mouse is not particularly susceptible to impacts from exogenous factors such as floods and cyclones. Mangrove environments are generally quite resilient to impacts from such events, and will recover from damage caused by cyclones once hydrological conditions return to normal.

Overall, there is a low potential for cumulative impacts on the Water mouse, when considering the combined effects of the Project, 'other projects' and exogenous factors.

The highest rated cumulative environmental risk for a mode of impact to Water mouse is assessed to be high, the same as for the Project alone.

21.5.7 Soft bottom benthic habitats

Construction of the WBE reclamation area bund walls and BUF will result in the permanent loss of wetland areas from within the Port Curtis Directory of Important Wetlands in Australia wetland and is likely to result in the loss of benthic habitats and associated benthic flora and fauna communities. Dredging of the barge access channel will also result in the direct loss of benthic habitats.

Dredging to duplicate the channels is situated directly adjacent to the existing shipping channel, and these benthic habitats have experienced previous disturbance due to capital and maintenance dredging operations associated with the existing shipping channel.

Potential impacts due to the operation of the duplication shipping channel are expected to occur over a medium term and be contained to relatively small areas within the marine environment. The barge access channel and surrounding areas may experience increased siltation (due to increased depth and reduced water velocity) during dredging activities but no change in the siltation rate is expected in the vicinity of the Barney Point pocket beach.

The main impact related to coastal processes and hydrodynamic modelling is a potential for some erosion to occur in the channels surrounding the WBE reclamation area (southern and northern areas). This erosion would continue (provided the bed material is erodible), until the channel reaches a new equilibrium depth. These activities are not expected to result in major changes to benthic communities in the affected areas.

Of the 'other projects' under consideration for cumulative impacts, the Clinton Vessel Interaction project, and annual maintenance dredging of the Port are the only projects that will have direct disturbance of benthic habitats. These projects can be expected to result in incremental additional impacts related to the loss of epibenthic biota and short term declines in water quality from dredging plumes.

Several studies report that climate change, along with exploitation, habitat alteration, and pollution, is reducing the abundance of many marine species and increasing the likelihood of local (and in some cases global) extinction (Harley et al. 2006). However, the most sensitive benthic habitats are those containing corals or seagrass, which are assessed specifically. Overall, the potential for cumulative impacts from 'other projects' and exogenous factors on benthic habitats is assessed to be medium. The potential for cumulative impacts will be carefully considered in management plans for dredging developed as part of the Project.

The highest rated cumulative environmental risk for a mode of impact to benthic habitats is assessed to be high, the same as for the Project alone.

21.5.8 Conservation significant fish

The Project will have direct and indirect impacts on intertidal and subtidal environments, which provide habitat value for conservation significant fish and fisheries resources. Eight listed fish species, Estuary stingray, Whale shark, Great white shark, Shortfin mako shark, Longfin mako shark, Porbeagle, Reef manta ray and Giant manta ray are considered to have a moderate likelihood of occurring within and/or adjacent to the Project impact areas. These species are classified as conservation significant and/or migratory species with a high sensitivity rating in the Project EIS.

There will be a direct loss of intertidal and subtidal habitat for conservation significant and/or migratory fish species associated with the establishment of the WBE reclamation area, the BUF and dredging activities.

Of the 'other projects' under consideration for cumulative impacts, the Pacificus Tourism project, Clinton Vessel Interaction project, and annual maintenance dredging of the Port are most relevant for impacts on conservation significant fish. These projects can be expected to result in incremental additional impacts related to:

- Disturbance from increased visitation and recreational boat use in the area
- Short term declines in water quality and impacts to habitat from dredging plumes
- Disturbance from the temporary use of dredging plant, including noise and vibration.

Conservation significant fish may be vulnerable to the influence of exogenous factors that affect the health of their habitat. Major flood events, such as that which occurred in 2011 can be expected to result in water quality declines within Port Curtis and surrounding areas, and the temporary reduction of seagrass. However, the mobile nature and oceanic habits of many of the listed fish species make them more resilient to such impacts that other fish species. Therefore, the potential for cumulative impacts is low.

The highest rated cumulative environmental risk for a mode of impact to conservation significant fish is assessed to be medium, the same as for the Project alone.

