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Northern Land Expansion Project Southern Reclamation Area Project Stage 1 Offset Strategy EPBC 2012/6558

Brief description

This document describes the Gladstone Ports Corporation's Offset Strategy approach for the Northern Land Expansion Project Southern Reclamation Area bund wall construction (the Project), which will take place in the Western Basin area, Port of Gladstone.

This document has been prepared to address the relevant Project *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) controlled action (**EPBC 2012/6558**) approval conditions.

EPBC Act controlled action approval information	
EPBC number	2012/6558
Project name	Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project, Gladstone, Queensland
Proponent/approval holder and ABN	Gladstone Ports Corporation Limited (ABN 96 263 788 242)
Proposed/approved action	To duplicate the existing Gatcombe and Golding Cutting shipping channel, disposal of capital dredge spoil to land reclamation, and upgrade associated infrastructure in the Port of Gladstone, Queensland (refer EPBC Act referral 2012/6558 received on 26 September 2012 and subject to the variations to the action accepted by the Minister for the Environment under Section 156B on 25 March 2019 and 26 August 2020).
Location of the action	Port of Gladstone

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Declaration of accuracy

In making this declaration, I am aware that Section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed	
Full name (please print)	Jenelle Druce
Organisation (please print)	Gladstone Ports Corporation Limited
Date	20/02/2025

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Terms and definitions

"ADCP" means Acoustic Doppler Current Profiler;

"CD Project" means Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project;

"Cth" means Commonwealth;

"DCCEEW" means Department of Climate Change, Energy, the Environment and Water;

"EIS" means Environmental Impact Statement;

"EP Act" means *Environmental Protection Act 1994* (Qld)

"EPBC Act" means *Environment Protection and Biodiversity Conservation Act 1999* (Cth);

"ERA" means Environmentally Relevant Activity;

"FGS" means fine-grained sediment;

"GBR" means Great Barrier Reef;

"GPC" means Gladstone Ports Corporation Limited;

"ha" means hectares;

"HAT" means highest astronomical tide;

"km" means kilometres;

"LiDAR" means light detection and ranging;

"LISST" means Laser In Situ Scattering and Transmissometry;

"Minister" means Minister for the Environment and Water;

"MNES" means matter of national environmental significance;

"NLEP" means Northern Land Expansion Project;

"NLEP SRA" means Northern Land Expansion Southern Reclamation Area Project;

"NLEP SRA Eastern Curlew Offset Strategy" means Eastern Curlew Offset Strategy: Northern Land Expansion Project – Southern Reclamation Area, Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (BAAM Ecological Consultants, 2024)

"NLEP SRA Seagrass and Macroalgae Offset Strategy" means Northern Land Expansion Project: Environmental Offsets Strategy for Seagrass and Macroalgae (Jackson and Ostrowski, 2024)

"NTU" means Nephelometric Turbidity Units;

"OAG" means EPBC Act Offset Assessment Guide;

"Offset Policy" means EPBC Act Environmental Offset Policy (2012) (Department of Sustainability, Environment, Water, Population and Communities, 2012)

"OUV" means outstanding universal value;

"Port" means Port of Gladstone;

"Project" means Northern Land Expansion Project Southern Reclamation Area Project;

"Qld" means Queensland;

"QPWS" means Queensland Parks and Wildlife Service;

"Reef 2050" means Reef 2050 Long-Term Sustainability Plan 2021–2025 (Commonwealth of Australia, 2023);

"REMP" means Receiving Environment Monitoring Program;

"RPEQ" means Registered Professional Engineer of Queensland;

"SDPWO Act" means *State Development and Public Works Organisation Act 1971* (Qld)

"TSS" means total suspended solids;

"WBRA" means Wester Basin Reclamation Area;

"WBE" means Western Basin Expansion (now referred to as the NLEP SRA).

1 Introduction

1.1 Background

The Gladstone Ports Corporation Limited (GPC) is proposing to construct a new reclamation area outer bund wall, referred to as the Northern Land Expansion Project Southern Reclamation Area Project (NLEP SRA or the Project) previously referred to as the Western Basin Expansion (WBE) Southern Reclamation Area.

The NLEP SRA has received Commonwealth and Queensland Government Environmental Impact Statement (EIS) approvals as part of the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (CD Project). The CD Project was subject to assessment under Commonwealth and State Government legislation via the CD Project EIS. As such, the CD Project has received the following primary approvals:

- 'Coordinated project' approval on the 6 July 2020 under the *State Development and Public Works Organisation Act 1971* (Queensland (Qld)) (SDPWO Act); and
- 'Controlled action' approval on 24 December 2020, under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth (Cth)) (EPBC Act) (EPBC 2012/6558).

The NLEP SRA, corresponds with Project Stage 1 of the CD Project as defined under the EPBC Act controlled action approval conditions.

It is to be noted that the construction of the barge unloading facility is not included in the current plan, as this facility is not currently being envisaged in the next 5 years. A revised NLEP SRA Project Stage 1 Offset Strategy will be prepared and submitted to the Minister for the Environment and Water (Minister) for approval in accordance with condition 71 of the CD Project EPBC Act controlled action approval prior to construction of the barge unloading facility.

A NLEP northern reclamation area Stage 3 Offset Strategy will be prepared and submitted to the Minister for approval in accordance with condition 30 of the CD Project EPBC Act controlled action approval prior to construction of the NLEP northern reclamation area.

The Project involves the establishment of a new reclamation area spanning 112.12 hectares (ha), positioned alongside the existing Western Basin Reclamation Area (WBRA) (refer Figure 1).

***Figure 1**: Footprint of the proposed NLEP SRA*

1.2 Project location

The Project is located within the Port of Gladstone (the Port) which is Queensland's largest multi-commodity port. The Port is located approximately 525 kilometres (km) north of Brisbane and approximately 100 km south of Rockhampton on the Capricorn Coast of Central Queensland. Gladstone is the closest city to the Project and is located approximately 10 km to the south-east. Gladstone has a population of 63,515 (2021 Census) and land uses consist predominantly of residential, industrial and port-related development.

The Project is located to the north-west of the existing WBRA. Figure 2 shows the location of the Project in the context of the wider locality.

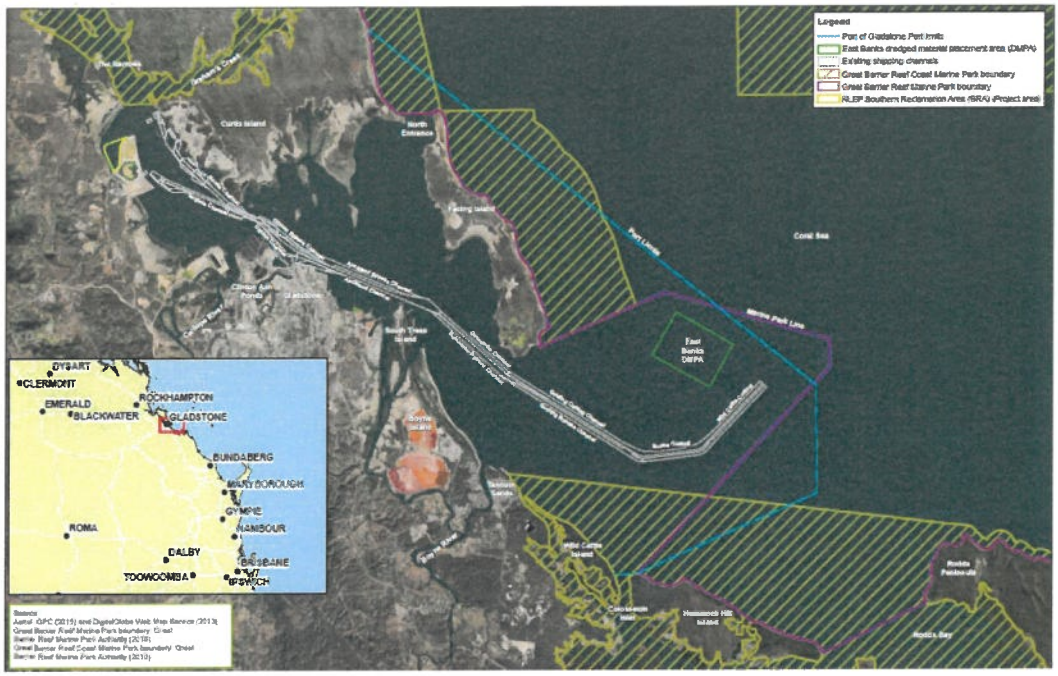

***Figure 2**: Project location in the context of the wider locality*

1.3 Project description

The proposed NLEP SRA outer bund wall has been designed as a fill embankment structure on Lot 510 on SP305597, Lot 511 on SP305597 and Lot 514 on SP311650. It will be located predominantly on land below the high-water mark,

In summary, the new bund wall will consist of the following key elements:

- The inner bund comprising of hard, durable core fill material with a particle size grading suitable for use in a marine environment;
- The ocean side face which will comprise of a filter rock layer and armour rock (rip rap revetment) on the face and toe;
- The reclamation side face which will consist of geotextile layers and a filter sand layer as well as a reshaping rock berm on the face and toe; and
- The top of bund which will consist of a compacted (unsealed) surface on the crest of the bund wall comprising of wearing course gravel material.

The bund wall construction will be conducted as per the engineering design drawings, specifications and certification of design of tidal works by a Registered Professional Engineer of Queensland (RPEQ). RPEQ sign off of the as-constructed drawings will be submitted to the regulators post completion of the construction of the outer bund wall.

An 18-month program is anticipated to be required to achieve full NLEP SRA outer bund wall construction and closure.

1.4 Project approval status

The CD Project was subject to assessment under Commonwealth and State Government legislation via the CD Project EIS. Table 1 summarised the CD Project and NLEP SRA outer bund wall approvals.

***Table 1**: List of approvals for the CD Project and NLEP SRA*

Approval/permit	Legislation	Approval number and date received	Edoc
CG Report	SDPWO Act	Approved on 6 July 2020	1627117
EPBC Act controlled action approval	EPBC Act	EPBC 2012/6558 approved on 24 December 2020	1673296
Development Permit for: • Material change of use for Port Services (dredged material placement or reclamation) • Material Change of Use for Environmentally Relevant Activity (ERA) 16(1)(d) (dredging) • Operational work for tidal works (reclamation including bund wall construction, demolition, and fish passage) • Operational work for the removal, damage, or destruction of marine plant under the *Fisheries Act 1994* (Qld) • Operational work for waterway barrier works under the *Fisheries Act 1994*.	*Planning Act 2016* (Qld)	DA2022/10/01 and 2205-28989 SRA approved on 16 June 2023	1882455
Environmental Authority for ERA 16(1)(d) (dredging)	*Environmental Protection Act 1994* (Qld) (EP Act)	PA-EA-100261837 approved on 3 April 2023	1882455

1.5 Purpose of this report

This report provides the NLEP SRA Project Stage 1 Offset Strategy as required by the CD Project EPBC Act controlled action approval (EPBC 2012/6558) conditions (refer Table 2).

2 Commonwealth Environment Protection and Biodiversity Conservation Act 1999 controlled action conditions

Table 2 provides the NLEP SRA Project Stage 1 Offset Strategy section, and where relevant the NLEP SRA Receiving Environment Monitoring Program (REMP) and/or specific Project matter of national environmental significance (MNES) offset strategy section that addresses the relevant CD Project EPBC Act controlled action approval conditions.

It is important to note this NLEP SRA Project Stage 1 Offset Strategy includes the following specific Project MNES offset strategies:

- *Eastern Curlew Offset Strategy: Northern Land Expansion Project – Southern Reclamation Area, Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project* (BAAM Ecological Consultants, 2024) (NLEP SRA Eastern Curlew Offset Strategy) (refer Appendix A); and
- *Northern Land Expansion Project: Environmental Offsets Strategy for Seagrass and Macroalgae* (Jackson and Ostrowski, 2024) (NLEP SRA Seagrass and Macroalgae Offset Strategy) (refer Appendix B).

Figure 3 provides a summary of the relevant CD Project EPBC Act controlled action approval conditions for the NLEP SRA Project Stage 1 Offset Strategy and their inter-relationship.

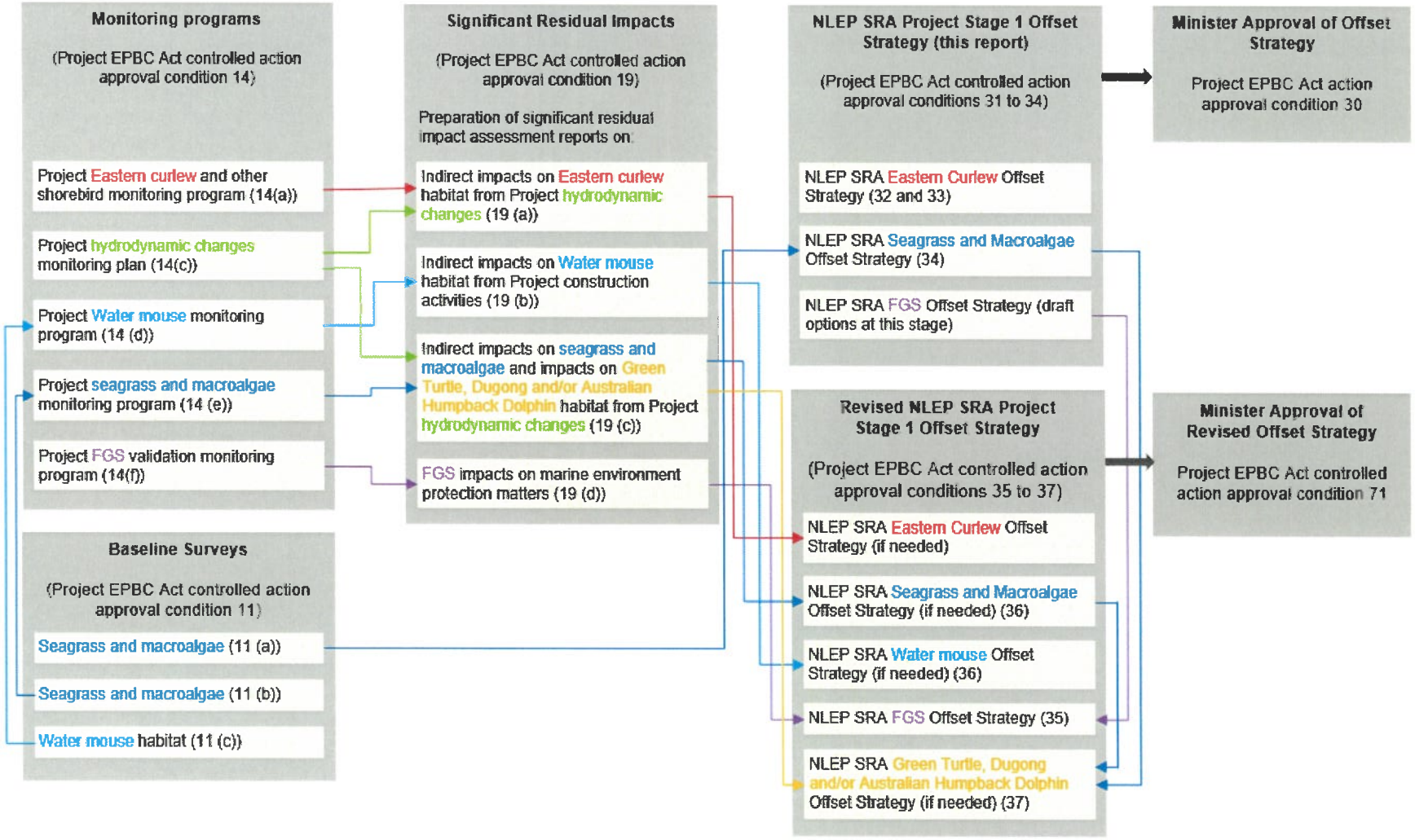

Figure 3: *Summary of the relevant CD Project EPBC Act controlled action approval conditions for the NLEP SRA Project Stage 1 Offset Strategy and their inter-relationship*

Table 2: *NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy section that addresses the CD Project EPBC Act controlled action approval conditions*

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
1.	19 (a)	Within 6 months following the completion of each monitoring program required under conditions 14, 15 and 16 for each Project Stage, the approval holder must engage a suitably qualified ecologist or marine sediment expert to prepare a report which quantifies all significant residual impacts on protected matters for each completed Project Stage(s), for the Minister's approval. The report must include: (a) the quantification of hydrodynamic impacts identified as required under condition 14 (c);	NLEP SRA Project Offset Strategy Section 4.2 REMP Section 8.9 (Hydrodynamic changes monitoring plan)	The following summarises how the condition 19 (a) and condition 14 (c) requirements have been addressed: • Bathymetric surveys of the channel to the west of the NLEP SRA will be undertaken immediately post completion of the construction. A follow up survey will be undertaken after three months post completion and then twice yearly for two years • Light detection and ranging (LiDAR) or drone surveys of the shoreline to the west of the NLEP SRA immediately post construction and at six-monthly intervals for a period of two years • Findings of the Project hydrodynamic changes monitoring plan will be incorporated into the significant residual impact assessments for Project impacts on seagrass and macroalgae, and Eastern curlew habitat.
2.	19 (b)	(b) Water mouse habitat impacted as determined by monitoring as required under condition 14 (d);	NLEP SRA Project Offset Strategy Section 6 REMP Section 8.4.2 (Water mouse monitoring program)	The following summarises how the condition 19 (b) and condition 14 (d) requirements have been addressed: • Water mouse monitoring program includes monitoring the extent, location and condition of the Water mouse foraging habitat on an annual basis during construction and for two years following the completion of construction • The Water mouse foraging habitat remote sensing data will be classified and evaluated according to three criteria, including a species-specific risk matrix, appropriate trigger criteria, and linked to an agreed Alert-to-Action protocol for assessment of the mangroves' condition along the shoreline • Significant residual impacts from the Project indirect impacts on Water mouse habitat will be undertaken by a suitably qualified ecologist and will be based on the: - Findings of the Project Water mouse monitoring program, including monitoring 2 years post completion of the NLEP SRA (refer REMP Section 8.4.2); and

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				- Significant impact assessment for the Project indirect impacts on seagrass and macroalgae in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013). • The Project Water mouse significant residual impact assessment report, prepared in accordance with the CD Project EPBC Act controlled action approval condition 19 (b), will be submitted by GPC within 6 months following the completion of the Project Water mouse monitoring program for the Minister's approval.
3.	19 (c)	(c) sub-lethal and lethal impacts to seagrass and macroalgae determined by monitoring 2 years post completion as required under condition 14 (e);	NLEP SRA Project Offset Strategy Section 4.5 REMP Section 8.3 (Seagrass and macroalgae monitoring program) and Section 8.9 (Hydrodynamic changes monitoring plan)	The following summarises how the condition 19 (c) requirements have been addressed: • Significant residual impacts from the Project sub-lethal and lethal impacts to seagrass and macroalgae will be undertaken by a suitably qualified ecologist and will be based on the: - Findings of the Project seagrass and macroalgae monitoring program, including monitoring 2 years post completion of the NLEP SRA (refer REMP Section 8.3); - Finding of the Project hydrodynamic changes monitoring plan (refer REMP Section 8.9); and - Significant impact assessment for the Project indirect impacts on seagrass and macroalgae in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013). • The Project seagrass and macroalgae significant residual impact assessment report, prepared in accordance with the CD Project EPBC Act controlled action approval condition 19 (c), will be submitted by GPC within 6 months following the completion of the Project seagrass and macroalgae monitoring program for the Minister's approval.

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
4.	19 (d)	(d) the amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension monitored in condition 14 (f);	NLEP SRA Project Offset Strategy Section 5 REMP Section 8.10 (FGS validation monitoring program)	The following summarises how the condition 19 (d) and condition 14 (f) requirements have been addressed: • The validation of the overall sediment release estimate will involve analysing the data that is collected as part of the REMP to confirm that the measured turbidity during bund construction was in line with expectations given the estimated quantity of fine sediment release • Significant residual impacts from the Project FGS impacts on the marine environment protected matters will be undertaken by a suitably qualified marine sediment expert and will be based on the: - Findings of the Project FGS validation monitoring program (refer REMP Section 8.10); and - Significant impact assessment for the Project FGS impacts on marine environment protected matters in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013). • The Project FGS significant residual impact assessment report, prepared in accordance with the CD Project EPBC Act controlled action approval condition 19 (d), will be submitted by GPC within 6 months following the completion of the Project FGS validation monitoring program for the Minister's approval.
5.	19 (e)	(e) sub-lethal or lethal impacts to seagrass and macroalgae determined by monitoring required under condition 15 (a);	-	Not applicable due to the Project stage not including dredging.
6.	19 (f)	(f) significant residual impacts on Loggerhead Turtles, Flatback Turtles and Australian Humpback Dolphins determined by monitoring required under condition 15 (b);	-	Not applicable due to the Project not including dredging.
7.	19 (g)	(g) significant residual impacts on Hawksbill Turtles and Olive Ridley Turtles determined by monitoring required under condition 16; and	-	Not applicable due to the Project not including dredging.

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
8.	19 (h)	(h) the amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension monitored in condition 15 (c).	-	Not applicable due to the Project not including dredging.
9.	30	The approval holder must submit an Offset Strategy for approval by the Minister for each Project Stage. The approval holder must not commence each Project Stage until the Offset Strategy for that Project Stage has been approved in writing by the Minister. The approval holder must implement the Offset Strategy approved by the Minister in respect of the relevant Project Stage.	-	The following summarises how the condition 30 requirements have been addressed: • This NLEP SRA Project Stage 1 Offset Strategy has been submitted to the Minister for approval of CD Project Stage 1, involving the construction of the NLEP SRA (excluding the barge unloading facility) • GPC commits to not commencing construction of the NLEP SRA outer bund wall until the Minister has approved the NLEP SRA Project Stage 1 Offset Strategy in writing • GPC commits to implementing the NLEP SRA Project Stage 1 Offset Strategy approved by the Minister.
10.	31 (a)	Each Project Stage Offset Strategy must propose offsets for that Project Stage and include the following: details of how the proposed offsets align with the broader strategies and programs for the Great Barrier Reef, including but not limited to the Reef 2050 Long-term Sustainability Plan and will provide a net benefit to the Great Barrier Reef World Heritage Area (GBRWHA);	NLEP SRA Project Stage 1 Offset Strategy Section 3.8.1 NLEP SRA Eastern Curlew Offset Strategy Section 10	The following summarises how the condition 31 (a) requirements have been addressed for the NLEP SRA Eastern Curlew Offset Strategy: • Reef 2050 Long-Term Sustainability Plan 2021–2025 (Commonwealth of Australia, 2023) (Reef 2050) work area: *Limit the impacts of climate change* and associated goals and strategic actions alignment by: - Managing threats to Eastern curlew habitat in an area with extensive intertidal areas and low-lying marine plains that provide potential for tidal flat foraging habitat in the GBRWHA to migrate with rising sea levels, an identified priority for mitigating climate change impacts on shorebirds, including Eastern curlew. • Reef 2050 work area: *Reduce impacts from land-based activities* and associated goals and strategic actions alignment by: - The control of feral pigs and livestock within a catchment of the GBRWHA that will reduce soil disturbance and thereby improve water quality entering the GBRWHA; and

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				- Monitoring of Eastern curlew use of habitats will improve knowledge of sensitive shoreline ecosystems and inform conservation planning for these areas.
			NLEP SRA Project Stage 1 Offset Strategy Section 4.6.1 NLEP SRA Seagrass and Macroalgae Offset Strategy Section 6	The following summarises how the condition 31 (a) requirements have been addressed for the NLEP SRA Seagrass and Macroalgae Offset Strategy: • Pilot and implement interventions that support the resilience of coral reefs, seagrass, other marine habitats and islands, for example establishment of a state-of-the-art seagrass nursery facilities (propagation, seed storage, pest management), and seed-based seagrass restoration (also resulting in enhancement of fish habitat) in response to more frequent La Niña climate conditions and severe storms • Gidarjil Development Corporation Sea Rangers working and training at the seagrass nursery and seagrass habitat restoration • Gidarjil Development Corporation Sea Rangers to ultimately manage the seagrass nursery facility and seagrass restoration activities in the region and beyond • The above specifically expands Indigenous land and sea ranger programs to additional areas to deliver on-ground activities, including compliance, marine monitoring and species protection and management • Net benefit to the GBRWHA is achieved by seagrass restoration and resilience (e.g. Pelican Banks) providing a significant contribution to the outstanding universal value (OUV) of the GBRWHA. Seagrass in the Port of Gladstone is an essential grazing area for Dugongs and turtles, fish habitat, foraging shorebird, and traps fine sediments and sequesters carbon at higher rates than terrestrial systems.
11.	31 (b)	(b) details to demonstrate how the proposed offsets will compensate for significant residual impacts on the relevant protected matters in accordance with the principles of the Environmental Offsets Policy;	NLEP SRA Project Stage 1 Offset Strategy Section 3.2 (Eastern curlew habitat)	The following summarises how the condition 31 (b) requirements have been addressed: • The significant residual impacts on Eastern curlew habitat (i.e. total of 121.24 ha, comprising 107.06 ha (direct impact) and 14.18 ha (indirect impact)) will be offset by the:

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
			NLEP SRA Eastern Curlew Offset Strategy Section 3	- Creation of a migratory shorebird roost, appropriate for the Eastern curlew, on part of the established NLEP SRA; and - Management of threats to Eastern curlew and Eastern curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern curlew habitat to improve habitat for the Eastern curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern curlew as part of a regionalised approach to threat abatement. • The Project significant residual indirect impacts on Eastern curlew habitat from hydrodynamic changes (i.e. a permanent narrow channel adjacent to the outer bund wall) will be confirmed by undertaking a significant impact assessment based on the: - Findings of the Project Eastern curlew and other shorebird monitoring program (refer REMP Section 8.7); - Findings of the Project hydrodynamic changes monitoring plan (refer REMP Section 8.9); and - Significant impact assessment for the Project indirect impacts on Eastern curlew habitat in accordance with the MNES SIG 1.1.
			NLEP SRA Project Stage 1 Offset Strategy Section 4.5 (seagrass and macroalgae) NLEP SRA Seagrass and Macroalgae Offset Strategy Section 6	• The significant residual impacts on seagrass and macroalgae (i.e. direct impact to 55 ha of seagrass and 1.1 ha of macroalgae) will be offset by: - Restoring the degraded seagrass meadow at Pelican Banks by seed enhancement on seagrass areas with low biomass and seedbanks to promote recovery and improve resilience against future disturbances; and - Creating 1.1 ha of macroalgal habitat on the NLEP SRA seawalls, specifically for brown algae, *Sargassum*, and red seaweed, *Asparagopsis taxiformis*. • The significant residual impacts from Project indirect impacts on seagrass and macroalgae will be determined based on the: - Findings of the Project seagrass and macroalgae monitoring program, including monitoring 2 years post completion of the NLEP SRA (refer REMP Section 8.3);

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				- Findings of the Project hydrodynamic changes monitoring plan (refer REMP Section 8.9); and - Significant impact assessment for the Project indirect impacts on seagrass and macroalgae in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013).
			NLEP SRA Project Stage 1 Offset Strategy Section 5 (fine-grained sediment (FGS)) Project REMP Section 8.10	• The significant residual impact from Project FGS impacts on marine environment protected matters will be determined by the: - Implementation and findings of the Project FGS validation monitoring program which will provide an estimate of the total amount of FGS that will be released to the marine environment due to the NLEP SRA bund wall construction, that was not previously available for resuspension (refer REMP Section 8.10); and - Significant impact assessment for the Project FGS impacts on the marine environment protected matters in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013). • The FGS offset for the NLEP SRA will be detailed in the revised NLEP SRA Project Stage 1 Offset Strategy to be submitted to the Minister for approval. Potential FGS offset opportunities include: - Option 1: Land rehabilitation of erosion prone stream banks to prevent sediment loss; - Option 2: Payment into the Reef Trust, with financial contributions calculated using the Reef Trust calculator; and - Option 3: Enter into sediment offset arrangement through procurement of reef credits.

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
			NLEP SRA Project Stage 1 Offset Strategy Section 6 (Water mouse habitat) Project REMP Section 8.4	• The significant residual impact on Water mouse habitat will be determined based on the: - Findings of the Project Water mouse monitoring program that will accurately monitoring and quantifying any changes to the extent, and location of Water mouse habitat, including foraging habitat and breeding places, during the NLEP SRA construction and until 2 years following completion of construction (refer REMP Section 8.4.2); and - Significant impact assessment for the Project indirect impacts on Water mouse habitat in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013). • If the findings of the significant impact assessment for Project indirect impacts on Water mouse habitat result in a significant residual impact, specific Water mouse direct offset options will be identified and assessed, and included in a revised NLEP SRA Project Stage 1 Offset Strategy which will be submitted to the Minister for approval in accordance with condition 71 of the CD Project EPBC Act controlled action approval. The Water mouse direct offset will be informed by the National Recovery Plan and in accordance with the Offset Policy for Water mouse impact in the plan. Other potential Water mouse habitat indirect offset option examples to be assessed, which are consistent with the National Recovery Plan for the Water Mouse (*Xeromys myoides*) (DCCEEW, 2022a) include: - Funding a Water mouse research program that involves research, monitoring and management actions that increase the understanding on how to reduce and mitigate the coastal development impacts on Water mouse habitat;

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				- Funding a Water mouse research program that addresses the gaps in knowledge about Water mouse ecology, detectability, the distribution and occurrence of Water mouse across its known and potential distribution; or - Funding for the development of a Port of Gladstone adaptive management plan for the threats to the Water mouse, identified in the threat abatement plans for predation by European red fox; predation, habitat degradation, competition and disease transmission by feral pigs; predation by feral cats; and to reduce the impacts on northern Australia's biodiversity by the five listed grasses.
			NLEP SRA Project Stage 1 Offset Strategy Section 7 (Green turtle, Dugong and Australian humpback dolphin habitat)	• The significant residual impact on Green turtle, Dugong and Australian humpback dolphin habitat will be determined based on the: • Findings of the Project seagrass and macroalgae monitoring program, including monitoring 2 years post completion of the NLEP SRA (refer REMP Section 8.3); • Findings of the Project hydrodynamic changes monitoring plan (refer REMP Section 8.9); and • Significant impact assessment for the Project in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013), taking into account the: - Implementation of the Project seagrass and macroalgae offset detailed in Section 4.3 - Revised offset if required under condition 36, on the NLEP SRA impacts to Green turtle foraging habitat, Dugong habitat and Australian humpback dolphin habitat.

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				• If the findings of the significant impact assessment for Project impacts on Green turtle foraging habitat, Dugong habitat and Australian humpback dolphin habitat result in a significant residual impact, specific Green turtle foraging habitat, Dugong habitat and Australian humpback dolphin offset options will be identified and assessed, and included in a revised NLEP SRA Project Stage 1 Offset Strategy which will be submitted to the Minister for approval in accordance with condition 71 of the CD Project EPBC Act controlled action approval. Potential Green turtle foraging habitat, Dugong habitat and Australian humpback dolphin habitat offset option examples to be assessed include: - Enhancing the resilience of degraded seagrass meadows within the Port of Gladstone; - Integrating macroalgal habitat into the other GPC reclamation bund walls within the Port of Gladstone; and/or - Funding another PhD project to further investigate blue carbon sequestration and other benefits arising from seagrass restoration.
12.	31 (c)	(c) evidence of how the proposed offsets take into account relevant approved conservation advices, relevant recovery plans and threat abatement plans, or other relevant contributions to species recovery and conservation;	NLEP SRA Project Stage 1 Offset Strategy Sections 3.8.3 and 3.8.4 (Eastern curlew) NLEP SRA Eastern Curlew Offset Strategy Section 10	The following summarises how the condition 31 (c) requirements have been addressed for the Eastern curlew proposed offset: • The strategy will improve habitat management and manage threats in north Curtis Island, which has been identified as a key site for Eastern curlew • The strategy will maintain and improve protection of roosting and feeding sites on Curtis Island from feral animal impacts and construct a protected roost site suitable for Eastern curlew • The management of feral animals on north Curtis Island will control and reduce the spread of invasive species

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				• The offset strategy monitoring program will include monitoring of disturbance at important roost sites that can inform subsequent management of these sites, collect data relevant to the assessment of population size and distribution, and collect information on threatening processes, including feral animals and disturbance.
			NLEP SRA Project Stage 1 Offset Strategy Section 4.6.3 (seagrass and macroalgae) NLEP SRA Seagrass and Macroalgae Offset Strategy Section 3.7	The following summarises how the condition 31 (c) requirements have been addressed for the seagrass and macroalgae proposed offset: • The strategy primary aim is to achieve 'no net loss' of seagrass and macroalgae habitat and a net benefit to the GBRWHA by seagrass restoration and resilience (e.g. Pelican Banks) providing a significant contribution to the OUV of the GBRWHA. Seagrass in the Port of Gladstone is an essential grazing area for Dugongs and turtles, fish habitat, foraging shorebird, and traps fine sediments and sequesters carbon at higher rates than terrestrial systems • Pilot and implement interventions that support the resilience of coral reefs, seagrass, other marine habitats and islands, for example establishment of a state-of-the-art seagrass nursery facilities (propagation, seed storage, pest management), and seed-based seagrass restoration (also resulting in enhancement of fish habitat) in response to more frequent La Niña climate conditions and severe storms • The strategy proposes reseeding to more than five times the biomass of seagrass impacted by the NLEP SRA construction • If the findings of the significant impact assessments referenced in Condition 31 (b) result in a significant residual impact, the offset obligations will take into account the relevant documents specified in Condition 31 (c).

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
13.	31 (d)	(d) a process to update the Offset Strategy and confirm the offset requirements for protected matters based on the report prepared under condition 19;	NLEP SRA Project Stage 1 Offset Strategy Sections 3.7 (Eastern curlew), Section 4.5 (seagrass and macroalgae), Section 5 (FGS), Section 6 (Water mouse) and Section 7 (Green turtle, Dugong and Australian humpback dolphin)	The following summarises how the condition 31 (d) requirements have been addressed: • Project significant residual impact assessment reports in accordance with the CD Project EPBC Act controlled action approval condition 19, will be submitted by GPC to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) within 6 months following the completion of the Project monitoring programs for the Minister's approval • In accordance with the CD Project EPBC Act controlled conditions 32 to 37, GPC will compensate for the significant residual impacts to protected matters from the construction of the NELP SRA. Any changes to the environmental offset for protected matter will be provided in the revised NLEP SRA Project Stage 1 Offset Strategy to the Minister for approval within 12 months of submitting the Project significant residual impact assessment reports.
14.	31 (e)	(e) a process for, at the minimum, a biannual review of the Offset Strategy and the performance of offsets for the period of effect of the approval including timeframes for conducting the reviews and for publishing the findings of each review on the website;	NLEP SRA Project Stage 1 Offset Strategy Section 8	The following summarises how the condition 31 (e) requirements have been addressed: • The NLEP SRA Project Stage 1 Offset Strategy will be reviewed twice each year to assess the performance of the offset strategies for the period of effect of the Offset Strategy approval by the Minister • The review of the Offset Strategy will assess the efficacy of current management actions and identify whether additional activities and responses to unexpected events or threats to the successful delivery of the NLEP SRA Project Stage 1 Offset Strategy are required • Should it become necessary to update the NLEP SRA Project Stage 1 Offset Strategy to incorporate additional information obtained through the implementation and performance monitoring of the Offset Strategy, any revision will be subject to an application to the Minister for a variation to the Offset Strategy in accordance with condition 71 of the CD Project EPBC Act controlled action approval.

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
15.	31 (f)	(f) where direct offsets are proposed, offset information for each offset site must be provided in the offset strategy;	NLEP SRA Project Stage 1 Offset Strategy Section 3.3 NLEP SRA Eastern Curlew Offset Strategy Section 3	The following summarises how the condition 31 (f) requirements have been addressed for Eastern curlew direct offsets: • Creation of a migratory shorebird roost, appropriate for the Eastern curlew, on part of the established NLEP SRA • Management of threats to Eastern curlew and Eastern curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern curlew habitat to improve habitat for the Eastern curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern curlew as part of a regionalised approach to threat abatement.
			NLEP SRA Project Stage 1 Offset Strategy Sections 4.3.1 and 4.3.2 NLEP SRA Seagrass and Macroalgae Offset Strategy Sections 3 and 4	The following summarises how the condition 31 (f) requirements have been addressed for seagrass and macroalgae direct offsets: • Restore the degraded seagrass meadow at Pelican Banks by seed enhancement on seagrass areas with low biomass and seedbanks to promote recovery and improve resilience against future disturbances • Create 1.1 ha of macroalgal habitat on the NLEP SRA seawalls, specifically for brown algae, *Sargassum*, and red seaweed, *Asparagopsis taxiformis*.
16.	31 (g)	(g) if indirect compensatory measures such as research are proposed, details of how the proposed offsets will be developed, the timeframe over which they would be undertaken and the expected outcomes of the compensatory measures. Indirect compensatory measures must be prepared in accordance with the Environmental Offsets Policy; and	NLEP SRA Project Stage 1 Offset Strategy Section 4.3.3 NLEP SRA Seagrass and Macroalgae Offset Strategy Section 5	The following summarises how the condition 31 (g) requirements have been addressed for the seagrass and macroalgae indirect offset: • Investigation of blue carbon sequestration and other benefits arising from seagrass restoration via GPC funding a PhD project over 5 years to provide insights into how restored seagrass ecosystems contribute to vital services, including carbon sequestration, nutrient cycling, habitat provision, and coastal protection.

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
17.	31 (h)(i)	(h) if a financial contribution is proposed (e.g. for the amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension before commencement of any Project Stage, and/or for lethal or sub-lethal impacts to seagrass and macroalgae), the Offset Strategy must: (i) explain the purpose of the financial contribution and demonstrate how it will result in a net benefit to the protected matter(s);	NLEP SRA Project Stage 1 Offset Strategy Section 5	The following summarises how the condition 31 (h)(i) requirements have been addressed for the potential FGS financial offset opportunities: • Payment into the Reef Trust, with financial contributions calculate using the Reef Trust calculator, which direct funding to deliver projects within the following four outcomes: 1. Improve the quality of water entering the Great Barrier Reef (GBR) from broad-scale land use to increase the health and resilience of the GBR; 2. Improve the health and resilience of coastal habitats; 3. Improve and protect marine biodiversity, including the reduction of Crown-of-Thorns Starfish (*Acanthaster* cf. *solaris*) and protection of listed threatened and migratory species such as Dugongs and marine turtles; and/or 4. Any new development maintains or improves the condition of MNES and matters of state environmental significance through the strategic delivery of offsets through the Reef Trust. • Enter into sediment offset arrangement through procurement of reef credits under the Reef Credit Scheme which delivers water quality benefits for the GBR. Reef credits is a voluntary environmental market scheme that financially rewards land managers within the GBR catchments for on-farm changes that measurably improve the quality of water flowing to the GBR resulting in a net benefit to the GBR World Heritage, marine threatened species and communities protected matters.
18.	31 (h)(ii)	(ii) provide details of and justification for the organisation(s) to which a contribution will be made;	NLEP SRA Project Stage 1 Offset Strategy Section 5	The following summarises how the condition 31 (h)(ii) requirements have been addressed: • Reef Trust – administrated by DCCEEW with Reef Trust investments developed and implemented through a rigorous process of stakeholder engagement and prioritisation. Decisions are aligned to implementing Reef 2050 work areas and enablers

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				• The Reef Credit Scheme is managed by independent, not-for-profit company, Eco-Markets Australia. For a project or action to be eligible to earn reef credits, it must follow certain rules, the Reef Credit Standard, and be undertaken in a certain way using a particular method or methods. These rules are administered by Eco-Markets Australia to ensure the reductions in nutrient or sediment run-off can be measured and verified. All reef credit projects must be registered with Eco-Markets Australia to earn reef credits.
19.	31 (h)(iii)	(iii) explain how the financial contribution will be calculated;	NLEP SRA Project Stage 1 Offset Strategy Section 5	The following summarises how the condition 31 (h)(iii) to (v) requirements have been addressed: • A revised NLEP SRA Project Stage 1 Offset Strategy will be prepared following the completion of the Project FGS significant residual impact assessment report which will include the financial contribution amount, how the financial contributions have been calculated (e.g. Reef Trust calculator), and the proportion of the offset obligation that would be met by the financial contribution (noting that 100% of any offset requirement that will or cannot be delivered through direct offsets will be provided through financial contributions). The revised NLEP SRA Project Stage 1 Offset Strategy will be submitted to the Minister for approval in accordance with condition 71 of the CD Project EPBC Act controlled action approval.
20.	31 (h)(iv)	(iv) specify the proportion of the offset obligation that would be met by any financial contribution; and		
21.	31 (h)(v)	(v) specify the proposed amount of the financial contribution (where known).		
22.	32	To compensate for impacts to Eastern curlew habitat, the approval holder must provide an environmental offset consistent with the Environmental Offsets Policy. This offset must be in accordance with the approved Project Stage 1 Offset Strategy and implemented within 12 months from the date that the Project Stage 1 Offset Strategy is approved in writing by the Minister. The quantum of impacts to Eastern curlew habitat must be confirmed in the Project Stage 1 Offset Strategy and based on the detailed design for the southern reclamation area.	NLEP SRA Project Stage 1 Offset Strategy Section 3 (proposed offset) and Section 3.8.2 (consistency with EPBC Act Environmental Offset Policy (2012) (Department of Sustainability, Environment, Water, Population and Communities, 2012) (Offset Policy))	The following summarises how the condition 32 requirements have been addressed: • The total quantum of direct and indirect significant residual impacts of the Project on Eastern curlew habitat is 121.24 ha, including 107.06 ha from direct impact based on the detailed design of the NLEP SRA, and an estimated indirect impact of 14.18 ha based on the predicted hydrodynamic changes creating a permanent narrow channel adjacent to the outer bund wall

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
			NLEP SRA Eastern Curlew Offset Strategy Section 3	• The Eastern curlew habitat offset, provided in the NLEP SRA Project Stage 1 Offset Strategy (this report) is consistent with the Offset Policy (refer Section 3.8.2) and includes the: - Creation of a migratory shorebird roost, appropriate for the Eastern curlew, on part of the established NLEP SRA; and - Management of threats to Eastern curlew and Eastern curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern curlew habitat to improve habitat for the Eastern curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern curlew as part of a regionalised approach to threat abatement. • The above Eastern curlew offset is consistent with the Offset Policy due to being built around providing direct offsets that will deliver an overall conservation outcome that improves the viability of Eastern curlew and Eastern curlew habitat within the Gladstone region, and in accordance with other Offset Policy principles • GPC commits to implementing the NLEP SRA Project Stage 1 Offset Strategy for Eastern curlew habitat within 12 months from the date that the Offset Strategy is approved in writing by the Minister.
23.	33 (a)	The environmental offset to compensate for impacts to Eastern curlew habitat must deliver direct on-ground benefits to the species and must include at a minimum: (a) activities to create or improve foraging habitat for the Eastern curlew within the Port Curtis area;	NLEP SRA Project Stage 1 Offset Strategy Section 3.3 NLEP SRA Eastern Curlew Offset Strategy Section 3	The following summarises how the condition 33 (a) to (d) requirements have been addressed: • Creation of a migratory shorebird roost, appropriate for the Eastern curlew, on part of the established NLEP SRA • Management of threats to Eastern curlew and Eastern curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern curlew habitat to improve habitat for the Eastern curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern curlew as part of a regionalised approach to threat abatement.
24.	33 (b)	(b) on-the-ground activities to aid the long-term conservation of areas of foraging habitat for the Eastern curlew, which may be within the entirety of the GBRWHA and/or within the Australian range of the species;		

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
25.	33 (c)	(c) creation of a migratory shorebird roost, appropriate for the Eastern curlew, on part of the WB reclamation area and/or WBE reclamation area. The design and construction of the migratory shorebird roost must be undertaken with advice from a suitably qualified ecologist, and the roost must be maintained for the period of the effect of the approval; and		
26.	33 (d)	(d) management of threats to the Eastern curlew within the Port of Gladstone area, such as invasive plant and animal control within or adjacent to Eastern curlew habitat as part of a regionalised approach to threat abatement.		
27.	34	To compensate for significant residual impacts to seagrass and macroalgae within the Project Stage 1 direct impact area (based on survey results undertaken in accordance with condition 11(a), the approval holder must provide an environmental offset proportionate to the condition and density of seagrass and macroalgae impacted, consistent with the Environmental Offsets Policy. This offset must be in accordance with the approved Project Stage 1 Offset Strategy and provided or commenced within 12 months from the date that the Project Stage 1 Offset Strategy is approved in writing by the Minister.	NLEP SRA Project Stage 1 Offset Strategy Section 4.3 (proposed offset) and Section 4.6.2 (consistency with Offset Policy) NLEP SRA Seagrass and Macroalgae Offset Strategy Sections 3 to 5	The following summarises how the condition 34 requirements have been addressed: • Restore the degraded seagrass meadow at Pelican Banks by seed enhancement on seagrass areas with low biomass and seedbanks to promote recovery and improve resilience against future disturbances • Create 1.1 ha of macroalgal habitat on the NLEP SRA seawalls, specifically for brown algae, *Sargassum*, and red seaweed, *Asparagopsis taxiformis* • Investigation of blue carbon sequestration and other benefits arising from seagrass restoration via GPC funding a PhD project over 5 years to provide insights into how restored seagrass ecosystems contribute to vital services, including carbon sequestration, nutrient cycling, habitat provision, and coastal protection

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				• The above seagrass and macroalgae offset is consistent with the Offset Policy due to proposed reseeding being more than five times the biomass of seagrass impacted by the NLEP SRA construction, and the offset strategy including piloting and implementing interventions that support the resilience of coral reefs, seagrass, other marine habitats and islands (e.g. establishment of a state-of-the-art seagrass nursery facilities (propagation, seed storage, pest management), and seed-based seagrass restoration (also resulting in enhancement of fish habitat) in response to more frequent La Niña climate conditions and severe storms) • GPC commits to providing or commencing the NLEP SRA Project Stage 1 Offset Strategy for seagrass and macroalgae within 12 months from the date that the Offset Strategy is approved in writing by the Minister.
28.	35	To compensate for any significant residual impacts of the action on protected matters, and to achieve a net benefit to the outstanding universal value of the GBRWHA, the approval holder must provide an environmental offset consistent with the Environmental Offsets Policy for the amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension before commencement of Project Stage 1, as determined in accordance with condition 19 (d). This offset must be in accordance with the approved Project Stage 1 Offset Strategy and implemented within 12 months of submitting the report required under condition 19.	NLEP SRA Project Stage 1 Offset Strategy Section 5	The following summarises how the condition 35 requirements have been addressed: • The FGS offset for the NLEP SRA will be detailed in the revised NLEP SRA Project Stage 1 Offset Strategy to be submitted to the Minister for approval. Potential FGS offset opportunities that are consistent with the Offset Policy include: - Option 1: Land rehabilitation of erosion prone stream banks to prevent sediment loss; - Option 2: Payment into the Reef Trust, with financial contributions calculated using the Reef Trust calculator; and - Option 3: Enter into sediment offset arrangement through procurement of reef credits. • GPC commits to implementing the revised NLEP SRA Project Stage 1 Offset Strategy for Project FGS impacts within 12 months from the date that the Offset Strategy (containing the final Project FGS offsets) is approved in writing by the Minister.

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
29.	36	If a significant residual impact to Water Mouse habitat, seagrass and/or macroalgae is identified in the report required under condition 19 (b), or 19 (c), the approval holder must provide an environmental offset for these protected matters in accordance with the Environmental Offsets Policy. The environmental offset must be consistent with the Project Stage 1 Offset Strategy and be provided to the Minister for approval within 12 months of submitting the report required under condition 19.	NLEP SRA Project Stage 1 Offset Strategy Section 6 (Water mouse)	The following summarises how the condition 36 requirements have been addressed for Water mouse habitat: • Within 6 months of completing the Project Water mouse monitoring completion report (refer REMP Section 8.4.2), GPC will engage a suitably qualified ecologist to prepare a report (for the Minister's approval) which quantifies the significant residual impacts on Water mouse habitat based on the Water mouse habitat impacted as determined by the Project Water mouse monitoring program • If the findings of the significant impact assessment for Project indirect impacts on Water mouse habitat result in a significant residual impact, specific Water mouse direct offset options will be identified and assessed, and included in a revised NLEP SRA Project Stage 1 Offset Strategy in accordance with condition 71 of the CD Project EPBC Act controlled action approval and will be submitted to the Minister for approval within 12 months of submitting the Project Water mouse significant residual impact assessment report. The Water mouse direct offset will be informed by the National Recovery Plan and in accordance with the Offset Policy for Water mouse impact in the plan. Other potential Water mouse habitat offset option examples to be assessed, which are consistent with the National Recovery Plan for the Water Mouse (*Xeromys myoides*) (DCCEEW, 2022a) include: - Funding a Water mouse research program that involves research, monitoring and management actions that increase the understanding on how to reduce and mitigate the coastal development impacts on Water mouse habitat; - Funding a Water mouse research program that addresses the gaps in knowledge about Water mouse ecology, detectability, the distribution and occurrence of Water mouse across its known and potential distribution; or

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
				- Funding for the development of a Port of Gladstone adaptive management plan for the threats to the Water mouse, identified in the threat abatement plans for predation by European red fox; predation, habitat degradation, competition and disease transmission by feral pigs; predation by feral cats; and to reduce the impacts on northern Australia's biodiversity by the five listed grasses.
			NLEP SRA Project Stage 1 Offset Strategy Section 4.5 (seagrass and macroalgae)	The following summarises how the condition 36 requirements have been addressed for seagrass and macroalgae: • Within 6 months of completing the Project seagrass and macroalgae monitoring (refer REMP Section 8.3), GPC will engage a suitably qualified ecologist to prepare a report (for the Minister's approval) which quantifies the significant residual indirect impacts on seagrass and macroalgae on the findings of the Project seagrass and macroalgae monitoring program (refer REMP Section 8.3) and the Project hydrodynamic changes monitoring plan (refer REMP Section 8.9) • If there is found to be a significant residual impact for the Project indirect impacts on seagrass and macroalgae from the construction of the NELP SRA, GPC will provide the environmental offset detail in the revised NLEP SRA Project Stage 1 Offset Strategy to the Minister for approval within 12 months of submitting the Project seagrass and macroalgae significant residual impact assessment report.

Ref	Cond. no.	EPBC Act controlled action condition requirement relevant to NLEP SRA Project Stage 1 Offset Strategy	NLEP SRA Project Stage 1 Offset Strategy, REMP and/or specific Project MNES offset strategy reference	How the NLEP SRA Project Stage 1 Offset Strategy addresses condition requirements and commitments made in the strategy to address condition requirements
30.	37	To compensate for significant residual impacts to Green Turtle foraging habitat, Dugong habitat and Australian Humpback Dolphin habitat in Project Stage 1, the approval holder must provide an additional offset in accordance with Environmental Offsets Policy, unless the Minister is satisfied that the offsets provided under Conditions 34 and 36 will adequately compensate for impacts to these species. Any offset must be in accordance with the approved Project Stage 1 Offset Strategy and be provided to the Minister for approval within 12 months of submitting the report required under Condition 19.	NLEP SRA Project Stage 1 Offset Strategy Section 7	The following summarises how the condition 37 requirements have been addressed: • The Project seagrass and macroalgae monitoring completion report (refer Section 4.5), will include a significant impact assessment in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013) (taking into account the implementation of the Project seagrass and macroalgae offset detailed in Section 4.3) on the NLEP SRA impacts to Green turtle foraging habitat, Dugong habitat and Australian humpback dolphin habitat • If the findings of the significant impact assessment result in an additional significant residual impact on Green turtle foraging habitat, Dugong habitat and/or Australian humpback dolphin habitat, GPC will provide an additional offset in accordance with the CD Project EPBC Act controlled action approval condition 37 • Any changes to the environmental offset for this matter will be provided in the revised NLEP SRA Project Stage 1 Offset Strategy to the Minister for approval within 12 months of submitting the Project seagrass and macroalgae significant residual impact assessment report.
31.	71	The approval holder may at any time, apply to the Minister for a variation to a management plan, program or strategy approved by the Minister by submitting an application in accordance with the requirements of section 143A of the EPBC Act. If the Minister approves a revised management plan, program or strategy then, from the date specified, the approval holder must implement the revised management plan, program or strategy in place of the previous action management plan.	NLEP SRA Project Stage 1 Offset Strategy Section 8	The following summarises how the condition 71 requirements have been addressed: • Should it become necessary to update the NLEP SRA Project Stage 1 Offset Strategy to incorporate additional information obtained through the implementation and performance monitoring of the Offset Strategy, any revision will be subject to an application to the Minister for a variation to the Offset Strategy in accordance with condition 71 of the CD Project EPBC Act controlled action approval.

3 Summary of NLEP SRA Eastern Curlew Offset Strategy

3.1 Purpose and scope

The NLEP SRA Eastern Curlew Offset Strategy has been prepared to allow GPC to deliver an environmental offset in accordance with the CD Project EPBC Act controlled action conditions 30 to 33 (refer Table 2 for details of conditions) and have alignment and consistency with the following relevant offset compliance documents:

- Reef 2050 (refer Section 3.8.1);
- Offset Policy (refer Section 3.8.2);
- Eastern curlew conservation advice (refer Section 3.8.3);
- Threatened Species Action Plan 2022-2032 (DCCEEW, 2022b) (refer Section 3.8.4); and
- Vulnerability Assessment for the Great Barrier Reef: Shorebirds (Great Barrier Reef Marine Park Authority, 2011) (refer Section 3.8.5).

3.2 Assessment of significant residual impact to be offset

The total quantum of direct and indirect significant residual impact of the Project on Eastern curlew habitat is 121.24 ha of intertidal mudflat foraging habitat that includes:

- A direct impact through the permanent loss of 107.06 ha of intertidal mudflat foraging habitat for the establishment of the NLEP-SRA outer bund wall and the reclamation area enclosed within the outer bund wall; and
- An indirect impact through the permanent loss of 14.18 ha of intertidal mudflat foraging habitat once hydrodynamic changes create a permanent narrow channel adjacent to the outer bund wall.

Baseline surveys found that an average of approximately 2.3 Eastern curlew (maximum of 6) use the Project impact area for foraging at low tide during the summer months when most Eastern curlew are present in Australia.

The indirect impact of 14.18 ha (predicted impact area) of intertidal mudflat foraging habitat from hydrodynamic changes that will create a permanent narrow channel adjacent to the outer bund wall, will be confirmed as part of the Project hydrodynamic changes monitoring plan (refer REMP Section 8.9) required under condition 14 (c) (quantifying the impact of hydrodynamic changes) and condition 19 (significant impact assessment).

3.3 Offset strategy description

The NLEP SRA Eastern Curlew Offset Strategy comprises two components, including:

- Creation of a migratory shorebird roost, appropriate for the Eastern curlew, on part of the established NLEP SRA (refer Section 3.3.1); and
- Management of threats to Eastern curlew and Eastern curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern curlew habitat to improve habitat for the Eastern curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern curlew as part of a regionalised approach to threat abatement (refer Section 3.3.2).

The sections below provide a summary of the key components of the NLEP SRA Eastern Curlew Offset Strategy. Further details on the offset strategy are provided in the *Eastern Curlew Offset Strategy: Northern Land Expansion Project – Southern Reclamation Area, Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project* (BAAM Ecological Consultants, 2024).

3.3.1 Artificial roost

To maintain flexibility and continuous availability of a roost site suitable for Eastern curlew across the WBRA and NLEP SRA and to ensure a smooth transition between the currently used artificial roost in the northern bund of the WBRA and a new roost on the established NLEP SRA, a two-stage approach will be implemented for the artificial roost component of the NLEP SRA Eastern Curlew Offset Strategy.

In Stage 1, a minimum 10 ha area (approximately 450 metres (m) x 250 m) of the currently used roost site in the northern bund of the WBRA will be maintained as a suitable artificial roost until after the completion of construction of the NLEP SRA bund wall.

In Stage 2, at least one year prior to the artificial roost in the northern bund of the WBRA needing to be capped to meet port development demand, a suitable artificial roost will be created on the established NLEP SRA.

The Stage 2 roost will be created initially by beneficially using dredged material to create a raised island within the northern portion of the NLEP SRA. At this stage, the NLEP SRA is expected to remain tidally influenced so the island will be built sufficiently high to ensure at least 1 ha of bare substrate remains above the highest astronomical tide (HAT) and the island has a shallow incline to ensure it is surrounded by shallow water that Eastern curlew can stand in on all high tides. The placement of the dredge material to form the island will be a component of the Project Stage 2 dredging. A fine sediment monitoring program for Project Stage 2 will be in place during the construction of the artificial roost. If the monitoring shows that the construction of the roost has resulted in release of fine sediment into the harbour, a fine sediment offset will be provided to meet the CD Project EPBC Act controlled action condition 19 (d).

Over time, the Stage 2 roost site will become confined to an area of at least 10 ha in size in the north of the NLEP SRA to ensure the long-edge of the roost is adjacent to the seaward boundary wall. The artificial roost will be constructed and managed to meet the recommended design principles for an Eastern curlew artificial roost as identified by technical advice from Professor Richard Fuller (Fuller, 2021), a shorebird expert at the University of Queensland.

3.3.2 Spadely offset management area

In late 2023, the Queensland Parks and Wildlife Service (QPWS) acquired the three properties below in the north-west corner of Curtis Island with a combined area of 1,635 ha:

- Spadely Station;
- A smaller adjoining property known as Grassy Hill; and
- A nearby property at Warners Point.

This acquisition also allowed QPWS to access the North Curtis Island State Forest (581 ha), since Spadely Station separates North Curtis Island State Forest from other lands managed by QPWS.

The three properties (i.e. Spadely Station, Grassy Hill, Warners Point) and North Curtis Island State Forest (hereafter referred to as the Spadely offset management area) adjoin approximately 2,693 ha of intertidal habitats, including:

- 2,121 ha of saltmarsh/saltpan and unconsolidated or consolidated tidal flat habitat that supports known foraging and roosting habitat for Eastern curlew;
- 572 ha of mangroves that serve as nursery areas; and
- Provide important nutrient inputs for the benthic invertebrates that Eastern curlew feed on.

Surveys conducted for the Ecosystem Research and Monitoring Program, funded by GPC has found an average of 298 Eastern curlew roosting on Curtis Island during the period of the year when most Eastern curlew are present, including an average total of 181 in north Curtis Island, of which an average total of 81 used roost sites adjacent to the Spadely offset management area. Eastern curlew typically use roost sites close to their foraging areas; therefore, a similar number of Eastern curlew are expected to use the extensive areas of tidal flat and saltpan foraging habitat that is present around the coastline of Curtis Island.

Most of the intertidal lands adjoining the Spadely offset management area are without tenure and therefore cannot be acquired and secured under traditional tenure protection arrangements. They are however part of the Great Barrier Reef Coast Marine Park, which QPWS also administers. Furthermore, the habitat condition of these non-tenured intertidal lands can benefit from sympathetic land management of the adjoining tenured areas that they are directly connected to. The significant conservation values of Curtis Island, including Eastern curlew habitats, are threatened by a variety of feral animals.

The acquisition of Spadely Station and Grassy Hill by QPWS provides an opportunity for QPWS to expand feral animal control operations to both Spadely Station and North Curtis Island State Forest, which currently serve as the last remaining large refuge for feral animals in the northern half of Curtis Island.