21.5.9 Inshore reefs

Construction of the WBE reclamation area and the BUF will result in the direct loss of intertidal and subtidal soft sediment habitat which do not support any known reef communities. Therefore, the potential for direct impacts on inshore reefs is negligible. Also, no hard structure reef habitat is located in any of the Project areas to be dredged. Some inshore coral communities occur within the broader Project area and may be subject to indirect impacts from increased sedimentation and suspended sediment concentrations.

Broad-scale benthic habitat classifications identified rocky/rubble reefs at two areas during the environmental baseline survey area (refer Appendix I1). These communities occurred as five smaller areas and encompassed the Project areas to be dredged and surrounds. Another benthic community type comprised mostly of open substrate interspersed with polychaetes and encrusting bryozoans, encompassed the southern end of the Project areas to be dredged. No macroalgal communities were observed in this region.

Although 'low to medium density', the regions made up of benthic macroinvertebrates and algae contribute value in the form of biodiversity to the Port Curtis ecosystem. These communities are a source of food for many consumers and benthic fauna also 'form a link between habitat substrata, detritus-based food chains and larger carnivores'. The communities also support fisheries productivity in the form of providing food, habitat and shelter for benthic animals and other larger carnivores as well as a source of food for some species of marine turtles that consume macroalgae.

The key potential stressors on reefs from the Project activities may include increased sedimentation and turbidity caused through the mobilisation of sediments associated with dredging activities and dredged material placement activities. A reduction of BPAR in the water column caused by light attenuation through increased turbidity reduces the photosynthetic potential and energy production of most reef building hard corals which rely on the photosynthetic activity of the microalgae zooxanthellae for their growth and survival. A reduction in BPAR may also lead to an increase in mucus production, changes in coral colour or darkening, and in extreme cases mortality and complete changes in reef community structure.

Other potential stressors on reefs from the Project activities may include changes in water quality, particularly salinity, temperature and increased nutrients from discharges of water into the marine environment from dredged material decant water, dredger overflow or runoff.

Of the 'other projects' under consideration for cumulative impacts, the Pacificus Tourism project, Clinton Vessel Interaction project, and annual maintenance dredging of the Port are most relevant for impacts on inshore reefs. These projects can be expected to result in incremental additional impacts related to short term declines in water quality.

Coral reefs are highly vulnerable to impacts from climate change, particularly, rising temperature, acidification and extreme weather events. Studies show that reef recovery from such exogenous factors is slow, as fewer corals survive to recolonise in the affected areas. Inshore coral reefs of the Great Barrier Reef have experienced significant declines over recent decades, through a range of pressures. In this context, protecting the remaining inshore reefs of the Gladstone region is important for maintaining the diversity and OUV of the GBRWHA.

Overall, the potential for cumulative impacts from the Project, combining with the effects of 'other projects' and exogenous factors, is assessed to be medium. Careful consideration will be given in management plans to monitoring inshore corals during the Project, particularly in the event of a bleaching or flood event in the region at a similar time to dredging.

The highest rated cumulative environmental risk for a mode of impact to inshore reefs (increased turbidity and sedimentation) is assessed as low, the same as for the Project alone.

21.5.10 Other values

For other values for which biological modes of impact are not relevant or are minor, cumulative impacts are predicted to be low and comparable with those outlined in the Project EIS. These values are presented in Table 21.8, with a description of the potential for cumulative impacts. The 'other projects' considered in the cumulative impact assessment are unlikely to have significant impacts on these values, that will act cumulatively with those of the Project.

Table 21.8 Summary of the potential for cumulative impacts on a range of non-biological values

Discipline	Comments on potential for cumulative impact
Social values	Construction and maintenance of the Project requires a small number of workers, and specialised skills and equipment that is unlikely to be affected by 'other projects'. Other projects have no significant impact on the existing visual amenity or landscape character of the Gladstone region.
Economics	The Project is required to accommodate medium and longer term future growth in industry and trade in the Gladstone region. The potential (positive) economic impact of the Project on the Queensland economy is substantial, where a $159 million investment will lead to generation of employment of 1,810 full time jobs, income generation of $177 million and economic growth of more than $300 million. If the project does not proceed, then future trades and economic growth will be restricted. The Project will have a positive effect on marine industry and shipping in the region, while having minimal to no effect on other industries such as tourism and fishing.