The second component of the NLEP SRA Eastern Curlew Offset Strategy is therefore focussed on implementing intensive feral animal control within the combined area of the Spadely offset management area (covering 2,216 ha) to improve the quality of adjoining intertidal habitats for Eastern curlew. Feral animal control will focus on feral pigs, foxes, wild dogs, feral cats, feral cattle and feral horses that are all known to occur on Curtis Island. GPC will provide an annual funding contribution to QPWS to conduct feral animal control for at least 20 years. The offset completion will be maintained until expiry of the approval.

3.3.3 Offset Acquittal

The habitats used by Eastern curlew are generally intertidal and therefore marine in nature. The EPBC Act Offset Assessment Guide (EPBC Act OAG) is not designed for marine offsets and therefore a bespoke offset assessment method was designed to fit as closely as possible to the EPBC Act OAG to demonstrate offset acquittal. Using this method, offset acquittal was calculated based on the number of Eastern curlew individuals impacted on the one hand and benefitting from the offset actions on the other hand.

The artificial roost component of the offset will construct an artificial roost suitable for Eastern curlew that will occupy an area of 10 ha within the impact area of the NLEP SRA. The artificial roost is expected to provide an alternative roosting site for an average of at least 30 Eastern curlew during the summer months, to provide an offset acquittal of 75.10% of the NLEP SRA impact on Eastern curlew habitat.

Feral animal control within the Spadely offset management area is predicted to increase Eastern curlew use of intertidal habitats in the offset target area adjoining the offset management area by at least 10%, to provide an offset acquittal of 25.03% of the NLEP SRA impact on Eastern curlew habitat.

3.4 Management objectives and actions

3.4.1 Artificial roost

The management objective of the artificial roost component of the NLEP SRA Eastern Curlew Offset Strategy is to construct and maintain a migratory shorebird roost, suitable for the Eastern curlew, on part of the established NLEP SRA, timed to ensure the continuous availability of a suitable artificial roost within the dredge reclamation areas of the WBRA and/or NLEP SRA.

To meet this objective, the NLEP SRA Eastern Curlew Offset Strategy outlines the management actions and their timing and frequency of implementation, together with the performance criteria, monitoring indicators, triggers for adaptive management and corrective actions to ensure an adaptive management approach. Table 4 details the performance targets for this component of the offset.

***Table 3**: Performance targets for the artificial roost offset component*

Year 5 interim performance target	Year 10 interim performance target	Year 15 interim performance target	Year 20 performance target
The artificial roost accounts for at least 75% of the impact (using the offset assessment method). An average of at least 30 Eastern curlew use the artificial roost during the summer months*.	The artificial roost accounts for at least 75% of the impact (using the offset assessment method). An average of at least 27.9 Eastern curlew use the artificial roost during the summer months, accounting for the background rate of population change*.	The artificial roost accounts for at least 75% of the impact (using the offset assessment method). An average of at least 25.9 Eastern curlew use the artificial roost during the summer months, accounting for the background rate of population change*.	The artificial roost accounts for at least 75% of the impact (using the offset assessment method). An average of at least 24.1 Eastern curlew use the artificial roost during the summer months, accounting for the background rate of population change*.

Table note: * = The background rate of population change is assumed to be -1.46% per year based on the estimate of (Rogers et al. 2023) for the most recent period 2012-2021 but will use updated estimates for the most relevant periods as they become available.

3.4.2 Spadely offset management area

The management objective of the Spadely offset management area component of the NLEP SRA Eastern Curlew Offset Strategy is to manage threats to Eastern curlew and Eastern curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern curlew habitat to improve habitat for the Eastern curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern curlew as part of a regionalised approach to threat abatement.

The feral animal control program will be undertaken by QPWS using financial support provided by GPC. QPWS will use a combination of control methods that have proven to be successful for feral animal control on Curtis Island, including aerial and ground shooting, soft jaw foothold trap lines and baiting. To meet the management objective for the Spadely offset management area, the NLEP SRA Eastern Curlew Offset Strategy outlines the management actions and their timing and frequency of implementation, together with the performance criteria, monitoring indicators, triggers for adaptive management and corrective actions to ensure an adaptive management approach. Table 4 details the performance targets for this component of the offset.

***Table 4**: Performance targets for the Spadely offset management area*

Year 5 interim performance target	Year 10 interim performance target	Year 15 interim performance target	Year 20 performance target
The change in Eastern curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method). An average of at least 54.7 Eastern curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method) An average of at least 50.8 Eastern curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method). An average of at least 47.2 Eastern curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method). An average of at least 43.9 Eastern curlew use the offset target area during the summer months, accounting for the background rate of population change*.

Table note: * = The background rate of population change is assumed to be -1.46% per year based on the estimate of (Rogers et al. 2023) for the most recent period 2012-2021 but will use updated estimates for the most relevant periods as they become available.

3.5 Monitoring program

The monitoring program for both components of the Project Eastern curlew offset will include monitoring of feral animal occurrence as well as monitoring of Eastern curlew use of habitats within or adjoining the Spadely offset management area and WBRA and/or NLEP SRA artificial roost as a direct measure of offset success. The frequency of occurrence of feral animals will be monitored in a standardised way using trail cameras.

A baseline assessment of the frequency of occurrence of feral animals will be undertaken over a 2-month period prior to the initiation of feral animal control within the Spadely offset management area. To monitor the success of feral animal control in reducing feral animal activity, the timing and frequency of the monitoring program is outlined in Table 5.

***Table 5**: Monitoring methods, timing and frequency of monitoring*

Component	Method	Timing	Frequency
Frequency of occurrence of feral animals – Spadely offset management area	Four trail cameras monitoring for two months	Within the period mid-October to mid-March when most Eastern curlew are present	Once, prior to feral animal control Annually from Year 1 to Year 10, biennial from Year 12 to Year 20
Frequency of occurrence of feral animals – artificial roost	One trail camera monitoring for two months at the WBRA and/or NLEP SRA	Within the period mid-October to mid-March when most Eastern curlew are present	Once each year from Year 1 to Year 20 of the offset
Monitoring Eastern curlew – Spadely offset management area	Observational surveys at high tide and low tide	Within the period mid-October to mid-March when most Eastern curlew are present	Twice each year from Year 1 to Year 5, once each year from Year 6 to Year 10, biennial from Year 12 to Year 20
Monitoring Eastern curlew – artificial roost	Observational surveys at high tide, covering the WBRA and/or NLEP SRA	Within the period mid-October to mid-March when most Eastern curlew are present	Monthly from one month prior to the start to one month after the end of construction of the NLEP SRA boundary wall*

Component	Method	Timing	Frequency
			Once each year from completion of the NLEP SRA boundary wall to Year 10, biennial from Year 12 to Year 20

Table note: * = This monthly monitoring of roost sites in the WBRA and NLEP SRA is already a component of the NLEP SRA construction monitoring program.

3.6 Reporting

An annual report will be prepared each year for the NLEP SRA Eastern Curlew Offset Strategy. The report will include the following information at a minimum:

- CD Project EPBC Act approval number;
- An overview of the management activities undertaken through the reporting year together with a summary of the numbers of feral animals removed from the Spadely offset management area and WBRA and/or NLEP SRA;
- Results of monitoring for the reporting year;
- Comparison of the monitoring results for the current year of reporting with the monitoring results from the previous years of reporting, including comparison with the baseline monitoring results;
- Progress towards achieving the performance targets;
- A description of any relevant performance criteria that were not satisfied and, where triggered, the corrective actions that have been implemented or are planned to be implemented in the subsequent year of management;
- An assessment of any risks or potential threats to the successful delivery of the offset that have become apparent through monitoring, and actions to be undertaken to manage any threats and risks; and
- If required, recommendations to be incorporated into the NLEP SRA Eastern Curlew Offset Strategy, including changes to management and monitoring methods.

3.7 Significant impact assessment

A significant impact assessment for the Project indirect impacts on Eastern curlew habitat will be undertaken by a suitably qualified ecologist to address the CD Project EPBC Act controlled action approval condition 19 (a).

The Project Eastern curlew habitat significant indirect impact assessment will be based on the following:

- The findings of the Project Eastern curlew and other shorebird monitoring program (refer REMP Section 8.7);
- The findings of the Project hydrodynamic changes monitoring plan (refer REMP Section 8.9); and
- The *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013).

In accordance with the CD Project EPBC Act controlled action approval condition 19 (a), the Project Eastern curlew habitat significant residual impact assessment report will be submitted by GPC to the DCCEEW within 6 months following the completion of the Project Eastern curlew and other shorebird monitoring program for the Minister's approval.

In accordance with the CD Project EPBC Act controlled action approval condition 32, GPC will compensate for the significant residual impacts to Eastern curlew habitat from the construction of the NELP SRA. Any changes to the environmental offset for this matter will be provided in the revised NLEP SRA Project Stage 1 Offset Strategy to the Minister in accordance with the CD Project EPBC Act controlled action approval condition 71.

3.8 Alignment with Reef 2050, EPBC Act Environmental Offset Policy and conservation advice

3.8.1 Reef 2050

Table 6 summarises the NLEP SRA Eastern Curlew Offset Strategy alignment with the relevant work areas and associated goals, strategic actions and enablers of Reef 2050.

***Table 6**: Summary of NLEP SRA Eastern Curlew Offset Strategy alignment with Reef 2050*

Relevant Reef 2050 work area (bold) and associated goals, strategic actions, and enablers (italics)	NLEP SRA Eastern Curlew Offset Strategy alignment details
Limit the impacts of climate change by contributing to global efforts to reduce greenhouse gas emissions, fostering partnerships and stewardship for climate mitigation, increasing the capacity of Reef communities, Traditional Owners and industries to adapt to a changing climate and supporting species and habitats to adapt to a changing climate.	Managing threats to Eastern curlew habitat in an area with extensive intertidal areas and low-lying marine plains that provide potential for tidal flat foraging habitat in the GBRWHA to migrate with rising sea levels, an identified priority for mitigating climate change impacts on shorebirds, including Eastern curlew.
Reduce impacts from land-based activities by improving water quality through increased effective land management practices in catchments, reducing cumulative impacts through integrated catchment-to-Reef management, and reducing lighting and recreational impacts on sensitive shoreline ecosystems and cultural sites	The control of feral pigs and livestock within a catchment of the GBRWHA that will reduce soil disturbance and thereby improve water quality entering the GBRWHA. Monitoring of Eastern curlew use of habitats will improve knowledge of sensitive shoreline ecosystems and inform conservation planning for these areas.
Reduce impacts from water-based activities by enhancing biodiversity and heritage protection and supporting ecosystem resilience through strengthened efforts to ensure water-based activities are sustainable, supporting Traditional Owners to continue to manage sea Country, reducing threats associated with legal and illegal fishing, reducing noise pollution and artificial light impacts from sources within and adjacent to the Marine Park, reducing new outbreaks of disease and preventing incursions of introduced species and pests, and reducing marine debris, rubbish pollution and at-sea disposal of waste.	The construction of an artificial roost will provide a safe roost site protected from potential disturbance associated with water-based activities. Monitoring of Eastern curlew use of habitats will improve knowledge of sensitive shoreline ecosystems and inform conservation planning for these areas.
Protect, rehabilitate and restore by reducing outbreaks of pests, introduced species and disease, actively rehabilitating or restoring key habitats, and conserving historic and cultural heritage sites.	The management of feral animals will protect and restore by reducing introduced species and restore key habitats.
Enable **collaboration and partnerships** to maintain and increase adoption of best-practice voluntary compliance and stewardship behaviours and ensuring Traditional Owner Indigenous heritage, rights and responsibilities are incorporated into all facets of management.	The strategy enables collaboration and partnership with QPWS to deliver best-practice feral animal control. The QPWS has a Memorandum of Understanding with the Gidarjil Development Corporation for participation and involvement by Land and Sea Country Rangers in marine park and national park management field operations.

Relevant Reef 2050 work area (bold) and associated goals, strategic actions, and enablers (italics)	NLEP SRA Eastern Curlew Offset Strategy alignment details
Enable **science and knowledge** to ensure science and knowledge are advanced, easily accessible and able to be used in decisions.	The monitoring program will contribute data to enable science and knowledge of feral animal control, Eastern curlew use of habitats and population trends that will be accessible and able to be used in decisions.
Enable **monitoring, evaluation and adaptive management** to support informed and agile management responses.	The strategy includes a monitoring program and adaptive management mechanisms to support informed and agile management responses.
Enable **investment** to support delivery of the Reef 2050 Plan.	The strategy includes investment by GPC in feral animal control and monitoring on Curtis Island that will contribute to delivery of components of the Reef 2050 Plan.

3.8.2 EPBC Act Environmental Offset Policy (2012)

Table 7 summarises the NLEP SRA Eastern Curlew Offset Strategy compliance with the principles of the Offset Policy to compensate for significant residual impacts on Eastern curlew habitat.

***Table 7**: Summary of NLEP SRA Eastern Curlew Offset Strategy compliance with the principles of the Offset Policy*

Offset Policy principles	NLEP SRA Eastern Curlew Offset Strategy compliance details
Deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environmental law and affected by the action.	The offsets directly contribute to the ongoing viability of the Eastern curlew habitat impacted by: • Providing an artificial roost site close to known Eastern curlew feeding habitat in an area where Eastern curlew are known to require a safe roost site; and • Managing feral animals that are known to threaten Eastern curlew survival and the condition of known Eastern curlew habitats at a location (Spadely offset management area) that is a known stronghold for Eastern curlew in the Port Curtis region. QPWS observations suggest foxes and wild dogs currently have a pervasive presence across intertidal habitats adjoining the Spadely offset management area and research supports that these animals are predicted to reduce Eastern curlew use of these intertidal habitats due to an elevated risk of disturbance and predation (refer Section 3.4.2 for further details). ERMP monitoring data suggest an apparent 65% reduction in Eastern curlew use of roost sites adjoining the Spadely offset management area over the most recent 3 years of that monitoring. The residual impact was calculated to be 121.24 ha of foraging habitat used by an average of 2.3 (maximum of 6) Eastern curlew. The artificial roost is expected to provide an alternative roosting site for an average of 30 (up to 133) Eastern curlew during the summer months, to offset 75% of the impact. The Spadely offset management area is predicted to increase Eastern curlew use of intertidal habitats by at least 10%, to offset 25% of the impact.
Be built around direct offsets but may include other compensatory measures.	The strategy is built around direct offsets (refer Section 3.3).
Be in proportion to the level of statutory protection that applies to the protected matter.	The size and scale of the Eastern curlew offset was determined using a modified version of the EPBC Act OAG. This accounts for the level of statutory protection (critically endangered) of the Eastern curlew in calculating the offset requirement.

Offset Policy principles	NLEP SRA Eastern Curlew Offset Strategy compliance details
Be of a size and scale proportionate to the residual impacts on the protected matter.	The size and scale of the offset was determined using a modified version of the EPBC Act OAG that directly measures the impact in terms of the average number of Eastern curlew impacted and the offset in terms of the change in the number of Eastern curlew using habitats in response to the offset actions. This direct measure of conservation gain provides a particularly robust approach to demonstrating the scale of the offset in relation to the impact. It also considers the equivalency between impact and offset habitat, time to ecological benefit and confidence in the result to ensure the offset is proportional to the impact. The residual impact was calculated to be 121.24 ha of foraging habitat used by an average of 2.3 (maximum of 6) Eastern Curlew. The artificial roost is expected to provide an alternative roosting site for an average of 30 (up to 133) Eastern curlew during the summer months, to offset 75% of the impact. The Spadely offset management area is predicted to increase Eastern curlew use of intertidal habitats by at least 10%, to offset 25% of the impact.
Effectively account for and manage the risks of the offset not succeeding.	The risk assessment is outlined in detail in Section 6 of the NLEP SRA Eastern Curlew Offset Strategy (refer Appendix A). The offset strategy includes an adaptive management process and specific management actions that are proven to manage habitat and threatening processes effectively.
Be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs.	The artificial roost component is additional to what is already required. QPWS has confirmed that while QPWS aims to manage pest animals as part of its approach to managing all protected areas, QPWS has not managed to source funding for pest management in the Spadely acquisition. The offset provides consistent annual funding for at least 20 years and therefore meets the additionality principle.
Be efficient, effective, timely, transparent, scientifically robust and reasonable.	The size and scale of the offset was determined using a modified version of the EPBC Act OAG that directly measures the impact in terms of the average number of Eastern curlew impacted and the offset in terms of the change in the number of Eastern curlew using habitats in response to the offset actions. This direct measure of conservation gain provides a particularly robust approach to demonstrating the effectiveness of the offset. Eastern curlew are already using reclamation ponds in the WBRA for roosting in advance of the impact; with sympathetic management the Eastern curlew using the WBRA will be transitioned to using the dedicated long-term NLEP SRA artificial roost component, providing a timely offset. The conservation benefit of the Spadely feral animal control component of the offset is expected to be achieved within 5 years of the impact. The offset assessment method and overall strategy was developed and peer-reviewed by relevant experts to ensure it is transparent, scientifically robust and reasonable. The strategy relies on specific management actions that are proven to manage habitat and threatening processes efficiently and effectively.
Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.	The offset strategy outlines a clear governance framework and delivery pathway to manage marine offsets and ensure the offset is monitored and audited/enforced in accordance with the CD Project EPBC Act approval conditions.

3.8.3 Conservation advice actions and priorities

Table 8 summarises how the NLEP SRA Eastern Curlew Offset Strategy has taken into account the relevant Eastern curlew conservation advice actions and priorities.

***Table 8**: Summary of how the NLEP SRA Eastern Curlew Offset Strategy has taken into account the relevant Eastern curlew conservation advice actions and priorities*

Conservation advice actions and priorities	NLEP SRA Eastern Curlew Offset Strategy compliance details
Support initiatives to improve habitat management at key sites.	The strategy will improve habitat management in north Curtis Island, which has been identified as a key site for Eastern curlew.
Maintain and improve protection of roosting and feeding sites in Australia.	The strategy will maintain and improve protection of roosting and feeding sites on Curtis Island from feral animal impacts and construct a protected roost site suitable for Eastern curlew.
Incorporate requirements for Eastern curlews into coastal planning and management.	The strategy incorporates requirements for Eastern curlews into coastal management by improving the protection of roosting and feeding sites on Curtis Island from feral animal impacts and constructing a protected roost site suitable for Eastern curlew.
Manage important sites to identify, control and reduce the spread of invasive species.	The management of feral animals on north Curtis Island will control and reduce the spread of invasive species.
Manage disturbance at important sites when Eastern curlews are present (e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures).	The control of feral animals on north Curtis Island will manage disturbance to Eastern curlews and habitat degradation from feral animals. The offset strategy monitoring program will include monitoring of disturbance at important roost sites that can inform subsequent management of these sites.
Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.	The offset strategy includes a monitoring program to support adaptive management.
Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia.	The offset strategy includes a monitoring program that will monitor Eastern curlew populations in areas not included in existing shorebird population monitoring programmes.
More precisely assess Eastern curlew life history, population size, distribution and ecological requirements particularly across northern Australia.	The monitoring of Eastern curlew included in the offset strategy will collect data relevant to the assessment of population size and distribution.
Improve knowledge about threatening processes including the impacts of disturbance and hunting.	The offset strategy includes a monitoring program that will collect information on threatening processes, including feral animals and disturbance.

3.8.4 Threatened Species Action Plan

Table 9 summarises how the NLEP SRA Eastern Curlew Offset Strategy has taken into account the relevant Threatened Species Action Plan 2022-2032 targets.

***Table 9**: Summary of how the NLEP SRA Eastern Curlew Offset Strategy has taken into account the relevant Threatened Species Action Plan targets*

Threatened Species Action Plan target	NLEP SRA Eastern Curlew Offset Strategy compliance details
All priority species are on track for improved trajectory.	The Eastern curlew is a listed priority species.
Species at high risk of imminent extinction are identified and supported to persist. Impacts of climate change on priority species and places are identified and actions are underway to strengthen resilience and adaptive capacity.	The offset strategy supports Eastern curlew to persist by managing threats to Eastern curlew habitat in an area that has been identified as a stronghold for the species and that has extensive intertidal areas and low-lying marine plains that provide potential for tidal flat foraging habitat in the GBRWHA to migrate with rising sea levels, an identified priority for mitigating climate change impacts on shorebirds, including Eastern curlew.
The area managed for conservation is increased by 50 million hectares.	The offset strategy works cooperatively with a conservation land manager (QPWS) to improve the conservation and condition of important habitat for a priority species.
Feral cats and foxes are managed across all important habitats for susceptible priority species using best practice methods.	The Eastern curlew is a listed priority species and a major component of the offset strategy involves the control of feral animals, including feral cats and foxes using best practice methods at important habitats for Eastern curlew.
First Nations' Knowledges are integrated in conservation assessments, processes and planning for threatened species and ecological communities. First Nations-led recovery activities for threatened species and ecological communities are increased.	The QPWS will be undertaking feral animal control consistent with a Memorandum of Understanding between Gidarjil Development Corporation and QPWS for participation and involvement by Land and Sea Country Rangers in marine park and national park management field operations.
Emergency response management and planning for critical biodiversity assets improves across jurisdictions.	The provision of financial support for feral animal management allows QPWS to use its limited budget for other management activities, including fire and emergency response management and planning for critical biodiversity assets on Curtis Island.
At least half the number of projects that benefit priority species and priority places receive private investment or support from partners.	The offset strategy provides private investment in a project that benefits Eastern curlew, a priority species.

3.8.5 Vulnerability Assessment for the Great Barrier Reef: Shorebirds

Table 10 summarises how the NLEP SRA Eastern Curlew Offset Strategy has taken into account the relevant suggested actions within the Vulnerability Assessment for the Great Barrier Reef: Shorebirds (Great Barrier Reef Marine Park Authority, 2011).

***Table 10**: Summary of how the NLEP SRA Eastern Curlew Offset Strategy has taken into account the relevant suggested actions within the Vulnerability Assessment for the Great Barrier Reef: Shorebirds*

Vulnerability Assessment for the Great Barrier Reef – shorebirds suggested action	NLEP SRA Eastern Curlew Offset Strategy compliance details
Continue long-term monitoring programs that provide vital information on population trends and breeding success for shorebirds used to inform management decisions.	Monitoring of Eastern curlew as part of the offset strategy will continue components of a monitoring program that has operated since 2011.
Continue natural resource management (control of pest flora and fauna and maintain the ecological influence of fire) and monitoring of key foraging, nesting and roosting sites for shorebirds through the Field Management Program and partnerships with nongovernment waterbird conservation groups.	The offset strategy includes control of pest fauna as well as monitoring of key foraging and roosting sites for shorebirds on Curtis Island, part of the GBRWHA.
Support and facilitate collaborations on shorebird research and monitoring programs with data-set custodians and researchers.	The monitoring program will capture data on shorebird use of habitats in areas not included in existing shorebird population monitoring programmes. The monitoring data will become available for researchers.
Implement effective management on a local and regional scale, such as protection of key foraging, roosting and nesting habitat.	The offset strategy will implement effective management of feral animals and thereby contribute to and enhance a whole-of-island management approach to improving management outcomes for key shorebird habitats on Curtis Island.
Advocate for increased protection for important shorebird habitats outside of current conservation reserves within (and adjacent to) the GBRWHA, in recognition of their important conservation value.	The offset strategy includes increased protection of important shorebird habitats from the impacts of feral animals within the GBRWHA.
Continue to monitor other key threats to shorebirds through the joint Australian and Queensland governments' Field Management Program for the GBRWHA and implement best-practice responses to minimise the impacts of these threats. Key threats that require a management focus within the World Heritage Area come from visitor disturbance and marine debris.	The offset strategy monitoring program will contribute to monitoring feral animals as well as monitoring disturbance to shorebirds, and the management program will implement best-practice management of feral animals to minimise their impacts on shorebirds on Curtis Island within the GBRWHA.

4 Summary of NLEP SRA Seagrass and Macroalgae Offset Strategy

4.1 Purpose and scope

The NLEP SRA Seagrass and Macroalgae Offset Strategy has been prepared to allow GPC to deliver an environmental offset in accordance with the CD Project EPBC Act controlled action conditions 30, 31 and 34 (refer Table 2 for details of conditions) and have alignment and consistency with the following relevant offset compliance documents:

- Reef 2050 (refer Section 4.6.1);
- Offset Policy (refer Section 4.6.2); and
- Relevant conservation advice (refer Section 4.6.3).

4.2 Hydrodynamic changes monitoring plan

A Project hydrodynamic changes monitoring plan has been developed to monitor and quantify impacts of hydrodynamic/morphological changes, including erosion, sedimentation, and channelisation, which may occur as a result of the construction of the NLEP SRA. Specifically, this monitoring program was developed to address the CD Project EPBC Act controlled action approval condition 14 (c).

In summary, the methods that will be used to assess morphological changes include:

- Bathymetric surveys of the channel to the west of the NLEP SRA will be undertaken immediately post completion of the construction. A follow up survey will be undertaken after three months post completion and then twice yearly for two years; and
- LiDAR or drone surveys of the shoreline to the west of the NLEP SRA immediately post construction and at six-monthly intervals for a period of two years.

A report outlining the quantification of Project hydrodynamic indirect impacts following completion of the NLEP SRA construction will be provided to the Minister within 6 months of the completion of the Project hydrodynamic changes monitoring plan. The Project hydrodynamic indirect impacts will provide one of the inputs into confirming the significant impact assessment for Project indirect impacts on seagrass and macroalgae (refer Section 4.5).

Further details on the Project hydrodynamic changes monitoring plan are provided in the REMP Section 8.9.

4.3 Summary of seagrass and macroalgae offset strategy

The *Northern Land Expansion Project: Environmental Offsets Strategy for Seagrass and macroalgae* (Project seagrass and macroalgae offset strategy) has been prepared by CQUniversity Coastal and Marine Ecosystems Research Centre (Jackson and Ostrowski, 2024) for GPC to address the CD Project EPBC Act controlled action approval conditions 30, 31 and 34 (refer Table 2 for details of conditions).

The relevant findings of the Project baseline seagrass and macroalgae monitoring program, undertaken in accordance with the CD Project EPBC Act controlled action approval conditions 11 (a) and (b), included:

- 55.04 ± 1.78 ha of Meadow 8 lies within the NLEP SRA footprint (representing a Project direct impact offset requirement of 55 ha);
- Seagrass within the NLEP SRA footprint comprises isolated patches of low-biomass *Halophila ovalis* and *H. decipiens*;

- Macroalgae was recorded throughout Meadow 8 within the NLEP SRA footprint, with filamentous algae being the most common algae recorded; and
- Macroalga coverage is 1.06 ha within the NLEP SRA footprint (representing a Project direct impact offset requirement of 1.1 ha).

Further details on the findings of the Project baseline seagrass and macroalgae monitoring program are provided in the REMP Section 7.3.2 and Smith *et al.* (2024).

Three projects are proposed to offset seagrass and macroalgal impacts as part of the NLEP SRA, including a direct seagrass offset, a direct macroalgae offset, and an indirect offset investigating the co-benefits of seagrass restoration (research component) and seaweed substrate optimisation (research component). Further details on the four offset projects are provided below.

4.3.1 Direct Offset Proposal: Enhancing Resilience of Degraded Seagrass at Pelican Banks

This project aims to restore the degraded seagrass meadow at Pelican Banks, the primary offset site, by enhancing seedbanks. Monitoring shows the area has not recovered from 2014 flood events. The initiative will focus on regions with low biomass and seedbanks to promote recovery and improve resilience against future disturbances.

The project aims to promote seagrass recovery through seed enhancement, expecting a more stable cover over time. Monitoring will focus on changes in area, landscape connectivity (aggregated vs. isolated patches), and seagrass persistence (enduring vs. transitory). Increased persistence and connectivity are anticipated to enhance biodiversity, improve sediment trapping, and boost carbon capture. Given the variability in seagrass cover, a robust sampling design will be employed using a Before-After Control-Impact approach for effective assessment.

Key stages of this project include:

- Year 1: Obtain permits, establish governance, collect seagrass spathes (flowers), extend SeaGrow nursery, and map baseline seagrass cover at target locations;
- Year 2: Collect baseline data on fish and bird habitats, initiate annual seed dispersal;
- Years 2-10: Annual seed dispersal and seagrass spathe collection;
- Years 3, 5, 7, 9: Conduct biannual monitoring and provide progress reports; and
- Year 5: Conduct a five-year review.

Completion of the offset will be achieved when the following criteria are met:

- By Year 20: At least 55.04 ha of intertidal *Z. muelleri* and mixed species must be rehabilitated, increasing biomass from ≤ 0.64 g DWm^{-2} to ≥ 5 g DWm^{-2} at the offset site (Meadow 43, Pelican Banks), compared to reference sites through repeated sowing;
- Rehabilitated areas are shown, over more than five years of biannual monitoring, to have greater persistence (from transitory to enduring, i.e. persist for > five years) compared to areas of no intervention (reference sites);
- Rehabilitated areas are shown, over more than five years of biannual monitoring, to have greater cohesion (less fragmentation or patchiness) compared to areas of no intervention (reference sites);
- Over five years of biannual monitoring, rehabilitated areas are shown to have increased in biomass from <0.64 to 5 g DWm^{-2} across the 55.04 ha of rehabilitated area (sufficient to support an estimated two dugongs over one year, and 114 turtles);
- More than one dugong feeding trail is observed in rehabilitated areas;

- Aerial surveys of turtles identify similar number using the rehabilitated areas compared to the reference areas; and
- Densities, species diversity and community composition of benthic invertebrates (epifauna and infauna) of rehabilitated areas are comparable to sites with no intervention (reference sites of similar biomass) and greater than the impacted site, to demonstrate increased food availability for foraging fish (available as food for dolphins).

The following interim completion targets will be used to assess the requirement for early intervention and adaptive management at 5 yearly review:

- By year 5, at least 10 ha of intertidal Z. muelleri with mixed species has been rehabilitated from a biomass ≤ 0.64 g DWm^{-2} to ≥ 5 g DWm^{-2} at the offset site (Meadow 43, Pelican Banks) compared to areas of no intervention (reference sites) through repeated sowing;
- By year 5 at least one dugong feeding trail is observed in rehabilitated areas;
- By year 5 densities, species diversity and community composition of benthic invertebrates (epifauna and infauna) of rehabilitated areas are greater than sites with no seagrass (unvegetated reference sites), to demonstrate increased food availability for foraging fish (available as food for dolphins);
- By year 10: Offset completion criteria (refer above for year 5) have been met in 20 ha of seagrass; and
- By year 15 Target: Offset completion criteria (refer above for year 5) have been met in 40 ha of seagrass.

A risk analysis and a risk management and mitigation strategy are in place to address potential risks to the successful implementation of the environmental offset and timely achievement of these completion criteria.

4.3.2 Direct Offset Proposal: Integrating Macroalgal Habitat into Seawall Design

This project aims to create 1.1 ha of macroalgal habitat on the NLEP SRA seawalls, specifically for brown algae, *Sargassum,* and red seaweed, *Asparagopsis taxiformis*. The goal is for 90% of this area (1 ha) to achieve at least 5% cover, while 10% (0.1 ha) should reach 40% cover.

The key project stages include:

1. Lab base selection of optimal substrate to maximise macroalgal cover;
2. Grow out of 'seeded' tiles in bunded area and to harden plants and select strains for the NLEP SRA environment;
3. Placement of algal-seeded substrate along the new NLEP SRA seawall; and
4. Conduct annual monitoring.

In the third year, recruitment to unseeded tiles will be assessed to inform the decision on whether to continue lab inoculation or rely on natural recruitment.

Completion of the offset will be achieved when the following criteria are met:

- By Year 5: Establish 0.1 ha of macroalgal habitat on the living seawall; and
- By Year 10: Achieve 1 ha of macroalgal habitat, with 80% of the area having at least 5% cover and 20% having 40% cover.

These targets signify a net gain in both area and coverage.

4.3.3 Indirect Offset Proposal: Co-Benefits of Restoration (Research Component)

This project aims to investigate blue carbon sequestration and other benefits arising from seagrass restoration. Large-scale seagrass restoration currently relies on funding from biodiversity offsets. Gathering data on the co-benefits of these restoration efforts is essential for attracting alternative funding sources, such as blue carbon credits, nature credits, reef credits, and sustainable seafood initiatives. The lack of specific data for the GBR presents a significant challenge for seagrass restoration. Further research would lead to benefits for the impacted seagrass by promoting an increase in seagrass restoration projects in the region, beyond those proposed by the current offset strategy.

To address this, it is proposed that GPC fund a PhD project to study changes in co-benefits from years two to five of the program. This research aims to provide insights into how restored seagrass ecosystems contribute to vital services, including carbon sequestration, nutrient cycling, habitat provision, and coastal protection. The findings will support the case for seagrass restoration as a conservation strategy, highlighting its socio-economic importance and offering evidence-based recommendations for future investments in conservation initiatives. Understanding these benefits is crucial for guiding conservation and management decisions to protect coastal habitats.

4.3.4 Indirect Offset Proposal: Seaweed Substrate Optimisation (Research Component)

This project seeks to identify optimal substrates to support the settlement, survival, and growth of local macroalgal species as a means to offset the ecological impact of seaweed loss. By fostering macroalgal establishment on artificial marine structures like seawalls, wharves, and breakwaters, this initiative aims to create new habitats that boost biodiversity and ecosystem resilience. Effective substrate selection is essential for successful macroalgal attachment and growth, helping restore lost ecological functions and biomass.

Macroalgae play a vital role in coastal ecosystems, providing habitat, food, and nutrient cycling services. To advance this work, GPC proposes funding a PhD project focused on identifying optimal substrate conditions for maximising germling settlement and growth in the Gladstone area and the Great Barrier Reef region.

4.4 Reporting

An annual report will be prepared each year for the NLEP SRA Seagrass and Macroalgae Offset Strategy. The report will include the following information at a minimum:

- CD Project EPBC Act approval number;
- An overview of the management activities undertaken through the reporting year together with a summary of the progress and status of the direct and indirect offsets;
- Results of monitoring for the reporting year;
- Comparison of the monitoring results for the current year of reporting with the monitoring results from the previous years of reporting, including comparison with the baseline monitoring results;
- Progress towards achieving the performance targets;
- A description of any relevant performance criteria that were not satisfied and, where triggered, the corrective actions that have been implemented or are planned to be implemented in the subsequent year of management;
- An assessment of any risks or potential threats to the successful delivery of the offset that have become apparent through monitoring, and actions to be undertaken to manage any threats and risks; and

- If required, recommendations to be incorporated into the NLEP SRA Seagrass and Macroalgae Offset Strategy, including changes to management and monitoring methods.

4.5 Significant impact assessment

A significant impact assessment for the Project sub-lethal and lethal indirect impacts to seagrass and macroalgae will be undertaken by a suitably qualified ecologist to address the CD Project EPBC Act controlled action approval condition 19 (c).

The Project seagrass and macroalgae significant impact assessment will be based on the following:

- The findings of the Project seagrass and macroalgae monitoring program, including monitoring 2 years post completion of the NLEP SRA (refer REMP Section 8.3);
- The findings of the Project hydrodynamic changes monitoring plan (refer REMP Section 8.9); and
- The *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013).

In accordance with the CD Project EPBC Act controlled action approval condition 19 (c), the Project seagrass and macroalgae significant residual impact assessment report will be submitted by GPC to the DCCEEW within 6 months following the completion of the Project seagrass and macroalgae monitoring program for the Minister's approval.

In accordance with the CD Project EPBC Act controlled action approval condition 34, GPC will compensate for the significant residual indirect impacts to seagrass and macroalgae from the construction of the NELP SRA. Any changes to the environmental offset for this matter will be provided in the revised NLEP SRA Project Stage 1 Offset Strategy to the Minister for approval in accordance with the CD Project EPBC Act controlled action approval condition 71.

4.6 Alignment with Reef 2050, offset policy and conservation advice

4.6.1 Reef 2050

Table 11 summarises the NLEP SRA Seagrass and Macroalgae Offset Strategy alignment with the relevant work area and associated strategic actions of Reef 2050.

***Table 11**: Summary of NLEP SRA Seagrass and Macroalgae Offset Strategy alignment with Reef 2050*

Reef 2050 work area (bold) and associated strategic actions	NLEP SRA Seagrass and Macroalgae Offset Strategy alignment details
Resilient seagrass meadows that maintain condition Populations of fish and invertebrate species that are important for recreational, commercial and culturally based fisheries are healthy	Pilot and implement interventions that support the resilience of coral reefs, seagrass, other marine habitats and islands, for example establishment of a state-of-the-art seagrass nursery facilities (propagation, seed storage, pest management), and seed-based seagrass restoration (also resulting in enhancement of fish habitat) in response to more frequent La Niña climate conditions and severe storms.
Traditional Owners caring for Country Local Traditional Owner land and sea management organisations are equipped to operate at the appropriate scale Strengthen Traditional Owner management of sea Country through agreements and partnerships	Gidarjil Development Corporation Sea Rangers working and training at the seagrass nursery and seagrass habitat restoration. Gidarjil Development Corporation Sea Rangers to ultimately manage the seagrass nursery facility and seagrass restoration activities in the region and beyond. The above specifically expands Indigenous land and sea ranger programs to additional areas to deliver on-ground activities, including compliance, marine monitoring and species protection and management.

The implementation of the NLEP SRA Seagrass and Macroalgae Offset Strategy will result in a net benefit to the GBRWHA by achieving seagrass restoration and resilience (e.g. Pelican Banks) resulting in a corresponding significant contribution to the OUV of the GBRWHA. Seagrass in the Port of Gladstone is an essential grazing area for Dugongs and turtles, fish habitat, foraging shorebird, and traps fine sediments and sequesters carbon at higher rates than terrestrial systems.

4.6.2 EPBC Act Environmental Offset Policy (2012)

Table 12 summarises the NLEP SRA Seagrass and Macroalgae Offset Strategy compliance with the principles of the Offset Policy to compensate for significant residual impacts on seagrass and macroalgae.

***Table 12**: Summary of NLEP SRA Seagrass and Macroalgae Offset Strategy compliance with the principles of the Offset Policy*

Offset Policy principles	NLEP SRA Seagrass and Macroalgae Offset Strategy compliance details
Deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environmental law and affected by the action	The primary aim of the NLEP SRA Seagrass and Macroalgae Offset Strategy is to achieve 'no net loss' of seagrass and macroalgae habitat and a net benefit to the GBRWHA by seagrass restoration and resilience (e.g. Pelican Banks) providing a significant contribution to the OUV of the GBRWHA. Seagrass in the Port of Gladstone is an essential grazing area for Dugongs and marine turtles, fish habitat, foraging shorebird, and traps fine sediments and sequesters carbon at higher rates than terrestrial systems.
Be built around direct offsets but may include other compensatory measures	The strategy is built around direct offsets.
Be in proportion to the level of statutory protection that applies to the protected matter	The proportion of the offset was determined by taking into consideration the level of statutory protection under the EPBC Act and the *Fisheries Act 1994* and the difficulty of offsetting the same NLEP SRA seagrass and macroalgae values lost elsewhere, the offset strategy proposes that the seagrass and macroalgae offsets include an option to rehabilitate existing meadows and create new seagrass as part of the NLEP SRA offset strategy.
Be of a size and scale proportionate to the residual impacts on the protected matter	The size and scale of the offset was determined based on residual significant impact on seagrass and macroalgae. Given the difficulty of offsetting the same NLEP SRA seagrass and macroalgae values lost elsewhere, the offset strategy proposes that the seagrass and macroalgae offsets include an option to rehabilitate existing meadows and create new seagrass as part of the NLEP SRA offset strategy. Despite NLEP SRA biodiversity offsets aiming to achieve 'no net loss', few offsets have been applied to seagrass restoration due to a lack of large-scale projects demonstrating confidence. Therefore, the proposed offset is proportionally bigger than the impact and also accounts for the level of confidence in the result. Consequently, the NLEP SRA Seagrass and Macroalgae Offset Strategy propose reseeding to more than five times the biomass of seagrass impacted by the NLEP SRA construction.
Effectively account for and manage the risks of the offset not succeeding	As stated above, the proposed offset is proportionally bigger than the impact and also accounts for the level of confidence in the result. Consequently, the NLEP SRA Seagrass and Macroalgae Offset Strategy propose reseeding to more than five times the biomass of seagrass impacted by the NLEP SRA construction. Following a review period (5 years), the success rate of the restoration will be assessed, and adjustments to the target area (i.e. increasing the area for rehabilitation and selecting more locations) will be applied where needed.

Offset Policy principles	NLEP SRA Seagrass and Macroalgae Offset Strategy compliance details
Be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs	The indirect offset research proposals are additional to what is already required. The research components of the offset include the co-benefits of restoration which aims to investigate blue carbon sequestration and other benefits arising from seagrass restoration, and seaweed substrate optimisation which seeks to identify optimal substrates to support the settlement, survival, and growth of local macroalgal species as a means to offset the ecological impact of seaweed loss.
Be efficient, effective, timely, transparent, scientifically robust and reasonable	A considerable body of research on the ecology and distribution of local seagrasses within the Port of Gladstone exists, together with assessments of sites that would benefit from restoration and methodologies that would support restoration interventions, including • Long-term monitoring data on other meadows in the region to identify meadows in decline, lost, or those unable to naturally recover; • Comprehensive data on the area of seagrass to be lost and a measure of its quality (e.g. density, biomass); • The connectivity between meadows, which is linked to recovery potential and identifying important sinks and sources in the population; • Reproductive effort of different populations and local phenology; • Data on the risk of disturbance of different meadows (including the potential for bi-stability); • Ecosystem function of different meadows and the services provided; and • Restoration methodologies developed for the local conditions and ecosystems. The offset strategy includes the pilot and implement interventions that support the resilience of coral reefs, seagrass, other marine habitats and islands, for example establishment of a state-of-the-art seagrass nursery facilities (propagation, seed storage, pest management), and seed-based seagrass restoration (also resulting in enhancement of fish habitat) in response to more frequent La Niña climate conditions and severe storms.
Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced	The offset strategy outlines a clear governance framework and delivery pathway to manage marine offsets and ensure the offset is monitored and audited/enforced in accordance with the CD Project EPBC Act controlled action approval.

4.6.3 Conservation advice

There are no approved conservation advice or threat abatement plans for seagrass and macroalgae meadows. However, certain species associated with seagrass do have recovery plans; for example, seagrass die off is identified in the Turtle Recovery Plan (Commonwealth of Australia, 2017) as impacting Green turtle foraging, with the loss of seagrass continuing to impact turtle health for several years. The Turtle Recovery Plan notes the influence of climatic factors, including the pulsed release of nutrients and fine sediments that quantify and predict the frequency of pulse flood events and their impacts on seagrass meadows. It also implements relevant mitigation measures, which the NLEP SRA Seagrass and Macroalgae Offset Strategy addresses.

5 Fine-grained sediment offset strategy

A Project FGS validation monitoring program has been developed in accordance with the CD Project EPBC Act controlled action approval condition 14 (f) to provide an estimate of the total amount of FGS that will be released to the marine environment due to the NLEP SRA bund wall construction, that was not previously available for resuspension. FGS is defined as sediment particles that are less than 15.6 micron in diameter.

No material with particles finer than 15.6 micron in diameter will be used in the construction of the new NLEP SRA perimeter bund wall. The finest-grained component of the construction material is fine sand, which will be composed of sediment grains larger than 75 microns in diameter. Any existing seabed material that is displaced or relocated during construction will be soft surface material that is already available for resuspension. Potential sources of resuspension of fine sediment from the construction are:

- Sediment release due to rock placement; and
- Scour and erosion of the seabed due to stronger currents around the end of the bund during construction and through the gap that remains prior to final closure of the bund.

The validation of the overall sediment release estimate will therefore involve analysing the data that is collected as part of the Project REMP to confirm that the measured turbidity during bund construction was in line with expectations given the estimated quantity of fine sediment release. Measurements of turbidity and particle size distribution will also be undertaken at an additional site close to the edge of the mudflat to provide additional data for the analysis. Baseline measurements of the flux of sediment entering the estuary from the mudflats to the north of the NLEP SRA will be undertaken using a boat-mounted ADCP, and additional measurements will be undertaken during similar tidal and weather conditions during construction to allow a comparison of the sediment fluxes.

Once the data has been collated, it will be analysed to confirm that the measured turbidity during construction was consistent with expectations (i.e. within the usual limits of variability observed in the Port of Gladstone, as observed in the long-term data). A statistical comparison of the baseline data and construction-period data will be undertaken. This will involve calculating the 20th, 50th and 80th percentiles of the turbidity time series within 14-day windows during the construction period, and determining where they lie within the statistical distribution of those same percentiles over a large number of 14-day windows in the baseline data. Any significant statistical anomaly that cannot be reasonably explained by a difference in the meteorological conditions will be identified. The estimated quantity of sediment release will be revised accordingly, if necessary.

At the conclusion of the construction of the NLEP SRA, a final report will be developed that uses the results of the monitoring program to confirm whether the estimated amount of fine sediment released was accurate. This report will address the requirements of the CD Project EPBC Act controlled action approval condition 19 (d), including the details of the FGS offset required for the construction of the NLEP SRA. Further details on the Project FGS validation monitoring program are provided in the REMP Section 8.10.

Potential FGS offset opportunities for the NLEP SRA that align with the Offset Policy include:

- **Option 1: Land rehabilitation of erosion prone stream banks to prevent sediment loss** – Multi-temporal analysis will be implemented to identify potential sites for further site-specific investigations preferably within the Fitzroy River and/or Calliope River catchments. The multi-temporal analysis enables a first pass identification of sites of significant change through streambank or gully erosion. Aerial imagery analysis will be used to develop a high-level understanding of the potential areas of erosion where there is no LiDAR coverage, or in conjunction with LiDAR data where available to assist in further understanding the landscape features, vegetation extent/condition, and geomorphic process and trajectory.

This FGS offset option will include a similar offset strategy, using the same methodology, as included in the GPC Clinton Vessel Interaction Project FGS Offset Plan (FBA and Alluvium, 2023).

- **Option 2: Payment into the Reef Trust** – The objective of the Reef Trust is to provide cost-effective, strategic investment in the protection and conservation of the GBR. The Reef Trust directs funding to deliver projects within the following four outcomes:
  - Outcome 1: Improve the quality of water entering the GBR from broad-scale land use to increase the health and resilience of the GBR;
  - Outcome 2: Improve the health and resilience of coastal habitats;
  - Outcome 3: Improve and protect marine biodiversity, including the reduction of Crown-of-Thorns Starfish (Acanthaster cf. solaris) and protection of listed threatened and migratory species such as Dugongs and marine turtles. Reef Trust funds may also be derived from the pooling of offset funds for actions that have a residual significant impact on matters of national and state environmental significance; and/or
  - Outcome 4: Any new development maintains or improves the condition of MNES and matters of state environmental significance through the strategic delivery of offsets through the Reef Trust.

  If this option is chosen for the NLEP SRA FGS offset, the financial contributions to the Reef Trust will be calculated using the Reef Trust calculator. Reef Trust investments are developed and implemented through a rigorous process of stakeholder engagement and prioritisation. Decisions are aligned to implementing Reef 2050 Plan work areas and enablers. The Reef Trust is an initiative administered by the Australian Government. Stringent financial, project management and reporting processes are in place.

- **Option 3: Enter into sediment offset arrangement through procurement of reef credits** – Reef credits are a voluntary environmental market scheme (Reef Credit Scheme) that financially rewards land managers within the GBR catchments for on-farm changes that measurably improve the quality of water flowing to the GBR resulting in a net benefit to the GBR World Heritage, marine threatened species and communities protected matters.

  The Reef Credit Scheme is managed by independent, not-for-profit company, Eco-Markets Australia. For a project or action to be eligible to earn reef credits, it must follow certain rules, the Reef Credit Standard, and be undertaken in a certain way using a particular method or methods. These rules are administered by Eco-Markets Australia to ensure the reductions in nutrient or sediment run-off can be measured and verified. All reef credit projects must be registered with Eco-Markets Australia to earn reef credits.

  A revised NLEP SRA Project Stage 1 Offset Strategy will be prepared following the completion of the Project FGS significant residual impact report, in accordance with the CD Project EPBC Act controlled action approval condition 19 (d). The revised NLEP SRA Project Stage 1 Offset Strategy will include the financial contribution amount, how the financial contributions have been calculated (e.g. Reef Trust calculator), and the proposition of the offset obligation that would be met by the financial contribution. Noting that 100% of any offset requirement that will or cannot be delivered through direct offsets will be provided through financial contributions). The revised NLEP SRA Project Stage 1 Offset Strategy will be submitted to the Minister for approval in accordance with condition71 of the CD Project EPBC Act controlled action approval.

Disclaimer: The options for offsetting for FGS will be based on acceptance of the Project FGS significant residual impact assessment report as required under the CD Project EPBC Act controlled action approval condition 19 (d). Suitable offset delivery options will be developed based on consultation with DCCEEW. This NLEP SRA Project Stage 1 Offset Strategy will be amended to address CD Project EPBC Act controlled action approval condition 35 and will be resubmitted to DCCEEW for the Minister's approval.

6 Water mouse significant impact assessment

The implementation of the Project Water mouse monitoring program in accordance with the CD Project EPBC Act controlled action approval condition 14 (d) will accurately monitor and quantify any changes to the extent, and location of Water mouse habitat, including foraging habitat and breeding places, during the NLEP SRA construction and until 2 years following completion of construction. Further details on the Project Water mouse monitoring program are provided in the REMP Section 8.4.2.

Within 6 months of completing the Project Water mouse monitoring completion report, GPC will engage a suitably qualified ecologist to prepare a report (for the Minister's approval) which quantifies the significant residual impacts on Water mouse habitat based on the Water mouse habitat impacted as determined by the Project Water mouse monitoring program.

In accordance with the CD Project EPBC Act controlled action approval condition 36, if there is found to be a significant residual impact for the Water mouse habitat from the construction of the NELP SRA, GPC will provide the environmental offset detail in the revised NLEP SRA Project Stage 1 Offset Strategy to the Minister for approval in accordance with the CD Project EPBC Act controlled action approval condition 71.

If the findings of the significant impact assessment for Project indirect impacts on Water mouse habitat result in a significant residual impact, specific Water mouse direct offset options will be identified and assessed, including providing a direct offset for Water mouse habitat informed by the National Recovery Plan and in accordance with the Offset Policy for Water mouse impact in the plan. Other potential Water mouse habitat indirect offset option examples to be assessed, which are consistent with the National Recovery Plan for the Water Mouse (*Xeromys myoides*) (DCCEEW, 2022a) include:

- Funding a Water mouse research program that involves research, monitoring and management actions that increase the understanding on how to reduce and mitigate the coastal development impacts on Water mouse habitat;
- Funding a Water mouse research program that addresses the gaps in knowledge about Water mouse ecology, detectability, the distribution and occurrence of Water mouse across its known and potential distribution; or
- Funding for the development of a Port of Gladstone adaptive management plan for the threats to the Water mouse, identified in the threat abatement plans for predation by European red fox; predation, habitat degradation, competition and disease transmission by feral pigs; predation by feral cats; and to reduce the impacts on northern Australia's biodiversity by the five listed grasses.

7 Green turtle, Dugong and Australian humpback dolphin significant impact assessment

In accordance with the CD Project EPBC Act controlled action approval condition 34, GPC will compensate for the significant residual impacts to seagrass and macroalgae from the construction of the NELP SRA. The Project seagrass and macroalgae offset strategy (refer Section 4.3) will provide an environmental offset for Green turtle foraging habitat, Dugong habitat and Australian humpback dolphin habitat.

The Project seagrass and macroalgae significant residual impact assessment report (refer Section 4.5), will include a significant impact assessment in accordance with the *Matters of National Environmental Significance – Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment, 2013) (taking into account the implementation of the Project seagrass and macroalgae offset detailed in Section 4.3) on the NLEP SRA impacts to Green turtle foraging habitat, Dugong habitat and Australian humpback dolphin habitat. If the findings of the significant impact assessment result in an additional significant residual impact on Green turtle foraging habitat, Dugong habitat and/or Australian humpback dolphin habitat, GPC will provide an additional offset in accordance with the CD Project EPBC Act controlled action approval condition 37.

Any changes to the environmental offset for this matter will be provided in the revised NLEP SRA Project Stage 1 Offset Strategy to the Minister for approval in accordance with the CD Project EPBC Act controlled action approval condition 71.

8 Offset Strategy review

The NLEP SRA Project Stage 1 Offset Strategy, including the NLEP SRA Eastern Curlew Offset Strategy, and NLEP SRA Seagrass and Macroalgae Offset Strategy will be reviewed twice each year to assess the performance of the offset strategies for the period of effect of the Offset Strategy approval by the Minister. The review of the Offset Strategy will assess the efficacy of current management actions and identify whether additional activities and responses to unexpected events or threats to the successful delivery of the NLEP SRA Project Stage 1 Offset Strategy are required.

Should it become necessary to update the NLEP SRA Project Stage 1 Offset Strategy to incorporate additional information obtained through the implementation and performance monitoring of the Offset Strategy, any revision will be subject to an application to the Minister for a variation to the Offset Strategy in accordance with condition 71 of the CD Project EPBC Act controlled action approval.

The biannual reviews will be finalised and published on GPC's website that is available to the public within two months of the 6-month and 12-month anniversary of the date of approval of the NLEP SRA Project Stage 1 Offset Strategy each year.

9 References

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10 Appendix A: NLEP SRA Eastern Curlew Offset Strategy

EASTERN CURLEW OFFSET STRATEGY

NORTHERN LAND EXPANSION PROJECT - SOUTHERN RECLAMATION AREA, PORT OF GLADSTONE GATCOMBE AND GOLDING CUTTING CHANNEL DUPLICATION PROJECT (CO22000089)

Prepared for
Gladstone Ports Corporation

Biodiversity Assessment and Management Pty Ltd
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BAAM
ECOLOGICAL CONSULTANTS

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Cover Page and Declaration of Accuracy (Proponent)

EPBC number: 2012/6558

Project name: Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (CD Project) Stage 1 (Project Stage 1 means any aspect of the construction of the barge unloading facility and the southern reclamation area), Gladstone, Queensland

Approval holder and ABN: Gladstone Ports Corporation Limited, ABN: 96 263 788 242

Approved action: To duplicate the existing Gatcombe and Golding Cutting shipping channel, disposal of capital dredge spoil to land reclamation, and upgrade associated infrastructure in the Port of Gladstone, Queensland (see EPBC Act referral 2012/6558 approved by the Minister on December 2020).

Location of the action: Port of Gladstone, Queensland

Declaration of accuracy

In making this declaration, I am aware that section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

This offset is not required under any other EPBC approvals or programs.

Signed	
Full name (please print)	Richard Haward
Organisation (please print)	Gladstone Ports Corporation Limited
Date	13/02/2025

Document Control Sheet

File Number: 0570-002b

Project Manager/s: Dr Penn Lloyd

Client: Gladstone Ports Corporation Limited

Project Title: Eastern Curlew Offset Strategy, Northern Land Expansion Project - Southern Reclamation Area, Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (CO22000089)

Project Author/s: Dr Penn Lloyd

Project Summary: An Eastern Curlew Offset Strategy has been prepared for Gladstone Ports Corporation Limited to deliver an environmental offset to compensate for impacts to habitat of Eastern Curlew (*Numenius madagascariensis*) to meet conditions of approval for the Northern Land Expansion Project - Southern Reclamation Area, Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (EPBC 2012/6558).

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0570-002b Version 6	12/02/2025	Penn Lloyd	Paulette Jones

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Signed on behalf of
Biodiversity Assessment and Management Pty Ltd

Date: 12/02/2025

Dr Penn Lloyd
Senior Principal Ecologist and Director

DECLARATION OF ACCURACY (AUTHOR)

I declare that:

1. To the best of my knowledge, all the information contained in, or accompanying this Eastern Curlew Offset Strategy is complete, current and correct.

2. I am aware that:

a. Section 490 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence for an approval holder to provide information in response to an approval condition where the person is reckless as to whether the information is false or misleading.

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c. The above offences are punishable on conviction by imprisonment, a fine or both.

Signed

Full name (please print)

Penn Lloyd

Organisation (please print)

Biodiversity Assessment and Management Pty Ltd

Date: 12/02/2025

Glossary

BAAM	Biodiversity Assessment and Management Pty Ltd
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
ERMP	Ecosystem Research and Monitoring Program
GBRWHA	Great Barrier Reef World Heritage Area
GPC	Gladstone Ports Corporation Limited
HAT	Highest astronomical tide
NLEP-SRA	Northern Land Expansion Project - Southern Reclamation Area
OAG	Offset assessment guide
QPWS	Queensland Parks and Wildlife Service
WBRA	Western Basin Reclamation Area

EXECUTIVE SUMMARY

BACKGROUND

Gladstone Ports Corporation Limited (GPC) is proposing to construct a new reclamation area outer bund wall, referred to as the Northern Land Expansion Project - Southern Reclamation Area (NLEP-SRA or Project), which has received Commonwealth and Queensland Government approvals as part of the Port of Gladstone Gatcombe and Golding Cutting Channel Project. The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) approval for the construction of the NLEP-SRA associated with the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (EPBC 2012/6558) requires GPC to comply with several conditions with regards to offsets for significant residual impacts on Eastern Curlew (*Numenius madagascariensis*), which is listed as a critically endangered threatened bird species under the EPBC Act. GPC commissioned Biodiversity Assessment and Management Pty Ltd (BAAM) to prepare an Eastern Curlew offset strategy to address the conditions of approval of EPBC 2012/6558 related to the provision of offsets for the significant residual impacts of the Project on Eastern Curlew.

PURPOSE AND SCOPE

This Eastern Curlew Offset Strategy has been prepared for GPC to deliver an environmental offset consistent with the EPBC Act Environmental Offsets Policy to compensate for Project impacts on Eastern Curlew to meet the Project's conditions of approval.

ASSESSMENT OF IMPACT TO BE OFFSET

The total quantum of direct and indirect significant residual impact of the Project on Eastern Curlew habitat is 121.24 ha of intertidal mudflat foraging habitat that includes:

- a direct impact through the permanent loss of 107.06 ha of intertidal mudflat foraging habitat for the establishment of the NLEP-SRA outer bund wall and the reclamation area enclosed within the outer bund wall; and
- an indirect impact through the permanent loss of 14.18 ha of intertidal mudflat foraging habitat once hydrodynamic changes create a permanent narrow channel adjacent to the outer bund wall.

Baseline surveys found that an average of approximately 2.3 Eastern Curlew (maximum of 6) use the impact area for foraging at low tide during the summer months when most Eastern Curlew are present in Australia.

OFFSET DESCRIPTION

The Eastern Curlew offset strategy includes two components:

- Creation of a migratory shorebird roost, appropriate for the Eastern Curlew, on part of the NLEP-SRA; and
- Management of threats to Eastern Curlew and Eastern Curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern Curlew habitat to improve habitat for the Eastern Curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern Curlew as part of a regionalised approach to threat abatement.