Discipline	Comments on potential for cumulative impact
Air quality and greenhouse gas emissions	Air quality changes and exhaust emissions arising from the Project are predicted to comply with relevant air quality objectives provided recommended controls are implemented. Dust emissions from the Project are predicted to be highest during construction of the WBE reclamation area bund wall and BUF. None of the 'other projects' assessed have the potential to impact on air quality in the vicinity of the WBE reclamation area bund wall and BUF.
Transport	Dredging activities, changes to navigational aids and the traffic generated from the Project activities, including workforce, will generate low levels of additional shipping and traffic movements in the region. The most significant transport impacts will occur temporarily during the construction of the bund wall for the WBE reclamation area and the BUF. None of the 'other projects' under consideration are in the vicinity of this area and do not have the potential to act cumulatively with the Project.
Waste	The generation of waste from the Project activities is expected to be minimal due to the dredged material being beneficially reused within the WB and WBE reclamation areas, the construction materials for the bund wall being sourced locally, and the construction workforce being relatively low. The Project is therefore unlikely to act cumulatively with 'other projects' to produce waste in volumes of concern.
Coastal resources (sediment, coastal processes and hydrodynamics)	Hydrodynamic and WAVE modelling indicates that the Project will have no impact on existing water levels within the Port. The wave climate on coastlines adjacent to the duplicated channels is also not expected to be impacted. The projected impacts of climate change and SLR on Port Curtis are not expected to be changed by the Project. Mitigation measures are in place to manage the potential impacts of coastal sediments on the environment, through the exposure of ASS or release of contaminants. No cumulative impacts from 'other projects' or exogenous factors are anticipated.
Water resources	There will be no direct impact on the freshwater surface water resources identified upstream of the WBE reclamation area. Dredging activities and changes to navigational aids will occur in tidal waters and have negligible impacts on water resources. Residual impact risk on groundwater resources is assessed as being low. No cumulative impacts from 'other projects' are therefore anticipated.
Cultural heritage	Due to the location of the majority of Project activities being within tidal waters, the potential for impact on known sites of aboriginal cultural heritage significance is predicted to be low. A number of recorded shipwreck sites are located within 5km of Project activities. However, with mitigation measures, indirect impacts are predicted to be negligible to minor. No cumulative impacts from 'other projects' are therefore anticipated.
OUV of the GBRWHA	A detailed assessment of the cumulative impacts of the Project on key and locally expressed OUV of the GBRWHA has been completed in the above sections. This has focussed on biological attributes of OUV. The Project is assessed to have minimal to no impact on other attributes of OUV not assessed above, including connectivity, continental islands, beaches, dune systems, river deltas, island plant species diversity and Traditional Owner interaction with the local environment. No cumulative impacts from 'other projects' or exogenous factors are therefore anticipated.

21.6 Summary

The cumulative impacts of the Project, combined with 'other projects' and exogenous factors has been assessed. The assessment approach is consistent with a key recommendation of the independent review of Gladstone Harbour (SEWPaC 2013), which noted the importance of completing CIA for future projects, where cumulative impacts are superimposed on the dynamics of natural impacts of severe episodic weather events that are expected to increase in frequency.

Overall, the potential for cumulative impacts arising from the Project was found to be low. However, risks associated with cumulative impacts on seagrass, inshore reefs, marine turtles and dugong, were found to be highest, with the influence of exogenous factors such as floods and coral bleaching events the key additional stressors of consideration, rather than the activities of reasonably foreseeable 'other projects'.

A flood event affecting Port Curtis in 2010-11 demonstrated that, like other estuarine environments within Queensland, the local environment has resilience thresholds that are relevant to the process of impact assessment. The aim of effective CIA is to manage the impacts of multiple projects to avoid passing a threshold at which ecosystem processes change, or their recovery from disturbance is significantly hampered.

Tools available to reduce the risk of cumulative impacts include the staging of projects, where possible, to avoid impacts on sensitive receptors from multiple projects at the same time. An awareness of the influence of exogenous factors such as bleaching events or floods on the resilience thresholds of ecosystems is also important. Detailed management plans will be developed to manage the potential cumulative effects of the Project, and 'other projects', should such events occur.