Artificial roost

To maintain flexibility and continuous availability of a roost site suitable for Eastern Curlew across the Western Basin Reclamation Area (WBRA) and NLEP-SRA and to ensure a smooth transition between the currently used artificial roost in the northern bund of the WBRA and a new roost in the NLEP-SRA, a 2-stage approach is proposed for the artificial roost component. In Stage 1, a minimum 10 ha area (approximately 450m x 250m) of the currently used roost site in the northern bund of the WBRA will be maintained as a suitable artificial roost until after the completion of construction of the NLEP-SRA bund wall. In Stage 2, at least one year prior to the artificial roost in the northern bund of the WBRA needing to be capped to meet port development demand, a suitable artificial roost will be created in the NLEP-SRA. The Stage 2 roost will be created initially by beneficially using dredged material to create a raised island within the northern portion of the NLEP-SRA. At this stage, the NLEP-SRA is expected to remain tidally influenced so the island will be built sufficiently high to ensure at least one hectare of bare substrate remains above the highest astronomical tide (HAT) and the island has a shallow incline to ensure it is surrounded by shallow water that the birds can stand in on all high tides. Over time, the Stage 2 roost site will become confined to an area of at least 10 hectares in size in the north of the NLEP-SRA to ensure the long-edge of the roost is adjacent to the seaward boundary wall. The artificial roost will be constructed and managed to meet the recommended design principles for an Eastern Curlew artificial roost as identified by technical advice from Professor Richard Fuller, a shorebird expert at the University of Queensland.

Spadely offset management area

In late 2023, the Queensland Parks and Wildlife Service (QPWS) acquired three properties in the north-west corner of Curtis Island: Spadely Station, a smaller adjoining property Grassy Hill, and a nearby property at Warners Point, which cover a combined area of 1,635 ha. This acquisition will also permit QPWS access to North Curtis Island State Forest (581 ha), since Spadely Station separates North Curtis Island State Forest from other lands managed by QPWS. The three properties (Spadely Station, Grassy Hill, Warners Point) and North Curtis Island State Forest (hereafter referred to as the Spadely offset management area) adjoin approximately 2,693 ha of intertidal habitats, including 2,121 ha of saltmarsh/saltpan and unconsolidated or consolidated tidal flat habitat that supports known foraging and roosting habitat for Eastern Curlew, as well as 572 ha of mangroves that serve as nursery areas and provide important nutrient inputs for the benthic invertebrates that Eastern Curlew feed on. Surveys conducted for the Ecosystem Research and Monitoring Program (ERMP), funded by GPC have found an average of 298 Eastern Curlew roosting on Curtis Island during the period of the year when most Eastern Curlew are present, including an average total of 181 in north Curtis Island, of which an average total of 81 used roost sites adjacent to the Spadely offset management area. Eastern Curlew typically use roost sites close to their foraging areas; therefore, a similar number of Eastern Curlew are expected to use the extensive areas of tidal flat and saltpan foraging habitat that is present around the coastline of Curtis Island.

Most of the intertidal lands adjoining the Spadely offset management area are without tenure and therefore cannot be acquired and secured under traditional tenure protection arrangements. They are however part of the Great Barrier Reef Coast Marine Park, which QPWS also administers. Furthermore, the habitat condition of these non-tenured intertidal lands can benefit from sympathetic land management of the adjoining tenured areas that they are directly connected to. The significant conservation values of Curtis Island, including Eastern Curlew habitats, are threatened by a variety of feral animals.

The acquisition of Spadely Station and Grassy Hill by QPWS provides an opportunity for QPWS to expand feral animal control operations to both Spadely Station and North Curtis Island State Forest, which currently serve as the last remaining large refuge for feral animals in the northern half of Curtis Island. The second component of the offset strategy is therefore focussed on implementing intensive feral animal control within the combined area of the Spadely offset management area (covering 2,216 ha) to improve the quality of adjoining intertidal habitats for

Eastern Curlew. Feral animal control will focus on feral pigs, foxes, wild dogs, feral cats, feral cattle and feral horses that are all known to occur on Curtis Island. GPC will provide an annual funding contribution to QPWS to conduct feral animal control for at least 20 years. The offset completion will be maintained until expiry of the approval.

Offset Acquittal

The habitats used by Eastern Curlew are generally intertidal and therefore marine in nature. The EPBC Act Offset Assessment Guide (OAG) is not designed for marine offsets and therefore a bespoke offset assessment method was designed to fit as closely as possible to the OAG to demonstrate offset acquittal. Using this method, offset acquittal was calculated based on the number of Eastern Curlew individuals impacted on the one hand and benefitting from the offset actions on the other hand.

The artificial roost component of the offset will construct an artificial roost suitable for Eastern Curlew that will occupy an area of 10 ha within the impact area of the NLEP-SRA. The artificial roost is expected to provide an alternative roosting site for an average of at least 30 Eastern Curlew during the summer months, to offset 75% of the impact.

Feral animal control within the Spadely offset management area is predicted to increase Eastern Curlew use of intertidal habitats in the offset target area adjoining the offset management area by at least 10%, to offset 25% of the impact.

MANAGEMENT OBJECTIVES AND ACTIONS

Artificial roost

The management objective of the artificial roost component of the offset strategy is to construct and maintain a migratory shorebird roost, suitable for the Eastern Curlew, on part of the NLEP-SRA, timed to ensure the continuous availability of a suitable artificial roost within the dredge reclamation areas of the WBRA and/or NLEP-SRA. To meet this objective, the offset strategy outlines the management actions and their timing and frequency of implementation, together with the performance criteria, monitoring indicators, triggers for adaptive management and corrective actions to ensure an adaptive management approach.

Spadely offset management area

The management objective of the Spadely offset component of the offset strategy is to manage threats to Eastern Curlew and Eastern Curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern Curlew habitat to improve habitat for the Eastern Curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern Curlew as part of a regionalised approach to threat abatement.

The feral animal control program will be undertaken by QPWS using financial support provided by GPC. QPWS will use a combination of control methods that have proven to be successful for feral animal control on Curtis Island, including aerial and ground shooting, soft jaw foothold trap lines and baiting. To meet the management objective for the Spadely offset management area, the offset strategy outlines the management actions and their timing and frequency of implementation, together with the performance criteria, monitoring indicators, triggers for adaptive management and corrective actions to ensure an adaptive management approach. Table ES.1 details the performance targets for this component of the offset.

Table ES.1. Performance targets for the Spadely offset management area.

Year 5 interim performance target	Year 10 interim performance target	Year 15 interim performance target	Year 20 performance target
The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method), i.e. an average of at least 54.7 Eastern Curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method), i.e. an average of at least 50.8 Eastern Curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method), i.e. an average of at least 47.2 Eastern Curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method), i.e. an average of at least 43.9 Eastern Curlew use the offset target area during the summer months, accounting for the background rate of population change*.

* The background rate of population change is assumed to be -1.46% per year based on the estimate of (Rogers *et al.* 2023) for the most recent period 2012-2021 but will use updated estimates for the most relevant periods as they become available.

MONITORING PROGRAM

The monitoring program for both components of the offset will include monitoring of feral animal occurrence as well as monitoring of Eastern Curlew use of habitats within or adjoining the offset areas as a direct measure of offset success. The frequency of occurrence of feral animals will be monitored in a standardised way using trail cameras. A baseline assessment of the frequency of occurrence of feral animals will be undertaken over a 2-month period prior to the initiation of feral animal control within the Spadely management area. To monitor the success of feral animal control in reducing feral animal activity, the timing and frequency of the monitoring program is outlined in Table ES.2.

Table ES.2. Monitoring methods, timing and frequency of monitoring.

Component	Method	Timing	Frequency
Frequency of occurrence of feral animals – Spadely	Four trail cameras monitoring for two months	Within the period mid-October to mid-March when most Eastern Curlew are present.	Once, prior to feral animal control. Annually from Year 1 to Year 10, biennial from Year 12 to Year 20.
Frequency of occurrence of feral animals – artificial roost	One trail camera monitoring for two months	Within the period mid-October to mid-March when most Eastern Curlew are present.	Once each year from Year 1 to Year 20 of the offset.
Monitoring Eastern Curlew - Spadely	Observational surveys at high tide and low tide	Within the period mid-October to mid-March when most Eastern Curlew are present.	Twice each year from Year 1 to Year 5, once each year from Year 6 to Year 10, biennial from Year 12 to Year 20.
Monitoring Eastern Curlew – artificial roost	Observational surveys at high tide, covering the Western Basin and NLEP-SRA.	Within the period mid-October to mid-March when most Eastern Curlew are present.	Monthly from one month prior to the start to one month after the end of construction of the NLEP-SRA boundary wall*. Once each year from completion of the NLEP-SRA boundary wall to Year 10, biennial from Year 12 to Year 20.

*Note: This monthly monitoring of roost sites in the WBRA and NLEP-SRA is already a component of the NLEP-SRA construction monitoring program.

REPORTING

An annual report will be prepared each year. The report will include the following information at a minimum:

- EPBC approval number;
- an overview of the management activities undertaken through the reporting year together with a summary of the numbers of feral animals removed from the NLEP-SRA and Spadely offset management area;
- results of monitoring for the reporting year;
- comparison of the monitoring results for the current year of reporting with the monitoring results from the previous years of reporting, including comparison with the baseline monitoring results;
- progress towards achieving the performance targets;
- a description of any relevant performance criteria that were not satisfied and, where triggered, the corrective actions that have been implemented or are planned to be implemented in the subsequent year of management;
- an assessment of any risks or potential threats to the successful delivery of the offset that have become apparent through monitoring, and actions to be undertaken to manage any threats and risks; and
- if required, recommendations to be incorporated into the offset strategy including changes to management and monitoring methods.

REVIEW

Once approved, the offset strategy will be reviewed twice each year to assess the efficacy of current management actions and identify whether additional activities and responses to unexpected events or threats to the successful delivery of the offset strategy are required. Should it become necessary to update the offset strategy to incorporate additional information obtained through the implementation of the strategy, any revision will be subject to an application to the Minister for a variation to the strategy in accordance with Condition 71 of approval EPBC 2012/6558. The biannual reviews will be finalised and published on the approval holder's website that is available to the public within two months of the 6-month and 12-month anniversary of the date of approval of the Eastern Curlew offset strategy each year.

EASTERN CURLEW OFFSET STRATEGY

NORTHERN LAND EXPANSION PROJECT - SOUTHERN RECLAMATION AREA, PORT OF GLADSTONE GATCOMBE AND GOLDING CUTTING CHANNEL DUPLICATION PROJECT (CO22000089)

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Appendix 5: Evidence of feral animal impacts on Curtis Island

Appendix 6: Risk assessment approach

1.0 INTRODUCTION

1.1 BACKGROUND

In 2020, Gladstone Ports Corporation Limited (GPC) received the following Commonwealth and Queensland Government approvals for the Port of Gladstone Gatcombe and Golding Cutting Channel Project (CD Project):

- 'Coordinated project' approval on 8 July 2020 under the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act)
- 'Controlled action' approval on 24 December 2020, under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) (EPBC 2012/6558).

This project will be conducted in stages, with Stage 1 currently scheduled to commence construction in May/June 2025. Stage 1 is named as the Northern Land Expansion Project Southern Reclamation Area (NLEP-SRA). The EPBC approval (EPBC 2012/6558) defines Project Stage 1 as meaning any aspect of the construction of the barge unloading facility and the southern reclamation area. However, the construction of the barge unloading facility is not being envisaged at this stage. Consequently, Project Stage 1 for the purposes of this Eastern Curlew and Other Shorebird Monitoring Plan is taken to mean any aspect of the construction of the southern reclamation area. A revised plan will be submitted for approval before any aspect of the construction of the barge unloading facility or Stage 3 can commence. Construction of the southern reclamation area involves the construction of a bund wall to create a new 111.12 ha reclamation area that will tie in west of the current Western Basin Reclamation Area (WBRA) for long-term placement of dredged material to the north of Fisherman's Landing. Construction of the barge unloading facility will occur at a later date and is not considered under this Eastern Curlew Offset Strategy.

The EPBC Act approval for the construction of the NLEP-SRA associated with the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (EPBC 2012/6558) requires GPC to comply with several conditions with regards to offsets for significant residual impacts on Eastern Curlew (*Numenius madagascariensis*), which is listed as a critically endangered threatened bird species under the EPBC Act. The relevant conditions are outlined in **Table 1.1**, together with a reference to which sections of the offset strategy each approval condition is addressed in.

Table 1.1. Outline of the Project conditions of approval (EPBC 2012/6558) relevant to the Eastern Curlew Offset Strategy together with a reference to which sections of the offset strategy each approval condition is addressed in.

Approval condition	Strategy reference
(31) Each Project Stage Offset Strategy must propose offsets for that Project Stage and include the following:	
a. details of how the proposed offsets align with the broader strategies and programs for the Great Barrier Reef, including but not limited to the Reef 2050 Long-term Sustainability Plan and will provide a net benefit to the Great Barrier Reef World Heritage Area (GBRWHA);	Section 10
b. details to demonstrate how the proposed offsets will compensate for significant residual impacts on the relevant protected matters in accordance with the principles of the Environmental Offsets Policy;	Sections 2 to 6, 10
c. evidence of how the proposed offsets take into account relevant approved conservation advices, relevant recovery plans and threat abatement plans, or other relevant contributions to species recovery and conservation;	Section 10
d. a process to update the Offset Strategy and confirm the offset requirements for protected matters based on the report prepared under condition 19;	Section 8

Approval condition	**Strategy reference**
e. a process for, at the minimum, a biannual review of the Offset Strategy and the performance of offsets for the period of effect of the approval including timeframes for conducting the re-views and for publishing the findings of each review on the website;	Section 8
f. where direct offsets are proposed, offset information for each offset site must be provided in the offset strategy;	Section 3
g. if indirect compensatory measures such as research are proposed, details of how the proposed offsets will be developed, the timeframe over which they would be undertaken and the expected outcomes of the compensatory measures. Indirect compensatory measures must be prepared in accordance with the Environmental Offsets Policy; and	Not applicable
h. if a financial contribution is proposed (e.g. for the amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension before commencement of any Project Stage, and/or for lethal or sub-lethal impacts to seagrass and macroalgae), the Offset Strategy must: i. explain the purpose of the financial contribution and demonstrate how it will result in a net benefit to the protected matter(s); ii. provide details of and justification for the organisation(s) to which a contribution will be made; iii. explain how the financial contribution will be calculated; iv. specify the proportion of the offset obligation that would be met by any financial contribution; and v. specify the proposed amount of the financial contribution (where known).	Not applicable
(32) To compensate for impacts to Eastern Curlew habitat[1], the approval holder must provide an environmental offset consistent with the Environmental Offsets Policy. This offset must be in accordance with the approved Project Stage 1 Offset Strategy and implemented within 12 months from the date that the Project Stage 1 Offset Strategy is approved in writing by the Minister. The quantum of impacts to Eastern Curlew habitat must be confirmed in the Project Stage 1 Offset Strategy and based on the detailed design for the southern reclamation area.	This strategy
(33) The environmental offset to compensate for impacts to Eastern Curlew habitat must deliver direct on-ground benefits to the species and must include at a minimum:	
a. activities to create or improve foraging habitat for the Eastern Curlew within the Port Curtis area;	Section 3.4
b. on-the-ground activities to aid the long-term conservation of areas of foraging habitat for the Eastern Curlew, which may be within the entirety of the GBRWHA and/or within the Australian range of the species;	Section 3.4
c. creation of a migratory shorebird roost, appropriate for the Eastern Curlew, on part of the WB reclamation area and/or WBE reclamation area. The design and construction of the migratory shorebird roost must be undertaken with advice from a suitably qualified ecologist, and the roost must be maintained for the period of the effect of the approval; and	Section 3.3
d. management of threats to the Eastern Curlew within the Port of Gladstone area, such as invasive plant and animal control within or adjacent to Eastern Curlew habitat as part of a regionalised approach to threat abatement.	Section 3.4

GPC commissioned Biodiversity Assessment and Management Pty Ltd (BAAM) to prepare an Eastern Curlew offset strategy to address the conditions of approval of EPBC 2012/6558 related to the provision of offsets for the significant residual impacts of the NLEP-SRA on Eastern Curlew.

[1] Eastern Curlew habitat means roosts such as claypans, sandbars, islands, creek banks, mangroves, beaches and ash ponds or foraging habitat such as inter-tidal mudflats, sandflats, salt flats, saltmarsh, rock pools, coral reefs, and beaches identified as being utilised by Eastern Curlew at any time.

1.2 PROJECT DESCRIPTION

The NLEP SRA will consist of a new 111.12 ha reclamation area that will tie in west of the current WBRA (see **Figure 3.1** for location). The NLEP SRA will provide additional storage capacity for future capital and maintenance (if required) dredging programs in the Port of Gladstone (e.g. Targinnie Channel, Gatcombe and Golding Cutting Channels).

The proposed NLEP SRA outer bund wall has been designed as a rock filled embankment structure comprising the following key elements:

- an inner bund comprising of hard, durable rock (core material) suitable for use in a marine environment;
- an outer, ocean-side face that will consist of a filter rock layer and armour rock (rip rap revetment) on the face and toe;
- an inner, reclamation-side face that will consist of geotextile layers and a filter sand layer as well as a reshaping rock berm on the face and toe; and
- a compacted (unsealed) surface on the crest of the bund wall composed of wearing course material.

1.3 PURPOSE AND SCOPE

This Eastern Curlew Offset Strategy has been prepared for Gladstone Ports Corporation Limited (GPC) to deliver an environmental offset consistent with the EPBC Act Environmental Offsets Policy to compensate for Project impacts to habitat of Eastern Curlew (*Numenius madagascariensis*), which is listed as a critically endangered threatened bird species under the EPBC Act, to meet the Project's conditions of approval outlined in **Section 1.1** above.

2.0 ASSESSMENT OF IMPACT TO BE OFFSET

The quantum of impacts of the NLEP-SRA on Eastern Curlew is described in the following sections in terms of the total area of Eastern Curlew habitat that is impacted as well as the average (and maximum) number of Eastern Curlews recorded using the area of impacted habitat. To assess the overall quantum of impact of the NLEP-SRA on Eastern Curlew in accordance with the EPBC Act Offsets Assessment Guide, an offset assessment method for Eastern Curlew was developed based on the number of individuals. The details of this assessment method are provided in **Appendix 1**.

2.1 IMPACT ON EASTERN CURLEW HABITAT

The direct and indirect impacts of the Project on intertidal mudflat that provides foraging habitat for Eastern Curlew have been detailed in the *Gatcombe and Golding Cutting Channel Duplication Project Significant Residual Impact Assessment Report (State Prescribed Environmental Matters) – Northern Land Expansion Project - Southern Reclamation Area (NLEP-SRA)* (Aurecon 2022). The total area within the NLEP-SRA is 111.12 ha (Aurecon 2022), which includes 107.06 ha of intertidal mudflat and 4.06 ha of subtidal seagrass (see **Figure 3.1**). Construction of the NLEP-SRA outer bund wall will therefore result in the permanent loss of 107.06 ha of intertidal mudflat within the direct footprint of the outer bund wall and the reclamation area enclosed within the outer bund wall. The impact on the intertidal mudflat within the outer bund wall footprint will start to occur as the outer bund wall is constructed. Once construction of the outer bund wall is complete, the hydrodynamics of the intertidal mudflat remaining enclosed within the outer bund wall will be modified, potentially affecting the quality of the foraging habitat for Eastern Curlew that will remain enclosed within the outer bund wall. Once the pumping of dredged material into the reclamation area enclosed within the outer bund wall commences, the remaining intertidal mudflat enclosed within the outer bund wall will be permanently lost.

Hydrodynamic modelling found that the establishment of the NLEP-SRA will cause no changes to water levels throughout most of the Port and will cause changes to current velocities only in areas immediately adjacent to the NLEP-SRA (Aurecon 2022). The modelling indicated that some deepening of the narrow channel on the tidal flat to the west of the NLEP-SRA is likely and erosion would continue (provided the bed material is erodible) until the narrow channel reaches a new equilibrium depth (Aurecon 2022). Based on the hydrodynamic modelling and implementation of the precautionary principle, erosion of the intertidal area from the establishment of the NLEP-SRA was predicted to cause a permanent narrow channel to form adjacent to the new reclamation area outer bund wall, occupying a horizontal area of 14.18 ha (Aurecon 2022).

The quantum of direct and indirect significant residual impact of the Project on Eastern Curlew therefore comprises a total impact of 121.24 ha that includes:

- a direct impact through the permanent loss of 107.06 ha of intertidal mudflat foraging habitat for the establishment of the NLEP-SRA outer bund wall and the reclamation area enclosed within the outer bund wall; and
- an indirect impact through the permanent loss of 14.18 ha of intertidal mudflat foraging habitat once hydrodynamic changes create a permanent narrow channel adjacent to the outer bund wall.

2.2 Impact on the Number of Eastern Curlews

Baseline surveys found that an average of 2.3 (maximum of 6) Eastern Curlew use the impact area for foraging at low tide during the summer months when most Eastern Curlew are present in Australia (see **Appendix 2**, Table A2.1 for details).

3.0 OFFSET DESCRIPTION

3.1 Background

The development of the Eastern Curlew offset strategy has been informed by a technical memorandum prepared by Professor Richard Fuller, a shorebird expert at the University of Queensland, to provide technical advice for development of Eastern Curlew offsets for EPBC2012/6558. This technical advice, included as **Appendix 3**, identified three options for meeting the offset requirements of the project:

- Option 1 – Construct an artificial roost suitable for Eastern Curlews;
- Option 2 – Enhanced protection for remaining intertidal habitat; and
- Option 3 – On-ground activities to aid long term conservation of foraging areas.

Options 1 and 3 were selected for inclusion in the offset strategy. The Balaclava Island option nominated under Option 2 was investigated but found to be an unsuitable option (see **Appendix 4** for details). Under Option 3, Professor Fuller recommended actions to reduce threats to migratory shorebirds, citing examples from Moreton Bay, but recommending that the actions be based on an assessment of threats to migratory shorebird habitats in the vicinity of the Project that will enable the design of a management plan together with an assessment of the size of the offset. Professor Fuller noted that analysis of benthic prey availability suggests that sufficient intertidal carrying capacity exists in the Gladstone region for Eastern Curlews (Choi *et al.* 2017), and thus tidal flat creation or enhancement would not deliver a significant increase in Eastern Curlew numbers.

A 9-year shorebird monitoring program focussed on monitoring shorebird populations, shorebird use of habitats and threats to shorebirds in the Port Curtis region (Sandpiper Ecological Surveys 2011a to 2011d, 2012a to 2012c, Wildlife Unlimited 2012 to 2020), noted the primary threats to shorebirds in the region being loss of tidal flat foraging habitat and disturbance from construction

and operation of new industrial development in the Port of Gladstone, as well as general statements regarding disturbance by people (e.g. birds flushing due to close approach by people on foot, in cars or in watercraft) and animals (e.g. dogs off leash at beaches, feral horses on Curtis Island); thus, this monitoring program did not identify specific management needs for shorebirds in the Port Curtis region. A four-year research program (Choi *et al.* 2017), which included review of the results of the shorebird monitoring program mentioned above, identified north Curtis Island as a stronghold for Eastern Curlew and the high-quality intertidal areas in the north of Curtis Island as a priority area for management. Consequently, informed by available information on threats to migratory shorebird habitats in the Port Curtis region, the development of management actions consistent with Option 3 has focused on north Curtis Island. Since Curtis Island is included within the Great Barrier Reef World Heritage Area (GBRWHA), this focus also fulfils offset condition requirements in relation to alignment of the offset with the broader strategies and programs for the Great Barrier Reef.

3.2 OFFSET COMPONENTS

The Eastern Curlew offset strategy includes two components:

- Creation of a migratory shorebird roost, appropriate for the Eastern Curlew, on part of the NLEP-SRA; and
- Management of threats to Eastern Curlew and Eastern Curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern Curlew habitat to improve habitat for the Eastern Curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern Curlew as part of a regionalised approach to threat abatement.

3.3 ARTIFICIAL ROOST

3.3.1 Artificial roost design principles

Technical advice from Professor Fuller recommended the following design principles for an artificial roost as part of the NLEP-SRA (included as **Appendix 3**):

1. minimum size of approximately 500 m x 200 m (10 ha);
2. predominantly marine environment, i.e. ability to flush with sea water; some tidal influence on water level is useful, but it is important that the roost site does not become fully inundated at high tide;
3. easily accessible to roosting birds and unobstructed from the seaward side – in practice, the long edge of a rectangular roost site should be adjacent to the sea wall;
4. as few obstructions as possible in the surrounding area, such that an uninterrupted view of the vicinity can be had by birds that are inside the roost. In particular, ensuring that surrounding dredged material heaps are not so high as to disrupt sightlines and bird access;
5. extensive shallow water of varying depths;
6. marshy or wet edges (controlled by varying the water level, in particular flooding the roost ahead of major migration periods, and then drawing down the water to create softer edges);
7. several islands, which allow for roosting even when the water level in the roost is high (e.g. after heavy rainfall, king tides); and
8. vegetation succession control (achieved through flooding with sea water).

The following design principles are also relevant to minimise the risk of disturbance to Eastern Curlew using the artificial roost:

9. a configuration of 400 m x 250 m (10 ha) would meet the minimum size recommendation while reducing the risk of disturbance along the long edges; and
10. minimize access of persons, vehicles and machinery (and other activities) to the artificial roost boundary walls, particularly the long-edge boundaries where the width of the roost is narrower.

During the construction of the Western Basin Reclamation Area (WBRA) for the Port of Gladstone Western Basin Strategic Dredging and Disposal Project (EPBC 2009/4904), GPC constructed an artificial wetland along the western boundary of the WBRA as a component of the WBRA. This artificial wetland is 1,400 m long and up to 175 m wide along most of its length. During several site visits in March 2023, this wetland was observed to comprise open, very shallow saline water fringed by a mosaic of sparse, low saltmarsh vegetation and bare, open substrate, conditions that are ideal for shorebird roosting. Furthermore, several hundred smaller migratory shorebirds, mostly Red-necked Stint, Sharp-tailed Sandpiper and Curlew Sandpiper, as well as a single Eastern Curlew were observed feeding and roosting within this artificial wetland during both high tide and low tide phases of the tide cycle. These observations confirm that the design and method of construction of the artificial wetland was successful in creating habitat consistent with the shorebird artificial roost design principles 2 to 8 listed above. Consequently, this method of construction will be replicated for the construction of the new artificial roost in the NLEP-SRA.

The artificial wetland was found to be used by only 1-2 Eastern Curlew, and only when no activity was occurring in the area. This was likely due to the artificial wetland being too narrow (maximum 175 m width), with site access roads running along the top of the artificial wetland bund walls on all sides. Consequently, the new artificial roost will be constructed to have a greater width (250 m) and managed to minimise the risk of disturbance (see under **Section 3.3.3** below).

3.3.2 Current Eastern Curlew roosting in the WBRA

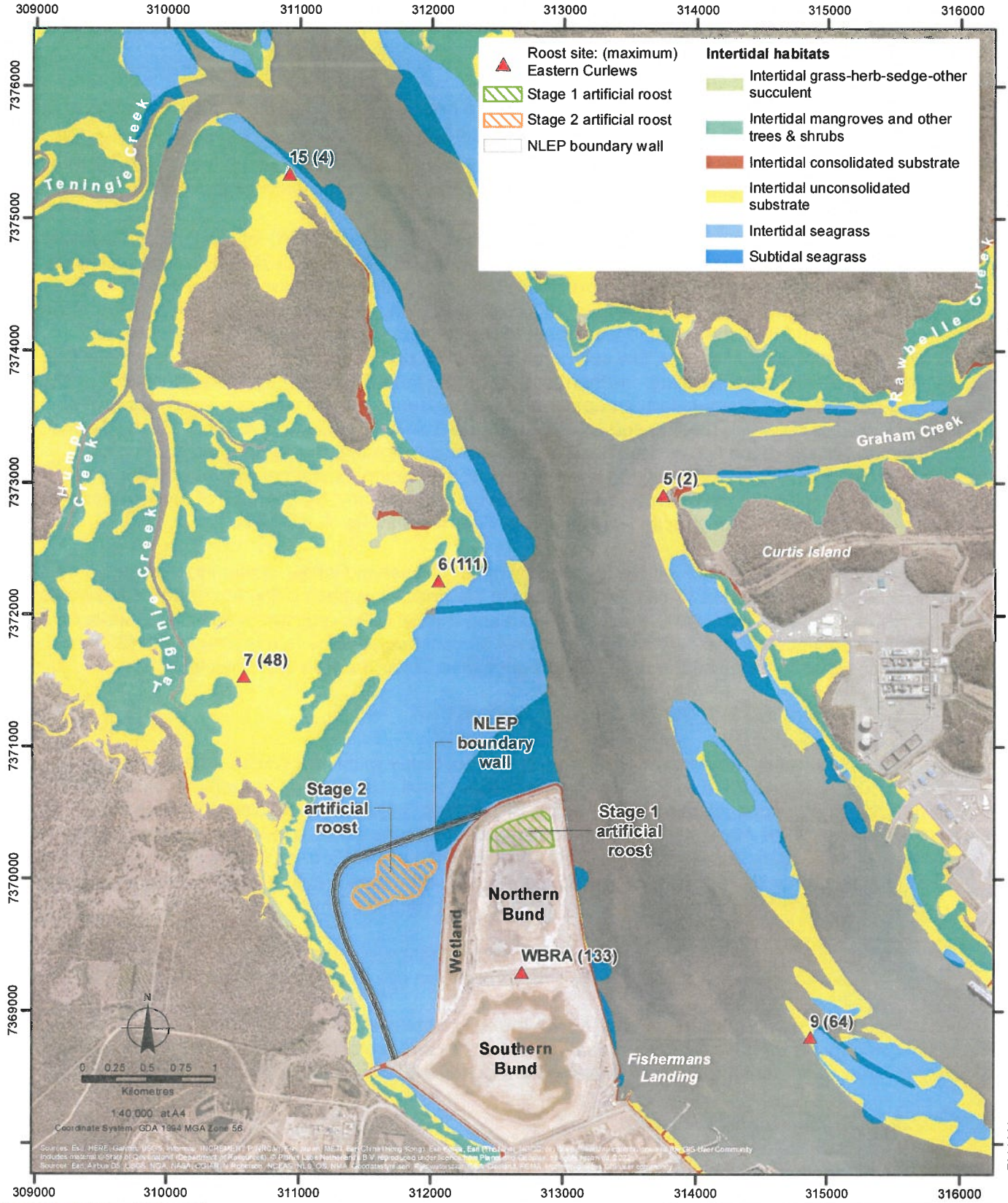
There are currently three known Eastern Curlew roost sites within the WBRA adjacent to the NLEP-SRA: the northern bund (75 ha), the southern bund (100 ha) and the artificial wetland (22 ha) that together comprise the WBRA roost site (**Figure 3.1**). These artificial roost sites in the WBRA (mostly the larger northern and southern bunds) have become increasingly used by Eastern Curlew since 2020, with an average of 64 and maximum of 133 Eastern Curlews recorded roosting at high tide within the months October to mid-March (when most Eastern Curlew are present) over the period 2020-2024 (see **Appendix 2**, Table A2.2 for details). These data confirm that:

- there is a high demand for a safe and protected roost site in the local area, since Eastern Curlew are choosing to roost in the WBRA in preference to alternative natural sites that are available in the area;
- an artificial roost within the NLEP-SRA is likely to be used by Eastern Curlew and will address a longer-term need for the maintenance of a safe and protected artificial roost site in the local area, given that the northern and southern bunds will be capped for port development in time.

3.3.3 Artificial roost provision

First the southern bund and then the northern bund of the WBRA will eventually be capped and incorporated into port development. To maintain flexibility and continuous availability of a roost site suitable for Eastern Curlew across the WBRA and NLEP-SRA and to ensure a smooth transition between the currently used artificial roost in the northern bund of the WBRA and a new roost in the NLEP-SRA, a 2-stage approach is proposed for the artificial roost component, as follows:

Stage 1: A minimum 10 ha area (approximately 450m x 250m) of the currently used roost site in the northern bund of the WBRA will be maintained as a suitable artificial roost until after the completion of construction of the NLEP-SRA bund wall (see **Figure 3.1**).



Data Sources:
Roost Sites:
BAAM - Sept 2023
Intertidal Habitats
https://gisservices2.information.qld.gov.au/arcgis/services, Name: WetlandMaps/MapB
Baseline Roads and Tracks - Queensland, Published 01/07/2022
Rail Network - Queensland, Published 17/05/2022
State of Queensland (Department of Resources) 2023

Drawn By: MapLass - KM Reviewed by: PL Date: 1/12/2023

Figure: 3.1

Title: Proposed location of artificial roost site

Project: Eastern Curlew Offset Strategy, NLEP-SRA

Client: Gladstone Ports Corporation Ltd

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Stage 2: At least one year prior to the artificial roost in the northern bund of the WBRA needing to be capped to meet port development demand, a suitable artificial roost will be created in the NLEP-SRA. The Stage 2 roost will be created initially by beneficially using dredged material to create a raised island within the northern portion of the NLEP-SRA (see **Figure 3.1** for approximate form and location). At this stage, the NLEP-SRA reclamation area is expected to remain tidally influenced so the island will be built sufficiently high to ensure at least one hectare of bare substrate remains above the highest astronomical tide (HAT) and the island has a shallow incline to ensure it is surrounded by shallow water that the birds can stand in on all high tides. The placement of the dredge material to form the island will be a component of the Project Stage 2 dredging. A fine sediment monitoring program for Project Stage 2 will be in place during the construction of the artificial roost. If the monitoring shows that the construction of the roost has resulted in release of fine sediment into the harbour, a fine sediment offset will be provided to meet Condition 19d.

As already noted above, the Stage 2 roost shall be created at least one year before the process of capping the Stage 1 roost site begins to ensure continuous availability of a suitable artificial roost site within the combined WBRA and NLEP-SRA. Over time, the Stage 2 roost site will become confined to an area of at least 10 hectares in size in the north of the NLEP-SRA to ensure the long-edge of the roost is adjacent to the seaward boundary wall.

Both the Stage 1 and Stage 2 artificial roosts will be designed and constructed to meet the design principles outlined in **Section 3.3.1** and management measures will be implemented to minimise the risk of disturbance to Eastern Curlew using either roost. These measures are expected to include:

- Using a raised bund wall to screen roosting birds from line-of-sight with surrounding construction or operational activities;
- Minimising access to the top of the bund wall by pedestrians and vehicles, particularly along the seaward boundary wall;
- Prohibiting dogs within 200 m of the roost; and
- Restrictions on the operation of drones within 300 m of the migratory shorebird roost within 4 hours either side of high tide.

The shifting of the Stage 2 roost to the west of the Stage 1 roost will move it closer to the mainland, which could reduce its perceived suitability for Eastern Curlew roosting compared to the location of the Stage 1 roost site that is closer to the main embayment. However, the Stage 2 roost will continue to be located on the northern edge of the reclamation area to ensure the long-edge of the roost remains adjacent to the seaward boundary wall, a location that is preferred by Eastern Curlew. Since Eastern Curlew also widely use mainland roost sites (Fuller *et al.* 2021), the risk of the Stage 2 roost site being considered unsuitable by Eastern Curlew is low.

The construction of Stage 3 of the Project is currently predicted to commence after 2023 and will entail the construction of an additional reclamation area to the north of the NLEP-SRA (hereafter referred to as the Northern Land Expansion Project – Northern Reclamation Area, or NLEP-NRA) that will tie into the northern boundary wall of the NLEP-SRA and the existing northern boundary wall of the WBRA. This will result in the artificial roost in the NLEP-SRA losing the seaward boundary on its long edge, which could negatively impact its effectiveness as an Eastern Curlew roost site. To maintain an artificial roost that has a long-edge adjacent to the seaward boundary wall closest to the main estuary, a new roost site will be built on the northern edge of the NLEP-NRA to capture the artificial roost component of the Stage 1 offset. The construction of this new roost site will follow the same process and design principles outlined for the construction of the NLEP-SRA Stage 2 roost, refined by any lessons learned from the construction and operation of the Stage 2 roost. This will effectively move the artificial roost to a new position within the NLEP Project area i.e. from the NLEP-SRA to the NLEP-NRA. The artificial roost in the NLEP-SRA will be retained until Eastern Curlews have begun roosting at the new artificial roost in the NLEP-NRA, whereafter the NLEP-SRA will be fully capped for Port infrastructure. The details of this

construction will be outlined in a revision to the Eastern Curlew offset strategy for the NLEP-SRA (Project Stage 1) that will be submitted to the Department for approval prior to construction of Stage 3 of the Project proceeding. The construction of the NLEP-NRA will entail additional impacts on Eastern Curlew foraging habitat that will be required to be offset. At this stage, it is envisaged that this additional impact will be offset using additional offset components that are yet to be identified and will be included in a new Eastern Curlew offset strategy for Stage 3 of the Project.

3.4 SPADELY OFFSET - MANAGING FERAL ANIMALS ON CURTIS ISLAND

3.4.1 Background

Curtis Island, in the southern region of the Great Barrier Reef World Heritage Area, is the third largest continental island in Queensland, covering an area of approximately 46,000 ha above the highest astronomical tide (HAT) as well as a further 11,000 ha of intertidal lands (Department of the Environment 2016). The island contains a high diversity of landforms and ecosystems, including a diversity of vegetation with both tropical and sub-tropical floristics. Curtis Island has biogeographical significance for species and communities that are at their distribution limits including 33 plant species, the southernmost rookery site of the vulnerable Flatback Turtle *Natator depressus* and the most southern occurrence of a tropical marine plain community. These features supported the listing of the eastern half of Curtis Island on the Register of the National Estate in 1993 (State of Queensland 2019). The 4,000-ha marine plain in the north-east of the island is a highly significant wetland at regional, state and national levels and is particularly important habitat for the critically endangered Capricorn Yellow Chat *Epthianura crocea* subsp *macgregori*, migratory shorebirds and other significant wetland species (State of Queensland 2019).

Curtis Island incorporates a variety of land tenures, including protected area estate (Curtis Island National Park, Curtis Island Conservation Park, Southend Conservation Park, Cape Capricorn Conservation Park, Great Barrier Reef Coast Marine Park), state forest (Curtis Island State Forest, North Curtis Island State Forest), other lands managed by QPWS for conservation (Curtis Island Environmental Management Precinct), the Curtis Island Industry Precinct and associated Materials Transportation and Services Corridor, and privately owned freehold lands that include the township of Southend. A vertebrate pest management plan for Curtis Island that was finalised in 2007 identified the need for a coordinated, strategic approach to managing impacts from pests on the environmental and production values of Curtis Island. The plan identified that feral pigs, feral horses, feral goats, feral cattle, wild dogs and foxes were causing extensive damage to environmental values, including feral pigs digging up extensive areas of coastal wetlands, fox predation on fauna and Flatback Turtle nests, and feral cattle and horse trampling impacts on the marine plain (Hall 2005, Melzer *et al.* 2007).

Subsequently, the Management Statement for lands managed by QPWS on Curtis Island identified pest animals as a key threatening process on Curtis Island and a high priority for management (State of Queensland 2019).

In response to the threats that feral animals pose to the environmental values of Curtis Island, QPWS has been conducting feral animal control on Curtis Island on an annual basis since 2005. Over a period of four years ending 2016/17, a total of 469 feral pigs, 315 feral cattle, 36 wild dogs, ten foxes, seven feral cats and one feral goat were removed from areas managed by QPWS on Curtis Island (State of Queensland 2017). Feral goats have since been eradicated from Curtis Island. Prior to the cessation of cattle operations on Curtis Island in 2014, damage to the marine plain by cattle and feral pigs was as high as 100%, whereas by 2021/22 the feral pig control program maintained feral pig damage to less than 2% (State of Queensland 2022). Following six years of control effort (2015 to 2020) the feral cattle population on QPWS managed estate was removed (State of Queensland 2022). Similarly, recent aerial shooting of feral horses has substantially reduced the feral horse population on QPWS managed estate (McGhee and Semmier 2022). Further evidence of the impact of feral animals on key environmental values of Curtis Island

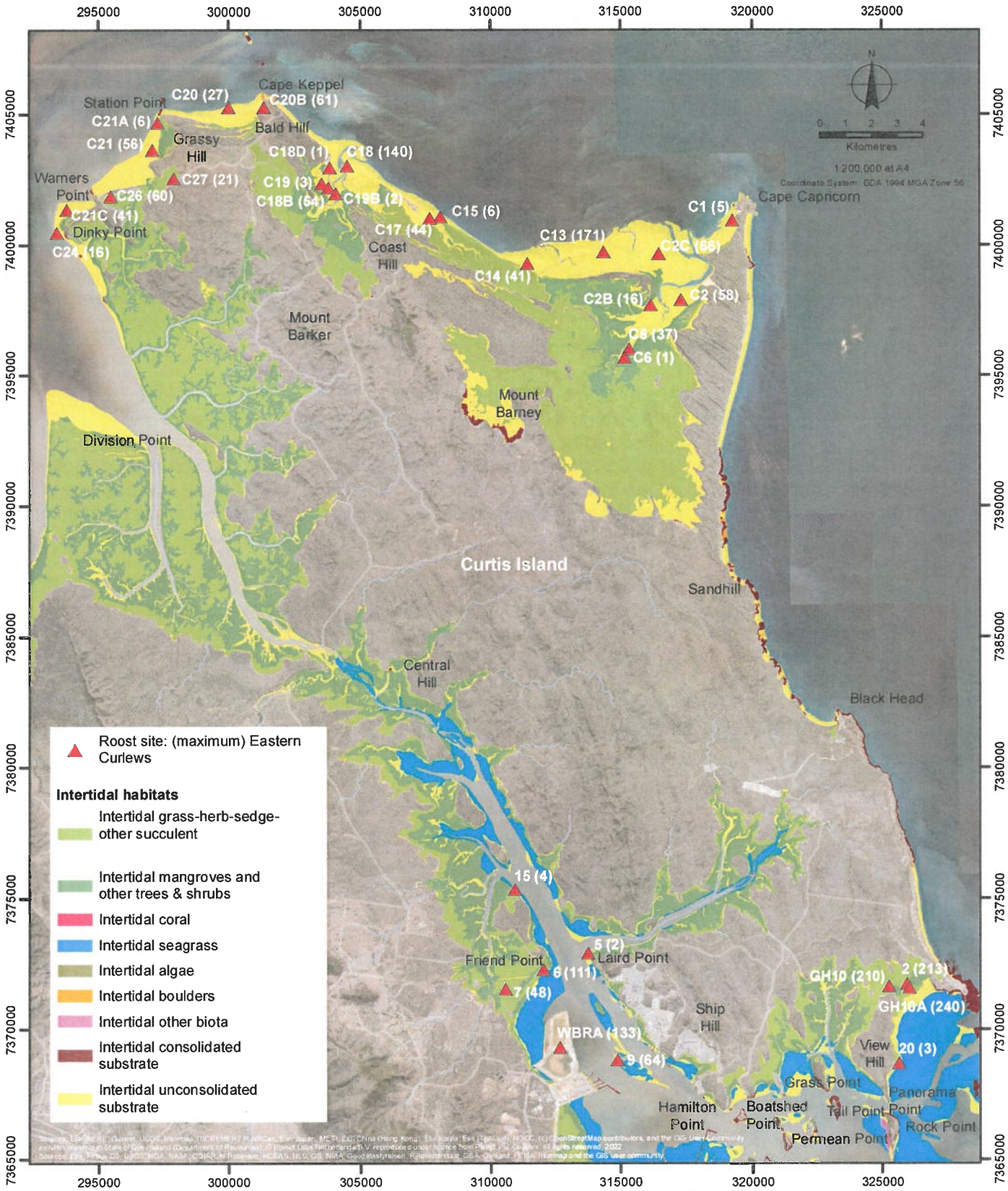
and the changes to these values following feral animal control on areas managed by QPWS is presented in Appendix 5.

The QPWS is only able to conduct feral animal control operations on lands it manages. Consequently, areas outside of QPWS managed estate remain largely free of feral animal control. Ecological theory (e.g. Fernandes *et al*. 2005, Casas *et al*. 2009, Grilo *et al*. 2019) supports the prediction that such areas will serve as both a refuge for feral animals and a source for feral animals to re-invade adjoining areas under QPWS management, which increases the cost and complexity of ongoing feral animal control on QPWS managed estate throughout Curtis Island.

3.4.2 Eastern Curlew population and habitats on Curtis Island

Over the period January 2011 to March 2021, a total of 22 summer surveys and 6 winter surveys of shorebirds roosting on Curtis Island were conducted for the Ecosystem Research and Monitoring Program (ERMP), funded by GPC (Sandpiper Ecological Surveys 2011a to 2011d, 2012a to 2012c, Wildlife Unlimited 2012 to 2020). These surveys identified and surveyed shorebird use of roost sites throughout the Port Curtis region at high tide, including throughout Curtis Island. The surveys also quantified the foraging densities of shorebirds in representative areas of tidal flat foraging habitat at low tide.

The ERMP surveys identified 28 roost sites used by Eastern Curlew on Curtis Island (**Figure 3.2**). To quantify Eastern Curlew use of roost sites, the average (and maximum) number of Eastern Curlew recorded roosting at each site was calculated based on the number of surveys for each site within the period late-September to mid-March when most Eastern Curlew are present in Australia (Higgins and Davies 1996, Driscoll and Ueta 2002, Minton *et al.* 2011, Morrick *et al.* 2022) and numbers of Eastern Curlew are relatively stable in south-east Queensland (Lloyd *et al.* 2021, 2022). These data are presented in **Table 3.1**.



Data Sources:
Roost Sites:
BAAM - Sept 2023
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https://gisservices2.information.qld.gov.au/arcgis/services, Name: WetlandMaps/MapB
Baseline Roads and Tracks - Queensland, Published 01/07/2022
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Figure: 3.2

Title: Eastern Curlew habitat and roost sites on Curtis Island

Project: Eastern Curlew Offset Strategy, NLEP-SRA

Client: Gladstone Ports Corporation Ltd

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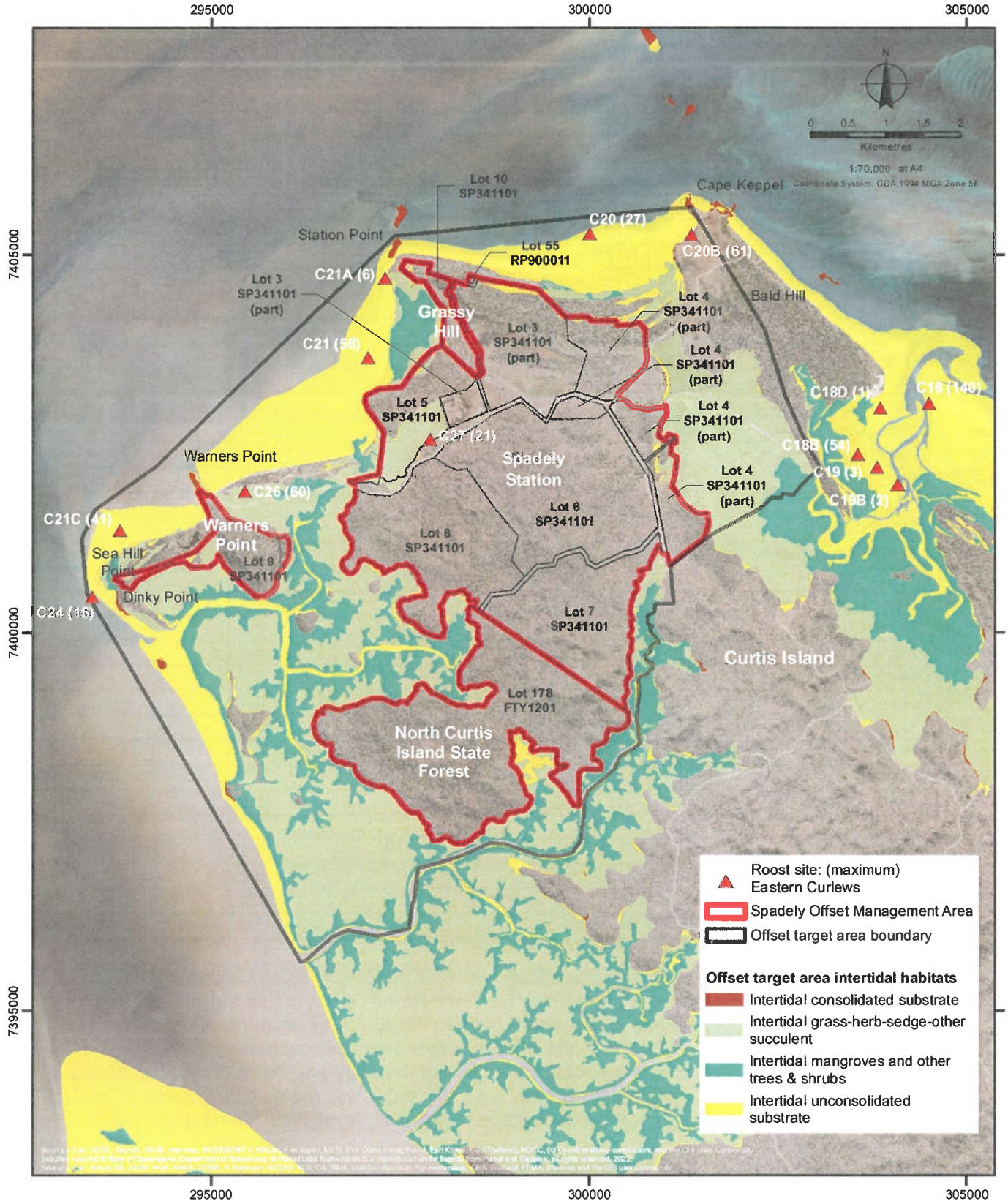
Table 3.1 Summary of the average count and maximum count of Eastern Curlews roosting at roost sites used by Eastern Curlew across Curtis Island, based on ERMP data from 22 summer surveys over the period 2011 to 2021.

Area	Site number	Average count	Maximum count
Roost sites adjacent to the Spadely offset management area			
North Curtis	C18	40.0	140
North Curtis	C18B	2.7	54
North Curtis	C18D	<0.1	1
North Curtis	C19	0.2	3
North Curtis	C19B	0.1	2
North Curtis	C20	7.5	27
North Curtis	C20B	4.2	61
North Curtis	C21	12.3	56
North Curtis	C21A	1.0	6
North Curtis	C21C	4.2	41
North Curtis	C24	0.7	16
North Curtis	C26	4.4	60
North Curtis	C27	3.9	21
Roost sites across the remainder of Curtis Island			
North Curtis	C1	0.7	5
North Curtis	C2	17.5	58
North Curtis	C2B	0.2	16
North Curtis	C2C	8.8	66
North Curtis	C5	1.7	37
North Curtis	C6	<0.1	1
North Curtis	C13	55.3	171
North Curtis	C14	4.5	41
North Curtis	C15	0.4	6
North Curtis	C17	11.0	44
South Curtis	2	27.0	213
South Curtis	5	0.1	2
South Curtis	20	0.2	3
South Curtis	GH10	41.6	210
South Curtis	GH10A	47.9	240

Summing the average number of Eastern Curlew across all roost sites on Curtis Island yielded an average total of 298 Eastern Curlew roosting on Curtis Island during the period when most Eastern Curlew are present, including an average total of 181 in north Curtis Island, of which an average total of 81 used roost sites adjacent to the Spadely offset management area (see Section 3.4.3 below). Eastern Curlew typically use roost sites close to their foraging areas (Finn *et al.* 2002); therefore, a similar number of Eastern Curlew are expected to use the extensive areas of tidal flat and saltpan foraging habitat that is present around the coastline of Curtis Island (**Figure 3.2**).

3.4.3 Spadely Station and North Curtis State Forest offset management area

In late 2023, QPWS acquired three properties in the north-west corner of Curtis Island: Spadely Station, a smaller adjoining property Grassy Hill, and a nearby property at Warners Point (State of Queensland 2023). Together, these properties cover an area of 1,635 ha in the north-west of Curtis Island (**Figure 3.3**). This acquisition will also permit QPWS access to North Curtis Island State Forest (581 ha), since Spadely Station separates North Curtis Island State Forest from other lands managed by QPWS. This acquisition provides an opportunity for QPWS to expand feral animal control operations to these properties and North Curtis Island State Forest, which currently serve as the last remaining large refuge for feral animals in the northern half of Curtis Island.



Data Sources:
Roost Sites:
BAAM - Sept 2023
Intertidal Habitats
Assessment of Common Conservation Values - Intertidal and Subtidal Environs of the Baffle to Fitzroy Coast - Version 1.1
Baseline Roads and Tracks - Queensland, Published 01/07/2022
Rail Network - Queensland, Published 17/05/2022
State of Queensland (Department of Resources) 2024

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Figure: 3.3

Title: Location of Spadely offset management area

Project: Eastern Curlew Offset Strategy, NLEP-SRA

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The three properties (Spadely Station, Grassy Hill, Warners Point) and North Curtis Island State Forest adjoin approximately 2,693 ha of intertidal habitats, including 2,121 ha of saltmarsh/saltpan and unconsolidated or consolidated tidal flat habitat that supports known foraging and roosting habitat for Eastern Curlew, as well as 572 ha of mangroves that serve as nursery areas and provide important nutrient inputs for the benthic invertebrates that Eastern Curlew feed on (**Figure 3.3**, **Table 3.2**). Most of these intertidal lands are without tenure and therefore cannot be acquired and secured under traditional tenure protection arrangements. They are however part of the Great Barrier Reef Coast Marine Park, which QPWS also administers. Furthermore, the habitat condition of these non-tenured intertidal lands can benefit from sympathetic land management of adjoining tenured areas that they are directly connected to (Ecofund 2013).

Table 3.2. Summary of the total area of intertidal habitats in the offset target area adjacent to the Spadely offset management area.

Intertidal habitat type	Area (ha)
Intertidal grass-herb-sedge-other succulent	1,308.5
Intertidal mangroves and other trees & shrubs	571.8
Intertidal unconsolidated substrate	800.4
Intertidal consolidated substrate	12.6
Total	***2,693.2***

Saltmarsh and saltpan vegetation is susceptible to trampling and pugging impacts by feral cattle and feral horses as well as digging impacts by feral pigs that degrade the condition or quality of this habitat (Hall 2005, Melzer *et al.* 2007, Ecofund 2013). Eastern Curlews foraging or roosting in saltmarsh/saltpan vegetation are at risk of predation by feral predators, including feral cats, foxes and wild dogs, and are sensitive to disturbance by feral predators and other feral animals that access the intertidal zone (Lilleyman *et al.* 2020). During a visit to Spadely Station in June 2024, QPWS staff observed fresh tracks of foxes and wild dogs on two of the beaches located to the north of the Spadely offset management area, and the station caretaker reported that he had made many observations of foxes, wild dogs and their tracks throughout the intertidal habitats adjacent to the Spadely offset management area (D. Orgill, personal communication).

Figure 3.4 below shows the average total count of Eastern Curlews using the network of roost sites adjacent to the Spadely offset management area (all roost sites shown in **Figure 3.3**) each year from 2011 to 2019. The average count over the last three years 2017-2019 (average of 36) was notably lower than the average count over the preceding years 2011-2016 (average of 102). Stigner *et al.* (2016) found that off-leash domestic dogs reduce the number of foraging shorebirds present in a location by about 20%, and importantly that includes only the acute effect of the presence of the dogs, not the long-term avoidance of an area that is subject to sustained high levels of disturbance. Foxes and feral cats are important predators of birds in Australia (Department of the Environment, Water, Heritage and the Arts 2008, Department of the Environment 2015, Woinarski *et al.* 2022). Shorebirds are also more sensitive at roost sites than in foraging habitats because they are concentrated into small areas closer to land where the risk of predation is greater with larger distances to the nearest suitable alternative sites (Fuller *et al.* 2021). Consequently, it is plausible that the observed reduction in Eastern Curlew use of roost sites adjacent to the Spadely offset management area may be linked to the recent evidence of the pervasive presence of foxes and wild dogs in the intertidal habitats of the area.

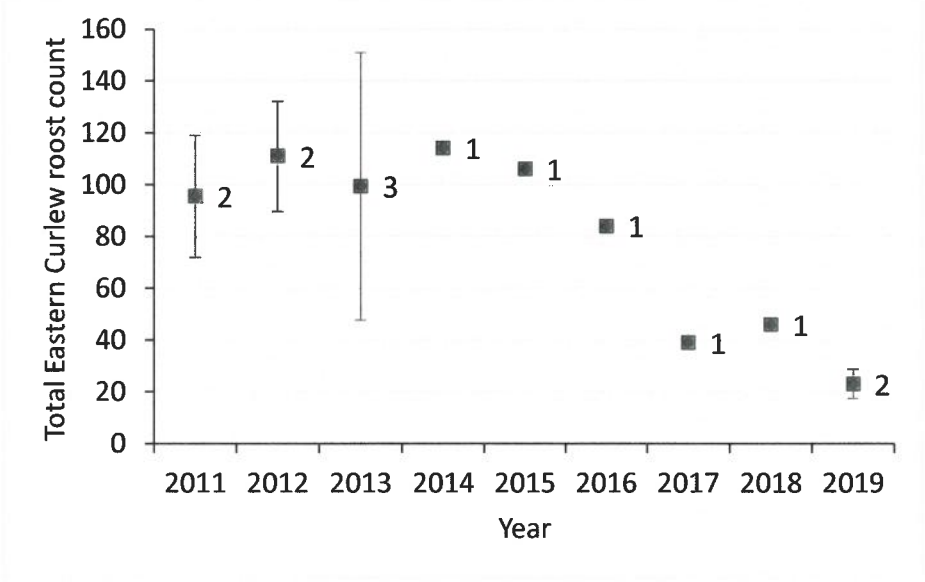


Figure 3.4. Average (±1SD, number of surveys indicated) total Eastern Curlew count using the network of roost sites adjacent to the Spadely offset management area each year, based on ERMP data.

The second component of the offset strategy is therefore focussed on implementing intensive feral animal control within the combined area of the three recently acquired properties (Spadely Station, Grassy Hill, Warners Point) and North Curtis Island State Forest (hereafter referred to as the Spadely offset management area, covering 2,216 ha) to improve the quality of adjoining intertidal habitats for Eastern Curlew. Feral animal control will focus on feral predators that pose a direct threat to Eastern Curlew (foxes, wild dogs, feral cats) as well as other ferals that may degrade Eastern Curlew habitat (feral pigs, cattle, horses), all of which are all known to occur on Curtis Island (Hall 2005, Melzer *et al.* 2007, Department of the Environment 2016, State of Queensland 2017, 2019, 2020).

The Spadely component of the offset strategy will complement the management activities associated with the Monte Christo offset in the central portion of Curtis Island. The Monte Christo offset involved the acquisition and/or surrendering of legal interests over 26,536 ha of Curtis Island (Ecofund 2013) and a funding contribution of $616,000 over 5 years to the QPWS for the management of the affected lands and surrounding protected area estate on Curtis Island. The Monte Christo offset acquitted the offset requirements for significant residual impacts of the Santos GLNG, Australia Pacific LNG and Queensland Curtis LNG projects on a wide variety of matters, including a combined impact on 130.24 ha of Eastern Curlew habitat (Ecofund 2013). To acquit this impact, the Monte Christo offset included 375 ha of RE 12.1.2 (Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains) that provides habitat for Eastern Curlew. The protection and sympathetic management of the Monte Christo offset, which included the cessation of cattle grazing and control of feral animals, was expected to improve habitat quality across a further 3,983 ha of non-tenured intertidal habitat (including mangroves) directly adjoining the properties subject to the offset (Ecofund 2013).

By complementing existing management activities, the Spadely component of the offset will contribute to and thereby enhance a whole-of-island management approach to improving management outcomes throughout Curtis Island and reducing the ongoing costs and complexity of feral animal management across the island. The strategy manages threats to Eastern Curlew habitat in an area with extensive intertidal areas and low-lying marine plains that provide potential for tidal flat foraging habitat to migrate with rising sea levels, an identified priority for mitigating climate change impacts on shorebirds including Eastern Curlew (Galbraith *et al.* 2002, Iwamura *et al.* 2014).

3.5 OFFSET ACQUITTAL

As outlined in **Section 2**, the construction and operation of the NLEP-SRA will result in a direct impact of 107.06 ha and an indirect impact of 14.18 ha, resulting in a total impact of 121.24 ha of Eastern Curlew foraging habitat that is used by an average of 2.3 Eastern Curlew for foraging at low tide during the summer months when most Eastern Curlew are present. The habitats used by Eastern Curlew are generally intertidal and therefore marine in nature. The EPBC Act Offset Assessment Guide (OAG) is not designed for marine offsets and therefore a bespoke offset assessment method (outlined in detail in **Appendix 1**) was designed to fit as closely as possible to the OAG to demonstrate offset acquittal. Using this assessment method, offset acquittal has been calculated based on the number of Eastern Curlew individuals impacted on the one hand and benefitting from the offset actions on the other hand. Offset acquittal is outlined separately for the two offset components in the sections that follow.

3.5.1 Artificial roost offset component

Acquittal of the artificial roost component of the offset is summarised in **Table 3.3**. The artificial roost offset acquits 75.10% of the impact.

Table 3.3. Summary of the calculation of offset acquittal for the artificial roost component in accordance with the Eastern Curlew offset assessment method outlined in Appendix 1.

Parameter	Value	Explanation
Average number of individuals using impact area foraging habitat	2.3	Average number of Eastern Curlew individuals using the NLEP-SRA footprint at low tide during summer months from baseline field surveys (see Section 2.2).
Equivalency factor	10	Offset includes roosting habitat only.
Adjusted number of birds impacted (present value)	23	Calculated as the product of the average number of individuals using the impact area foraging habitat and the equivalency factor.
Start number	0	No Eastern Curlew are currently roosting within the indicative location of the NLEP-SRA artificial roost site, which is inundated at high tide.
Future number without offset	0	No Eastern Curlew are expected to roost within the indicative location of the NLEP-SRA artificial roost site in the absence of the offset.
Future number with offset	30	The observed average number of Eastern Curlew using the much larger ponds within the WBRA within the past 5 years has been 64 (see Section 3.3.2); with sympathetic management, it is expected that these birds will transition to using the NLEP-SRA artificial roost once it is constructed and the WBRA becomes capped for port development. The future average number was conservatively estimated as 30 to account for a smaller artificial roost size (10 ha) relative to the current WBRA ponds being used by Eastern Curlew (75 ha and 100 ha) and greater levels of construction and operational activity adjacent to the new NLEP-SRA artificial roost site.
Confidence in offset result (probability)	0.8	GPC has previously successfully created suitable artificial roost habitat within the WBRA and the observed Eastern Curlew use of artificial roost habitat in the WBRA confirms the high demand for a suitable artificial roost in the local area. Consequently, there is high (80%) confidence that the NLEP-SRA artificial roost will be successful.
Conservation significance score (probability)	0.068	Annual probability of extinction + probability of catastrophe (from EPBC Offset Assessment Guide for a critically endangered species, based on IUCN category definitions).

Parameter	Value	Explanation
Time to ecological benefit (years)	5	Eastern Curlews are already using artificial roosts in the WBRA; these birds will be transitioned to using the NLEP-SRA artificial roost before the WBRA is fully capped for port development. Construction activities have the potential to cause a temporary reduction in Eastern Curlew use of the WBRA and NLEP-SRA artificial roosts initially; therefore, the time to ecological benefit is conservatively estimated to be 5 years.
Net present value	17.27	The output of the offset calculator.
Percentage of impact that is offset	75.10	The output of the offset calculator, as a percentage.

3.5.2 Spadely offset component

Acquittal of the Spadely component of the offset is summarised in **Table 3.4**. The Spadely offset acquits 25.03% of the impact.

Table 3.4. Summary of the calculation of offset acquittal for the Spadely component in accordance with the Eastern Curlew offset assessment method outlined in Appendix 1.

Parameter	Value	Explanation
Average number of individuals using impact area foraging habitat	2.3	Average number of Eastern Curlew individuals using the NLEP-SRA footprint at low tide during summer months from baseline field surveys (see Section 2.2).
Equivalency factor	5	Offset incorporates foraging and roosting habitat.
Adjusted number of birds impacted (present value)	11.5	Calculated as the product of the average number of individuals using the impact area foraging habitat and the equivalency factor.
Start number	53.5	Average count of the total number of Eastern Curlew roosting at the network of all roosts adjoining the Spadely offset management area based on most recent 5 years of ERMP monitoring data (see Section 3.4.3).
Future number without offset	49.7	The start number is discounted by the background annual rate of Eastern Curlew population change for the duration of time to ecological benefit.
Future number with offset	56.2	Assumes a 10% increase in Eastern Curlew use of intertidal habitats adjoining the Spadely offset management area following feral control, after accounting for the background annual rate of Eastern Curlew population change for the duration of time to ecological benefit. This estimate is considered conservative given the apparent 65% reduction in Eastern Curlew use of roost sites adjoining the Spadely offset management area over the last 3 years of ERMP monitoring (see Section 3.4.3) and research showing that the presence of dogs can reduce the number of foraging shorebirds present in a location by about 20%, not including the long-term avoidance of an area subject to dog impacts (Stigner *et al.* 2016).

Parameter	Value	Explanation
Confidence in offset result (probability)	0.8	QPWS observations suggest foxes and wild dogs currently have a pervasive presence across intertidal habitats adjoining the Spadely offset management area and research supports that these animals are predicted to reduce Eastern Curlew use of these intertidal habitats due to an elevated risk of disturbance and predation. ERMP monitoring data suggest an apparent 65% reduction in Eastern Curlew use of roost sites adjoining the Spadely offset management area over the most recent 3 years of that monitoring. The estimated 5% increase in Eastern Curlew use of the intertidal habitats following feral animal control is considered conservative. QPWS has a proven record of successful implementation of feral animal control on Curtis Island (see Section 3.4.1) and the long-term, annual support of feral animal control as part of coordinated approach to feral animal control throughout Curtis Island is expected to result in a sustained reduction in the impacts of feral animals. Consequently, there is high (80%) confidence that the offset component will be successful.
Conservation significance score (probability)	0.068	Annual probability of extinction + probability of catastrophe (from EPBC Offset Assessment Guide for a critically endangered species, based on IUCN category definitions).
Time to ecological benefit (years)	5	QPWS has a proven record of successful implementation of feral animal control on Curtis Island (see Section 3.4.1); therefore, a reduction in the occurrence of feral animals, including foxes and wild dogs is expected after the first year and a substantial reduction is expected within 5 years. Consequently, the time to ecological benefit is estimated to be 5 years.
Net present value	2.88	The output of the offset calculator.
Percentage of impact that is offset	25.03	The output of the offset calculator, as a percentage.
Background annual rate of Eastern Curlew population change	-0.0146	Estimate of Rogers *et al.* (2023) for the most recent period 2012-2021.

4.0 MANAGEMENT OBJECTIVES AND ACTIONS

This section outlines the management objectives of the offset strategy, the management actions that will be implemented to meet the objectives, their timing and frequency of implementation, the interim performance criteria that will monitor progress towards achieving the objectives and the completion criteria for the offset strategy, and the triggers for adaptive management and corrective actions to ensure an adaptive management framework.

Adaptive management is a procedure for simultaneously implementing management while learning about the effects of management actions in achieving specified objectives for natural resource management (Williams 2011). The procedure involves setting clear objectives and measurable performance indicators for management, defining the management actions that will be implemented to meet the objectives, planning the implementation of the management actions, implementing a monitoring programme to monitor the effectiveness of the management actions, and analysing and evaluating the monitoring data to inform a process of reviewing and updating the management actions.

The key performance criteria for the two offset components address performance in relation to the offset assessment method calculations outlined in **Section 3.5**. Consequently, annual reporting on progress of each offset component will include calculations of the percentage of the impact that each component has achieved based on the average number of Eastern Curlew that have been

recorded using the offset-enhanced habitats. For these calculations, the *future number with offset* will be the observed average number of Eastern Curlew using the relevant habitat in the year of assessment, and the *adjusted number of individuals impacted* will be discounted by the background annual rate of Eastern Curlew population change for the number of years that have elapsed since the impact eventuated i.e. since the start of NLEP-SRA construction.

4.1 ARTIFICIAL ROOST

The management objective of the artificial roost component of the offset strategy is to construct and maintain a migratory shorebird roost, suitable for the Eastern Curlew, on part of the NLEP-SRA, timed to ensure the continuous availability of a suitable artificial roost within the dredge reclamation areas of the Western Basin Reclamation Area and/or NLEP-SRA. To meet this objective, **Table 4.1** outlines the management actions and their timing and frequency of implementation, together with the performance criteria, monitoring indicators, triggers for adaptive management and corrective actions to ensure an adaptive management approach. **Table 4.2** provides additional detail on performance targets for this component of the offset. The key performance criterion for each year will be that the artificial roost accounts for at least 75% of the impact, using the offset assessment method outlined in **Appendix 1** and **Section 3.5.1** above.

Table 4.1. Adaptive management framework details for the artificial roost.

Management action	Timing and frequency	Performance criteria	Monitoring indicators	Triggers for adaptive management	Corrective actions
Design and construct a migratory shorebird roost in the NLEP-SRA to meet the design principles outlined in Section 2.1.	To be constructed at least one year prior to the artificial roost in the northern bund of the WBRA needing to be capped to meet port development demand.	A suitable migratory shorebird roost constructed.	Presence of artificial roost suitable for Eastern Curlew.	Absence of artificial roost suitable for Eastern Curlew after the specified timing for its construction.	Construct artificial roost suitable for Eastern Curlew.

Management action	Timing and frequency	Performance criteria	Monitoring indicators	Triggers for adaptive management	Corrective actions
Maintain a migratory shorebird roost suitable for Eastern Curlew in the WBRA initially, transitioning to an artificial roost in the NLEP-SRA.	From the start of NLEP-SRA construction, for the duration of the impact.	The artificial roost accounts for at least 90% of the impact (using the offset assessment method).	Average number of Eastern Curlew using the artificial roosts within the WBRA and/or NLEP-SRA (within the period two hours either side of high tide during the months October-February when most Eastern Curlew are present).	The artificial roost accounts for less than 90% of the impact over a 12-month period (using the offset assessment method).	Investigate to identify the likely causes of the roost not being used by Eastern Curlew and recommend appropriate corrective actions, which may include improved management of potential disturbance. Implement the recommendations. Increase the frequency of monitoring to at least twice each year (within the period mid-October to mid-March when most Eastern Curlew are present) for two years after trigger exceedance.
Maintain a migratory shorebird roost free of encroaching vegetation.	From the start of NLEP-SRA construction, for the duration of the impact.	The suitability of the artificial roost is not reduced by encroaching vegetation.	Type and extent of vegetation across the artificial roost.	Establishment of vegetation that may reduce the suitability of the artificial roost.	Remove the vegetation using effective control methods, which may include manual removal, use of a herbicide suitable for aquatic environments, or water level management.
Maintain a migratory shorebird roost that is fringed with shallow water suitable for Eastern Curlew to stand in on all high tides.	From the start of NLEP-SRA construction, for the duration of the impact.	Eastern Curlew are present at high tide, or if no Eastern Curlew are present then at least 50 m of the artificial roost perimeter (including outer perimeter and all islands) is fringed with shallow water suitable for Eastern Curlew to stand in (less than 5 cm deep at 1 m from the shoreline).	Number of Eastern Curlew, or total length of roost perimeter that is fringed by water less than 5 cm deep at 1 m from the shoreline at high tide.	The total length of roost perimeter that is fringed by water less than 5 cm deep at 1 m from the shoreline at high tide falls below 50 m on any high tide when no Eastern Curlew are present.	Re-establish a shallow gradient across the artificial roost substrate and ensure the artificial roost contains shallow water fringing the roost on all high tides.

Management action	Timing and frequency	Performance criteria	Monitoring indicators	Triggers for adaptive management	Corrective actions
Protect the migratory shorebird roost from disturbance by domestic dogs by implementing a ban on domestic dogs entering within 200 m of the roost.	From the start of NLEP-SRA construction, for the duration of the impact.	No domestic dogs enter within 200 m of the migratory shorebird roost.	Frequency of occurrence of domestic dogs from trail camera monitoring, shorebird surveys or general activities.	Detection of any domestic dog within 200 m of the migratory shorebird roost.	Review and revise the implementation of internal management procedures to ensure no domestic dogs enter within 200 m of the roost.
During NLEP-SRA construction*, minimise the use of drones within 300 m of the roost and within line of sight of roosting Eastern Curlew within 4 hours either side of high tide	For the duration of NLEP-SRA construction.	Written justification for why the drone survey cannot be conducted outside of line of sight of roosting Eastern Curlew when operating within 300 m of the roost site within 4 hours either side of high tide	Number of drone surveys requiring written justification.	Drone survey conducted within 300 m of the roost and within line of sight of roosting Eastern Curlew within 4 hours either side of high tide without written justification	Review and revise the implementation of internal management procedures to ensure no drone survey conducted within 300 m of the roost and within line of sight of roosting Eastern Curlew within 4 hours either side of high tide without written justification
After the completion of NLEP-SRA construction, protect the migratory shorebird roost from disturbance by drones by implementing a ban on drones being used within 300 m of the roost within 4 hours either side of high tide, unless they are operated in such a way that there is no line of sight between the drone and roosting Eastern Curlew.	From the completion of NLEP-SRA construction, for the duration of the impact.	No drones operate within 300 m of the migratory shorebird roost within 4 hours either side of high tide unless they are out of sight of roosting Eastern Curlew.	Frequency of occurrence of drones during shorebird surveys or general activities.	Detection of any drone operating within 300 m and within line of sight of the migratory shorebird roost within 4 hours either side of high tide.	Review and revise the implementation of internal management procedures to ensure no drones operate within 300 m of the migratory shorebird roost within 4 hours either side of high tide unless they are out of sight of roosting Eastern Curlew.

Management action	Timing and frequency	Performance criteria	Monitoring indicators	Triggers for adaptive management	Corrective actions
Eradicate feral predators (foxes, cats, dogs) within 200 m of the migratory shorebird roost.	From the start of NLEP-SRA construction, for the duration of the impact.	No feral predators (foxes, cats, dogs) enter within 200 m of the migratory shorebird roost.	Frequency of occurrence of feral cats, dogs and foxes from trail camera monitoring.	Detection of any feral predator within 200 m of the migratory shorebird roost.	Removal of feral predator(s) using live trapping and/or approved lethal control methods.

* During NLEP-SRA construction, regulatory approval requirements for bathymetric and sediment plume monitoring studies will require the use of drones adjacent to the NLEP-SRA and WBRA.

Table 4.2. Performance targets for the artificial roost offset component.

Year 5 interim performance target	Year 10 interim performance target	Year 15 interim performance target	Year 20 performance target
The artificial roost accounts for at least 75% of the impact (using the offset assessment method), i.e. an average of at least 30 Eastern Curlew use the artificial roost during the summer months.	The artificial roost accounts for at least 75% of the impact (using the offset assessment method), i.e. an average of at least 27.9 Eastern Curlew use the artificial roost during the summer months, accounting for the background rate of population change*.	The artificial roost accounts for at least 75% of the impact (using the offset assessment method), i.e. an average of at least 25.9 Eastern Curlew use the artificial roost during the summer months, accounting for the background rate of population change*.	The artificial roost accounts for at least 75% of the impact (using the offset assessment method), i.e. an average of at least 24.1 Eastern Curlew use the artificial roost during the summer months, accounting for the background rate of population change*.

* The background rate of population change is assumed to be -1.46% per year based on the estimate of (Rogers *et al.* 2023) for the most recent period 2012-2021 but will use updated estimates for the most relevant periods as they become available.

4.2 SPADELY OFFSET

The management objective of the Spadely offset component of the offset strategy is to manage threats to Eastern Curlew and Eastern Curlew habitat within the Port of Gladstone area through invasive animal control within or adjacent to Eastern Curlew habitat to improve habitat for the Eastern Curlew within the Port Curtis area and to aid the long-term conservation of habitat for the Eastern Curlew as part of a regionalised approach to threat abatement.

The feral animal control program will be undertaken by QPWS using financial support provided by GPC. QPWS will use a combination of control methods that have proven to be successful for feral animal control on Curtis Island, including aerial and ground shooting, soft jaw foothold trap lines and baiting. QPWS is also planning to use thermal camera, thermal sensor and alignment laser technology to trial with aerial shooting in 2024/25. Feral animal control will focus on feral pigs, foxes, wild dogs, feral cats, feral cattle, and feral horses that are all known to occur on Curtis Island (Hall 2005, Melzer *et al.* 2007, Department of the Environment 2016, State of Queensland 2017, 2019, 2020). The proposed control methods for each target species are summarised in **Table 4.3** below.

Table 4.3. Proposed primary control methods and frequency of implementation for feral animal control in the Spadely offset management area.

Feral animal	Primary control methods	Control frequency
Wild dogs	Aerial shooting; 1080 baiting; soft jaw foothold traps.	QPWS proposes to conduct 3 aerial shoots, 4 baiting and 2 leghold trapping activities per annum
Feral cats	Aerial and ground shooting.	QPWS proposes to conduct 3 aerial and 4 ground shoots per annum

Feral animal	Primary control methods	Control frequency
Red foxes	Aerial shooting; baiting with FOXOFF®; soft jaw foothold traps.	QPWS proposes to conduct 3 aerial shoots, 4 baiting and 2 leghold trapping activities per annum
Feral pigs	PIGOUT®, HOGGONE® and/or 1080 baiting	QPWS proposes to conduct 4 baiting trips per annum
Feral horses	Aerial and ground shooting	QPWS proposes to conduct 3 aerial and 4 ground shoots per annum
Feral cattle	Aerial and ground shooting	QPWS proposes to conduct 3 aerial and 4 ground shoots per annum

An alternative method for feral cat control in remote locations, namely the Felixer™ feral cat grooming trap (Dunlop *et al.* 2020, Bettink and Townsend 2023) may be implemented if the primary control method for this species is not sufficiently effective.

To meet the management objective for the Spadely offset management area, **Table 4.4** outlines the management actions and their timing and frequency of implementation, together with the performance criteria, monitoring indicators, triggers for adaptive management and corrective actions to ensure an adaptive management approach. **Table 4.5** provides additional detail on performance targets for this component of the offset. The key performance criterion from year 5 onwards will be that the Spadely offset component accounts for at least 25% of the impact, using the offset assessment method outlined in **Appendix 1** and **Section 3.5.2** above.

Table 4.4. Adaptive management framework details for the Spadely offset management area.

Management action	Timing and frequency	Performance criteria	Monitoring indicators	Triggers for adaptive management	Corrective actions
Implement proven and effective control measures for feral animals (pigs, horses, cattle, dogs, cats and foxes) for the duration that each species is known to occur on north Curtis Island.	Annually from approval of this offset strategy, for at least 20 years. The offset completion will be maintained until expiry of the approval.	The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method). Percent reduction in the frequency of occurrence of feral animals from baseline or unmanaged control.	Average number of Eastern Curlew using the network of roost sites adjoining the offset management area shown in Figure 5.1 (within the period two hours either side of high tide during the months October-February when most Eastern Curlew are present). Frequency of occurrence of feral predators (fox, wild dog, feral cat) from trail camera monitoring.	Performance criteria specified in Table 4.4 are not met. The year-on-year frequency of feral predator occurrence (3 species combined) increases and is not ≤1 per 100 camera trap days.	Review the feral animal control program to increase the frequency of feral animal control and/or implement alternative control methods to increase the effectiveness of species-specific feral animal control. Increase the frequency of monitoring to at least twice each year (within the period mid-October to mid-March when most Eastern Curlew are present) for two years after trigger exceedance.

Table 4.5. Performance targets for the Spadely offset management area.

Year 5 interim performance target	Year 10 interim performance target	Year 15 interim performance target	Year 20 performance target
The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method), i.e. an average of at least 54.7 Eastern Curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method), i.e. an average of at least 50.8 Eastern Curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method), i.e. an average of at least 47.2 Eastern Curlew use the offset target area during the summer months, accounting for the background rate of population change*.	The change in Eastern Curlew use of the offset target area accounts for at least 25% of the impact (using the offset assessment method), i.e. an average of at least 43.9 Eastern Curlew use the offset target area during the summer months, accounting for the background rate of population change*.

* The background rate of population change is assumed to be -1.46% per year based on the estimate of (Rogers *et al.* 2023) for the most recent period 2012-2021 but will use updated estimates for the most relevant periods as they become available.

5.0 MONITORING PROGRAM

The monitoring program for both components of the offset will include monitoring of feral animal occurrence as well as monitoring of Eastern Curlew use of habitats within or adjoining the offset areas as a direct measure of offset success.

5.1 MONITORING FERAL ANIMAL OCCURRENCE

The frequency of occurrence of feral animals will be monitored in a standardised way using trail cameras. Trail cameras using passive infrared (PIR)-triggering have proven to be a cost-effective method for monitoring the frequency of occurrence of a variety of mammals, including feral animals (Robley *et al.* 2010, Meek *et al.* 2015, Churchill *et al.* 2023). One camera will be used to monitor the boundary of the artificial roost within the WBRA and/or NLEP-SRA and four cameras will be used to monitor feral animal occurrence in intertidal habitats adjoining the Spadely offset management area. The four Spadely cameras will be set up in the general vicinity of roost sites C20, C26, C27 and adjacent to North Curtis Island State Forest. Cameras will be unbaited and attached to stakes 0.5 m from the ground and all obstructions within 2 m of the front of the camera will be removed. Cameras will be placed on the boundary of the intertidal because feral animals frequently move along the intertidal/land ecotone. The cameras will be set up during the first summer-season shorebird monitoring survey each year and collected approximately two months later during the second summer-season shorebird monitoring survey. Cameras will be programmed for continuous operation, set to take three photographs at 1 s intervals when triggered (a trigger event) with no delay before being able to respond to additional triggers. The frequency of occurrence of each feral animal species (*Frequency*) shall be quantified as:

$$Frequency = \frac{Total\ individuals}{Total\ camera\ days}$$

Where *Total individuals* is the number of different individuals recorded per visit event summed across all visit events across all cameras; and *Total camera days* is the sum of the number of days of operation across all cameras (a measure of camera monitoring effort). A visit event is the sequence of triggers that the same animal(s) trigger the camera, with the interval between successive triggers no longer than one minute.

A baseline assessment of the frequency of occurrence of feral animals will be undertaken over a 2-month period prior to the initiation of feral animal control within the Spadely management area. To monitor the success of feral animal control in reducing feral animal activity, the frequency of occurrence of feral animals will be monitored over a 2-month period each year as summarised in **Table 5.1**.

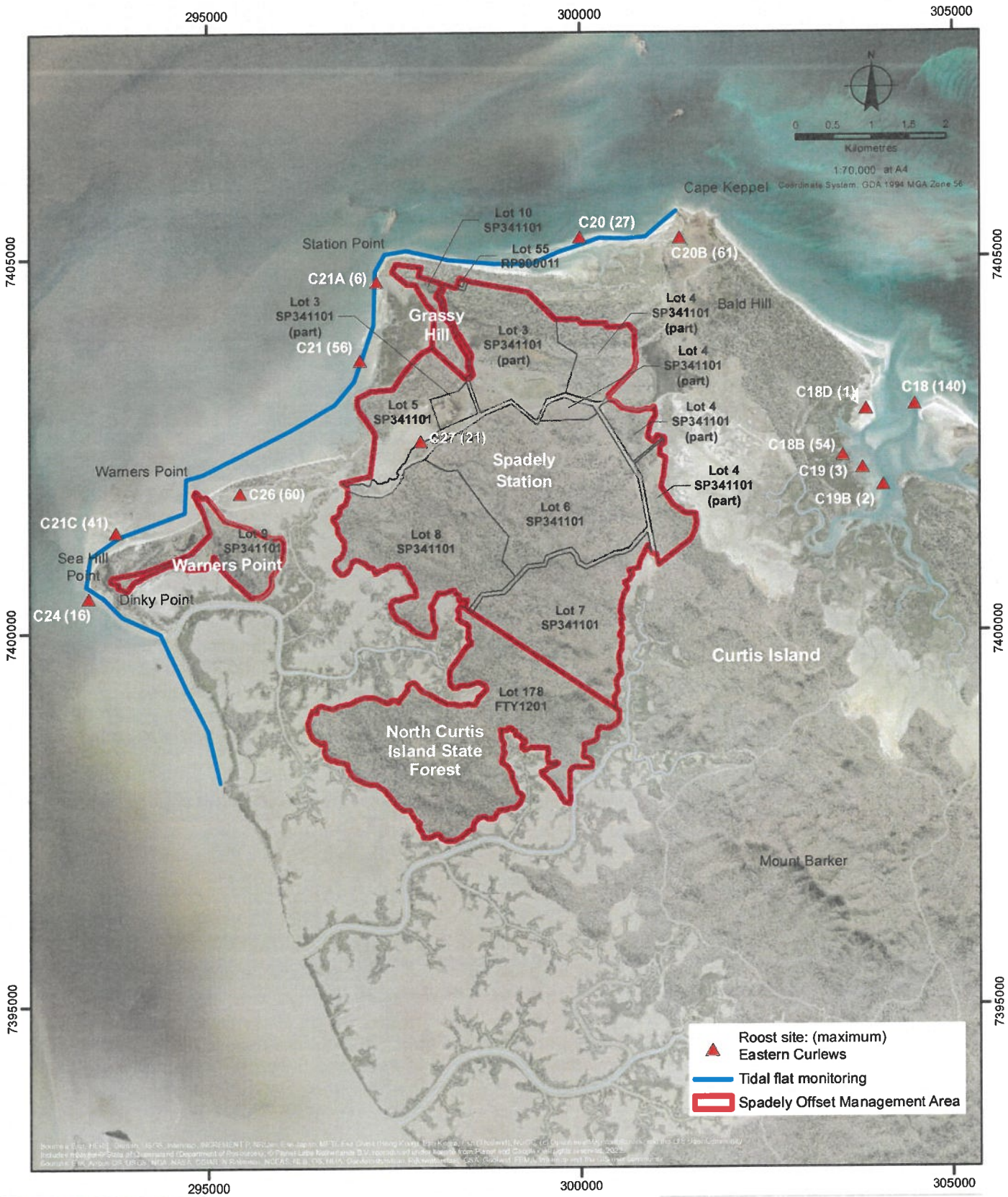
5.2 MONITORING EASTERN CURLEW

The monitoring of Eastern Curlew use of habitats within or adjoining the offset areas will have four main components:

- Monitoring Eastern Curlew use of artificial roost sites within the Western Basin and NLEP-SRA at high tide;
- Monitoring Eastern Curlew use of roost sites adjacent to the Spadely offset management area at high tide (sites C18 to C27 shown in **Figure 5.1**, including the saltpan/saltmarsh areas adjoining sites C26 and C27);
- Monitoring Eastern Curlew use of representative areas of Eastern Curlew foraging habitat adjacent to the Spadely offset management area at low tide, including approximately 14 km of tidal flats (see **Figure 5.1**); and
- Monitoring the frequency of occurrence of potential and actual sources of disturbance to Eastern Curlew during all high tide and low tide monitoring surveys.

The surveys will be conducted in accordance with the survey guidelines for migratory shorebirds (Commonwealth of Australia 2015b), as follows:

- during the period when the majority of Eastern Curlew are expected to be present in the area (i.e. within the period mid-October to mid-March (Higgins and Davies 1996, Driscoll and Ueta 2002, Minton *et al.* 2011, Lloyd *et al.* 2021, 2022, Morrick *et al.* 2022);
- surveys for foraging shorebirds will be conducted as close to the time of low tide as practicable and at a maximum of no more than two hours either side of low tide;
- surveys for roosting shorebirds will be conducted as close to the time of high tide as practicable and at a maximum of no more than two hours either side of high tide;
- surveys will not be undertaken during periods of high rainfall or strong winds or when activities are taking place which cause shorebird disturbance;
- data collection for roost sites and foraging habitat areas will include species abundance (number of birds of each species present);
- data collection will include spatial data of the area used by shorebirds for feeding or roosting;
- Survey conditions, including date, time of day, tide height, weather conditions (precipitation, wind speed and direction) will be recorded.



Data Sources:
Roost Sites:
BAAM - Sept 2023
Intertidal Habitats
https://gisservices2.information.qld.gov.au/arcgis/services, Name: WetlandMaps/MapB
Baseline Roads and Tracks - Queensland, Published 01/07/2022
Rail Network - Queensland, Published 17/05/2022
State of Queensland (Department of Resources) 2023

State of Queensland 2024
Biodiversity Assessment and Management P/L
While every care is taken to ensure the accuracy of this data BAAM Ecology makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation liability in negligence) for all expenses, losses, damages (including indirect consequential damage) and costswhich might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason

Drawn By: MapLass - KM Reviewed by: PL Date: 16/07/2024

Figure: 5.1

Title: Monitoring sites for Spadely offset management area

Project: Eastern Curlew Offset Strategy, NLEP-SRA

Client: Gladstone Ports Corporation Ltd

BAAM ECOLOGICAL CONSULTANTS

5.3 MONITORING SCHEDULE

The timing and frequency of the monitoring program is outlined in **Table 5.1** below.

Table 5.1. Monitoring methods, timing and frequency of monitoring.

Component	Method	Timing	Frequency
Frequency of occurrence of feral animals – Spadely	Four trail cameras monitoring for two months	Within the period mid-October to mid-March when most Eastern Curlew are present.	Once, prior to feral animal control. Annually from Year 1 to Year 10, biennial from Year 12 to Year 20.
Frequency of occurrence of feral animals – artificial roost	One trail camera monitoring for two months	Within the period mid-October to mid-March when most Eastern Curlew are present.	Once each year from Year 1 to Year 20 of the offset.
Monitoring Eastern Curlew - Spadely	Observational surveys at high tide and low tide	Within the period mid-October to mid-March when most Eastern Curlew are present.	Twice each year from Year 1 to Year 5, once each year from Year 6 to Year 10, biennial from Year 12 to Year 20.
Monitoring Eastern Curlew – artificial roost	Observational surveys at high tide, covering the Western Basin and NLEP-SRA.	Within the period mid-October to mid-March when most Eastern Curlew are present.	Monthly from one month prior to the start to one month after the end of construction of the NLEP-SRA boundary wall*. Once each year from completion of the NLEP-SRA boundary wall to Year 10, biennial from Year 12 to Year 20.

*Note: This monthly monitoring of roost sites in the WBRA and NLEP-SRA is already a component of the NLEP-SRA construction monitoring program.

6.0 RISK ASSESSMENT

A risk assessment was undertaken for each potential risk to the successful implementation of the Easter Curlew offset strategy by estimating the likelihood and consequence of each potential risk and then combining them to generate a risk rating of low, medium, high or severe. The definitions of likelihood and consequence together with the matrix of risk ratings are provided in **Appendix 6**. The results of the risk assessment are presented in **Table 6.1**. Potential risks to the successful implementation of the Easter Curlew offset strategy were assessed to be low to medium and therefore able to be managed under the adaptive management framework.

Table 6.1. Risk assessment summary for the risks to the successful implementation of the Easter Curlew offset strategy.

Potential risk	Likelihood	Consequence	Risk rating	Explanation
QPWS does not have capacity to undertake feral animal control within the Spadely offset management area.	Unlikely	Moderate	Low	In the unlikely event that this scenario eventuates, an alternative contractor could be engaged to undertake feral animal control, subject to agreement with QPWS.
QPWS withdraws from the agreement to undertake feral animal management within the Spadely offset management area.	Rare	High	Low	In the rare likelihood that this scenario eventuates, an alternative contractor could be engaged to undertake feral animal control, subject to agreement with QPWS.
Control methods are ineffective in controlling feral animals within the Spadely offset management area.	Unlikely	High	Medium	QPWS has proven the effectiveness of a variety of control methods for controlling feral animals on Curtis Island, and proven alternatives exist should they be required.
The feral animal control program does not increase Eastern Curlew use of intertidal habitats adjoining the Spadely offset management area to the extent predicted.	Possible	High	Medium	QPWS observations suggest foxes and wild dogs currently have a pervasive presence across intertidal habitats adjoining the Spadely offset management area and research supports that these animals are predicted to reduce Eastern Curlew use of these intertidal habitats due to an elevated risk of disturbance and predation. ERMP monitoring data suggest an apparent 65% reduction in Eastern Curlew use of roost sites adjoining the Spadely offset management area over the most recent 3 years of that monitoring. The estimated 5% increase in Eastern Curlew use of the intertidal habitats following feral animal control is considered conservative. QPWS has a proven record of successful implementation of feral animal control on Curtis Island (see Section 3.4.1) and the long-term, annual support of feral animal control as part of coordinated approach to feral animal control throughout Curtis Island is expected to result in a sustained reduction in the impacts of feral animals. Consequently, there is high (80%) confidence that the offset component will be successful.
The artificial roost is not constructed or does not meet the design principles.	Rare	Major	Medium	GPC is committed to constructing the artificial roost to meet Project approval conditions and GPC has successfully constructed an artificial wetland meeting roost design principles within the WBRA, proving that the design principles can be met.
The artificial roost is not used by Eastern Curlew.	Possible	High	Medium	GPC has successfully constructed an artificial wetland used by Eastern Curlew previously within the WBRA, and artificial roosts are used by Eastern Curlew in operational port situations elsewhere in Australia (for example, Darwin Port, Port of Brisbane, Manly Yacht Harbour). GPC is committed to managing disturbance to maintain the suitability of the artificial roost for Eastern Curlew roosting.
The artificial roost is removed without replacement in future development of the Port.	Rare	Major	Medium	GPC is committed to maintaining an artificial roost within the NLEP to meet Project approval conditions.

7.0 REPORTING

An annual report will be prepared each year. The report will include the following information at a minimum:

- EPBC approval number;
- an overview of the management activities undertaken through the reporting year together with a summary of the numbers of feral animals removed from the NLEP-SRA and Spadely offset management area;
- results of monitoring for the reporting year;
- comparison of the monitoring results for the current year of reporting with the monitoring results from the previous years of reporting, including comparison with the baseline monitoring results;
- progress towards achieving the performance targets;
- a description of any relevant performance criteria that were not satisfied and, where triggered, the corrective actions that have been implemented or are planned to be implemented in the subsequent year of management;
- an assessment of any risks or potential threats to the successful delivery of the offset that have become apparent through monitoring, and actions to be undertaken to manage any threats and risks; and
- if required, recommendations to be incorporated into the offset strategy including changes to management and monitoring methods.

8.0 REVIEW

The Project's EPBC Act approval (EPBC 2012/6558) condition 31 requires that the offset strategy include a process for, at the minimum, a biannual review of the offset strategy and the performance of offsets for the period of effect of the approval including timeframes for conducting the reviews and for publishing the findings of each review on the approval holder's website that is available to the public.

Once approved, the offset strategy will be reviewed twice each year to assess the efficacy of current management actions and identify whether additional activities and responses to unexpected events or threats to the successful delivery of the offset strategy are required. Should it become necessary to update the offset strategy to incorporate additional information obtained through the implementation of the strategy, any revision will be subject to an application to the Minister for a variation to the strategy in accordance with Condition 71 of approval EPBC 2012/6558. The biannual reviews will be finalised and published on the approval holder's website that is available to the public within two months of the 6-month and 12-month anniversary of the date of approval of the Eastern Curlew offset strategy each year.

9.0 LEGAL SECURING MECHANISM AND GOVERNANCE ARRANGEMENTS

9.1 LEGAL SECURING MECHANISM

The impact of the Project on Eastern Curlew habitat comprises an impact in the marine environment. Similarly, the offset involves management of feral animals on land to improve the quality of Eastern Curlew habitats in the marine environment. The EPBC Act Environmental Offsets Policy specifies that offsets in the marine environment should be developed in consultation with governing jurisdiction(s). The Queensland Government is the governing jurisdiction over the marine environment as well as the Spadely offset management area, which is managed by the

QPWS. The Spadely offset component of the offset has been developed in consultation with the QPWS.

9.2 GOVERNANCE ARRANGEMENTS

In accordance with the Project's EPBC Act approval (EPBC 2012/6558) conditions 30 and 31, GPC, as the proponent for the Project will be responsible for ensuring that the Eastern Curlew offset strategy is implemented within 12 months from the date that the Eastern Curlew offset strategy is approved in writing by the Minister. GPC will provide annual funding to QPWS to cover the cost of feral animal control in the Spadely offset management area in accordance with a Memorandum of Understanding that is expected to be signed between GPC and QPWS. The QPWS staff or contractors implementing the feral animal control will be suitably qualified and experienced professionals.

GPC will engage suitably qualified and experienced contractors for the construction of the artificial roost. GPC will engage suitably qualified and experienced professionals to ensure that persons implementing the feral animal management and monitoring activities described in this strategy have appropriate skills and qualifications. For the purposes of this offset strategy, suitably qualified and experienced professionals are defined as:

Persons who have professional qualifications, training, skills or experience related to the nominated subject matter and can implement the required management or monitoring activities or give authoritative assessment, advice and analysis on performance relative to the subject matter using the applicable protocols, standards, methods or literature.

GPC will be responsible for annual compliance reporting in accordance with the Project's EPBC Act approval.

10.0 EPBC ACT DOCUMENTS

Table 10.1 summarises how this Eastern Curlew Offset Strategy aligns with relevant policies and plans that have effect under the EPBC Act as well as with the broader strategies and programs for the Great Barrier Reef to provide a net benefit to the Great Barrier Reef World Heritage Area (GBRWHA).

Table 10.1 Summary outline of how this Eastern Curlew Offset Strategy aligns with relevant policies and plans that have effect under the EPBC Act as well as with the broader strategies and programs for the Great Barrier Reef to provide a net benefit to the GBRWHA.

Policy/Plan	Principle/objective	Eastern Curlew Offset Strategy
EPBC Act Environmental Offsets Policy	Deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environmental law and affected by the action.	The offsets directly contribute to the ongoing viability of the specific protected matter impacted by: (1) providing an artificial roost site close to known Eastern Curlew feeding habitat in an area where Eastern Curlew are known to require a safe roost site; and (2) managing feral animals that are known to threaten Eastern Curlew survival and the condition of known Eastern Curlew habitats at a location that is a known stronghold for Eastern Curlew in the Port Curtis region. QPWS observations suggest foxes and wild dogs currently have a pervasive presence across intertidal habitats adjoining the Spadely offset management area and research supports that these animals are predicted to reduce Eastern Curlew use of these intertidal habitats due to an elevated risk of disturbance and predation (see Section 3.4.3 for further details). ERMP monitoring data suggest an apparent 65% reduction in Eastern Curlew use of roost sites adjoining the Spadely offset management area over the most recent 3 years of that monitoring. The residual impact was calculated to be 121.24 ha of foraging habitat used by an average of 2.3 (maximum of 6) Eastern Curlew. The artificial roost is expected to provide an alternative roosting site for an average of 30 (up to 133) Eastern Curlew during the summer months, to offset 75% of the impact. The Spadely offset management area is predicted to increase Eastern Curlew use of intertidal habitats by at least 10%, to offset 25% of the impact.
	Be built around direct offsets but may include other compensatory measures	The strategy is built around direct offsets.
	Be in proportion to the level of statutory protection that applies to the protected matter	The size and scale of the offset was determined using a modified version of the EPBC Act Offset Assessment Guide. This accounts for the level of statutory protection (critically endangered) of the relevant protected matter in calculating the offset requirement.
	Be of a size and scale proportionate to the residual impacts on the protected matter	The size and scale of the offset was determined using a modified version of the EPBC Act Offset Assessment Guide that directly measures the impact in terms of the average number of Eastern Curlew impacted and the offset in terms of the change in the number of Eastern Curlew using habitats in response to the offset actions. This direct measure of

Policy/Plan	Principle/objective	Eastern Curlew Offset Strategy
		conservation gain provides a particularly robust approach to demonstrating the scale of the offset in relation to the impact. It also considers the equivalency between impact and offset habitat, time to ecological benefit and confidence in the result to ensure the offset is proportional to the impact. The residual impact was calculated to be 121.24 ha of foraging habitat used by an average of 2.3 (maximum of 6) Eastern Curlew. The artificial roost is expected to provide an alternative roosting site for an average of 30 (up to 133) Eastern Curlew during the summer months, to offset 75% of the impact. The Spadely offset management area is predicted to increase Eastern Curlew use of intertidal habitats by at least 10%, to offset 25% of the impact.
	Effectively account for and manage the risks of the offset not succeeding	The risk assessment is outlined in detail in Section 6. The offset strategy includes an adaptive management process and specific management actions that are proven to manage habitat and threatening processes effectively.
	Be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs	The artificial roost component is additional to what is already required. QPWS has confirmed that while QPWS aims to manage pest animals as part of its approach to managing all protected areas, QPWS has not managed to source funding for pest management in the Spadely acquisition. The offset provides consistent annual funding for at least 20 years and therefore meets the additionality principle.
	Be efficient, effective, timely, transparent, scientifically robust and reasonable	The size and scale of the offset was determined using a modified version of the EPBC Act Offset Assessment Guide that directly measures the impact in terms of the average number of Eastern Curlew impacted and the offset in terms of the change in the number of Eastern Curlew using habitats in response to the offset actions. This direct measure of conservation gain provides a particularly robust approach to demonstrating the effectiveness of the offset. Eastern Curlew are already using reclamation ponds in the WBRA for roosting in advance of the impact; with sympathetic management the Eastern Curlew using the WBRA will be transitioned to using the dedicated artificial roost component, providing a timely offset. The conservation benefit of the Spadely feral animal control component of the offset is expected to be achieved within 5 years of the impact. The offset assessment method and overall strategy was developed and peer-reviewed by

Policy/Plan	Principle/objective	Eastern Curlew Offset Strategy
		relevant experts to ensure it is transparent, scientifically robust and reasonable. The strategy relies on specific management actions that are proven to manage habitat and threatening processes efficiently and effectively.
	Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced	The offset strategy outlines a clear governance framework and delivery pathway to manage marine offsets and ensure the offset is monitored and audited/enforced in accordance with the Project's EPBC Act approval.
Reef 2050 Long-Term Sustainability Plan 2021–2025	Limit the impacts of climate change by contributing to global efforts to reduce greenhouse gas emissions, fostering partnerships and stewardship for climate mitigation, increasing the capacity of Reef communities, Traditional Owners and industries to adapt to a changing climate and supporting species and habitats to adapt to a changing climate.	The strategy manages threats to Eastern Curlew habitat in an area with extensive intertidal areas and low-lying marine plains that provide potential for tidal flat foraging habitat in the GBRWHA to migrate with rising sea levels, an identified priority for mitigating climate change impacts on shorebirds including Eastern Curlew (Galbraith et al. 2002, Iwamura et al. 2014).
	Reduce impacts from land-based activities by improving water quality through increased effective land management practices in catchments, reducing cumulative impacts through integrated catchment-to-Reef management, and reducing lighting and recreational impacts on sensitive shoreline ecosystems and cultural sites.	The control of feral pigs and livestock will reduce soil disturbance and thereby improve water quality in a catchment in the Great Barrier Reef World Heritage Area. Monitoring of Eastern Curlew use of habitats will improve knowledge of sensitive shoreline ecosystems and inform conservation planning for these areas.
	Reduce impacts from water-based activities by enhancing biodiversity and heritage protection and supporting ecosystem resilience through strengthened efforts to ensure water-based activities are sustainable, supporting Traditional Owners to continue to manage sea Country, reducing threats associated with legal and illegal fishing, reducing noise pollution and artificial light impacts from sources within and adjacent to the Marine Park, reducing new outbreaks of disease and preventing incursions of introduced species and pests, and reducing marine debris, rubbish pollution and at-sea disposal of waste.	The construction of an artificial roost will provide a safe roost site protected from potential disturbance associated with water-based activities. Monitoring of Eastern Curlew use of habitats will improve knowledge of sensitive shoreline ecosystems and inform conservation planning for these areas.
	Influence the reduction of international sources of impact by fostering international efforts to reduce marine debris entering the Reef and promoting international cooperation for the protection of migratory species.	Not applicable.
	Protect, rehabilitate and restore by reducing outbreaks of pests, introduced species and disease, actively rehabilitating or restoring key habitats, and conserving historic and cultural heritage sites.	The management of feral animals will protect and restore by reducing introduced species and restore key habitats.

Policy/Plan	Principle/objective	Eastern Curlew Offset Strategy
	Enable collaboration and partnerships to maintain and increase adoption of best-practice voluntary compliance and stewardship behaviours and ensuring Traditional Owner Indigenous heritage, rights and responsibilities are incorporated into all facets of management.	The strategy enables collaboration and partnership with QPWS to deliver best-practice feral animal control. The QPWS has a Memorandum of Understanding with the Gidarjil Development Corporation for participation and involvement by Land and Sea Country Rangers in marine park and national park management field operations.
	Enable science and knowledge to ensure science and knowledge are advanced, easily accessible and able to be used in decisions	The monitoring program will contribute data to enable science and knowledge of feral animal control, Eastern Curlew use of habitats and population trends that will be accessible and able to be used in decisions.
	Enable monitoring, evaluation and adaptive management to support informed and agile management responses	The strategy includes a monitoring program and adaptive management mechanisms to support informed and agile management responses.
	Enable investment to support delivery of the Reef 2050 Plan	The strategy includes investment by GPC in feral animal control and monitoring on Curtis Island that will contribute to delivery of components of the Reef 2050 Plan.
Conservation Advice *Numenius madagascariensis* Eastern Curlew[2]	Work with governments along the East Asian – Australasian Flyway to prevent destruction of key migratory staging sites	Not applicable.
	Develop and implement an International Single Species Action Plan for eastern curlew with all range states	Not applicable.
	Support initiatives to improve habitat management at key sites	The strategy will improve habitat management in north Curtis Island, which has been identified as a key site for Eastern Curlew.
	Maintain and improve protection of roosting and feeding sites in Australia	The strategy will maintain and improve protection of roosting and feeding sites on Curtis Island from feral animal impacts and construct a protected roost site suitable for Eastern Curlew.
	Incorporate requirements for Eastern Curlews into coastal planning and management	The strategy incorporates requirements for Eastern Curlews into coastal management.
	Manage important sites to identify, control and reduce the spread of invasive species	The management of feral animals on north Curtis Island will control and reduce the spread of invasive species.

[2] No recovery plan or threat abatement plan has been made for Eastern Curlew since the approved conservation advice for the species provides sufficient direction to implement priority actions and mitigate against key threats (Department of the Environment 2023).

Policy/Plan	Principle/objective	Eastern Curlew Offset Strategy
	Manage disturbance at important sites when Eastern Curlews are present – e.g. discourage or prohibit vehicle access, horse riding and dogs on beaches, implement temporary site closures	The control of feral animals will manage disturbance to Eastern Curlews and habitat degradation from feral animals. The monitoring program included in the offset strategy will include monitoring of disturbance at important roost sites that can inform subsequent management of these sites.
	Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary	The strategy includes a monitoring program to support adaptive management.
	Enhance existing migratory shorebird population monitoring programmes, particularly to improve coverage across northern Australia	The strategy includes a monitoring program that will monitor Eastern Curlew populations in areas not included in existing shorebird population monitoring programmes.
	More precisely assess Eastern Curlew life history, population size, distribution and ecological requirements particularly across northern Australia	The monitoring of Eastern Curlew included in the strategy will collect data relevant to the assessment of population size and distribution.
	Improve knowledge about dependence of Eastern Curlew on key migratory staging sites, and wintering sites to the north of Australia	Not applicable.
	Improve knowledge about threatening processes including the impacts of disturbance and hunting	The strategy includes a monitoring program that will collect information on threatening processes, including feral animals and disturbance.
Threatened Species Action Plan 2022-2032	All priority species are on track for improved trajectory	The Eastern Curlew is a listed priority species.
	Implementation of priority actions for priority species is tracked and published	Not applicable.
	Species at high risk of imminent extinction are identified and supported to persist	The strategy supports Eastern Curlew to persist by managing threats to Eastern Curlew habitat in an area that has been identified as a stronghold for the species and that has extensive intertidal areas and low-lying marine plains that provide potential for tidal flat foraging habitat in the GBRWHA to migrate with rising sea levels, an identified priority for mitigating climate change impacts on shorebirds including Eastern Curlew (Galbraith *et al.* 2002, Iwamura *et* al. 2014).
	All priority places are on track for improved condition	Not applicable.
	Implementation of priority actions for priority places is tracked and published	Not applicable.
	The area managed for conservation is increased by 50 million hectares	The strategy works cooperatively with a conservation land manager (QPWS) to improve the conservation and condition of important habitat for a priority species.

Policy/Plan	Principle/objective	Eastern Curlew Offset Strategy
	Impacts of climate change on priority species and places are identified and actions are underway to strengthen resilience and adaptive capacity	The strategy manages threats to Eastern Curlew habitat in an area with extensive intertidal areas and low-lying marine plains that provide potential for tidal flat foraging habitat in the Great Barrier Reef World Heritage Area to migrate with rising sea levels, an identified priority for mitigating climate change impacts on shorebirds including Eastern Curlew to strengthen resilience and adaptive capacity (Galbraith *et al.* 2002, Iwamura *et al.* 2014).
	Feral cats and foxes are managed across all important habitats for susceptible priority species using best practice methods	The Eastern Curlew is a listed priority species and a major component of the offset strategy involves the control of feral animals, including feral cats and foxes using best practice methods at important habitats for Eastern Curlew.
	Feral cats and foxes are managed in all priority places where they are a key threat to condition, using best practice methods for the location	Not applicable.
	Gamba Grass is reduced to an area less than its 2022 range	Not applicable.
	Introduction and establishment of new exotic environmental pests, weeds and diseases is reduced	Not applicable.
	Five new populations of appropriate species are added across the national safe-haven network to improve representation of invasive predator-susceptible threatened species	Not applicable.
	At least 80 per cent of nationally listed threatened plant species are secured in insurance collections	Not applicable.
	All nationally listed threatened plant species affected by Myrtle Rust are secured in insurance collections and populations	Not applicable.
	First Nations' Knowledges are integrated in conservation assessments, processes and planning for threatened species and ecological communities	The QPWS will be undertaking feral animal control consistent with a Memorandum of Understanding between Gidarjil Development Corporation and QPWS for participation and involvement by Land and Sea Country Rangers in marine park and national park management field operations.
	First Nations-led recovery activities for threatened species and ecological communities are increased	The QPWS will be undertaking feral animal control consistent with a Memorandum of Understanding between Gidarjil Development Corporation and QPWS for participation and involvement by Land and Sea Country Rangers in marine park and national park management field operations.
	Emergency response management and planning for critical biodiversity assets improves across jurisdictions	The provision of financial support for feral animal management allows QPWS to use its limited budget for other

Policy/Plan	Principle/objective	Eastern Curlew Offset Strategy
		management activities, including fire and emergency response management and planning for critical biodiversity assets on Curtis Island.
	At least half the number of projects that benefit priority species and priority places receive private investment or support from partners	The strategy provides private investment in a project that benefits Eastern Curlew, a priority species.
A Vulnerability Assessment for the Great Barrier Reef: Shorebirds	Continue long-term monitoring programs that provide vital information on population trends and breeding success for shorebirds used to inform management decisions	Monitoring of Eastern Curlew will continue components of a monitoring program that has operated since 2011.
	Continue natural resource management (control of pest flora and fauna and maintain the ecological influence of fire) and monitoring of key foraging, nesting and roosting sites for shorebirds through the Field Management Program and partnerships with nongovernment waterbird conservation groups	The strategy includes control of pest fauna as well as monitoring of key foraging and roosting sites for shorebirds on Curtis Island, part of the GBRWHA.
	Support and facilitate collaborations on shorebird research and monitoring programs with data-set custodians and researchers.	The monitoring program will capture data on shorebird use of habitats in areas not included in existing shorebird population monitoring programmes. These data will become available for researchers.
	Implement effective management on a local and regional scale, such as protection of key foraging, roosting and nesting habitat.	The strategy will implement effective management of feral animals and thereby contribute to and enhance a whole-of-island management approach to improving management outcomes for key shorebird habitats on Curtis Island.
	Advocate for increased protection for important shorebird habitats outside of current conservation reserves within (and adjacent to) the Great Barrier Reef World Heritage Area, in recognition of their important conservation value.	The strategy includes increased protection of important shorebird habitats from the impacts of feral animals within the GBRWHA.
	Continue to implement and strengthen international and intergovernmental partnerships and agreements to ensure key habitat is protected and threatening processes are addressed throughout the range of migratory species.	Not applicable.
	Work with national and interstate governing bodies to ensure a network of important habitat for migratory species is maintained across Australia, to maintain crucial linkages for shorebirds migrating along the East Asian-Australasian Flyway.	Not applicable.
	Additional research on shorebird biology, ecology, population status, key habitats and threats is required to better inform management decisions for this group of species.	Not applicable.

Policy/Plan	Principle/objective	Eastern Curlew Offset Strategy
	Work with key non-government environmental management groups such as Birds Australia (and their Australasian Wader Studies Group) to align monitoring efforts and increase the usability of monitoring data for management purposes.	Not applicable.
	Identify and support research options that further improve knowledge of species-specific foraging strategies, localities and trophic interplays within the Great Barrier Reef Region for shorebird species.	Not applicable.
	Increase awareness of the threats to shorebirds and the importance of conserving shorebirds and their habitats. Increase the level of collaboration between decision makers and the community in conservation programs.	Not applicable.
	Continue to monitor other key threats to shorebirds through the joint Australian and Queensland governments' Field Management Program for the Great Barrier Reef World Heritage Area and implement best-practice responses to minimise the impacts of these threats. Key threats that require a management focus within the World Heritage Area come from visitor disturbance and marine debris.	The monitoring program will contribute to monitoring feral animals as well as monitoring disturbance to shorebirds, and the management program will implement best-practice management of feral animals to minimise their impacts on shorebirds on Curtis Island within the GBRWHA.
	Great Barrier Reef Marine Park Authority (GBRMPA) Guidelines for managing visitation to islands where shorebirds breed should be periodically reviewed in line with current knowledge. The effectiveness of the management response must also be monitored and reviewed.	Not applicable.
	Work to establish arrangements with key authorities and non-government organisations to prevent rubbish entering the marine environment and support the removal of discarded fishing gear/marine debris.	Not applicable.

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APPENDIX 1

Offset assessment method for Eastern Curlew

OFFSET ASSESSMENT METHOD FOR EASTERN CURLEW (CO22000090)

Prepared for
Gladstone Ports Corporation

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Principal Ecologist

OFFSET ASSESSMENT METHOD FOR EASTERN CURLEW (CO22000089)

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Table of Terms and Abbreviations

DCCEEW	Department of Climate Change, Energy, the Environment and Water
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
GPC	Gladstone Ports Corporation Limited

1.0 INTRODUCTION

1.1 OFFSETS ASSESSMENT UNDER THE EPBC ACT

The *EPBC Act Environmental Offsets Policy* (the policy) outlines the Australian Government's approach to the use of environmental offsets ('offsets') under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The policy is accompanied by the *Offsets Assessment Guide* (the guide). The guide was developed to give effect to the requirements of the policy, using a balance sheet approach to estimate impacts and offsets for threatened species and ecological communities.

The policy and guide provide a decision support framework to normalise the judgements associated with determination of proposed offsets for a given impact when a proposed action is likely to have a residual significant impact on a threatened species or ecological community. The overarching test of both the policy and the guide is that suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action.

The guide is an Excel spreadsheet with embedded formulae, which can be downloaded at www.environment.gov.au/epbc/publications/environmental-offsets-policy.html. The guide is comprised of four parts:

- Matter of National Environmental Significance assessment box;
- Impact calculator;
- Offset calculator; and
- Summary box.

The impact and offset calculator components of the guide with regards to threatened species first require the selection of the most appropriate protected matter attribute. Protected matter attributes are the various options to calculate the quantum of impact and associated suitable offset depending on whether the impact affects the threatened species' habitat or ecology (birth rate, death rate or number of individuals). The type and quality of the data available should also inform this decision (e.g. if the number of individuals can be counted or accurately estimated from sampling then *number of individuals* should be used). If the appropriate attribute is the habitat area, then the calculation of the total quantum of both impact and suitable offset requires measures of both the area of habitat and the quality of that habitat.

1.2 OBJECTIVE

The EPBC Act approval conditions for the construction of the Northern Land Expansion Project - Southern Reclamation Area (NLEP-SRA) associated with the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (EPBC 2012/6558) require Gladstone Ports Corporation (GPC) to deliver an environmental offset to compensate for impacts to Eastern Curlew habitat. Furthermore, the assessment of site habitat quality that is required to be included in the offset assessment must use a method agreed to in writing by the Department.

The objective of this document is to outline an assessment method suitable for the assessment of the quantum of impact and suitable offset for Eastern Curlew that is consistent with the policy and guide. The habitats used by Eastern Curlew are generally intertidal and therefore marine in nature. The guide is not designed for marine offsets and therefore a bespoke offset assessment method was designed to fit as closely as possible to the guide to demonstrate offset acquittal.

2.0 APPROACH TO DEVELOPING THE OFFSET ASSESSMENT METHOD

To be consistent with two overarching principles of the policy, the development of the offset assessment method should be:

- informed by scientifically robust information and incorporate the precautionary principle in the absence of scientific certainty; and
- conducted in a consistent and transparent manner.

To meet these principles, the development of the offset assessment method for Eastern Curlew was informed by a review of published information on the species' ecology and the threats facing the species, including but not limited to the following:

- The approved conservation advice for the Eastern Curlew (Department of Climate Change, Energy, the Environment and Water 2023);
- The Industry Guidelines for avoiding, assessing and mitigating impacts on EBBC Act listed migratory shorebird species (Department of the Environment 2015);
- The Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia 2006);
- A Vulnerability Assessment for the Great Barrier Reef: Shorebirds (GBRMPA 2012);
- The Threatened Species Action Plan 2022-2032 (Department of Climate Change, Energy, the Environment and Water 2022);
- The National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (Department of the Environment and Energy 2020);
- Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species (Hansen *et al.* 2016); and
- The extensive published literature on Eastern Curlew ecology and conservation.

This offset assessment method was developed by Dr Penn Lloyd, a suitably qualified ecologist and Eastern Curlew expert, who holds a PhD in Ornithology, has worked as an academic researcher on the conservation ecology of birds for 17 years, as a consultant for the past 14 years, is an active member of the Queensland Wader Study Group, and is a Certified Environmental Practitioner (CEnvP) Ecology Specialist of the Environment Institute of Australia & New Zealand (EIANZ). He has authored over 270 consultancy reports and over 60 peer-reviewed scientific publications, the latter including four publications that included monitoring of Eastern Curlew. Over the past 14 years he has led baseline assessments and monitoring surveys for 35 different projects that have included survey and assessment for Eastern Curlew.

To ensure the development of the offset assessment method is conducted in a consistent and transparent manner, the draft offset assessment method was independently peer reviewed by Professor Richard Fuller, an independent migratory shorebird and Eastern Curlew expert at the University of Queensland. Prof. Fuller is a conservation biologist who integrates pure and applied topics in biodiversity and conservation to answer fundamental questions around a sustainable environmental future. His research topics include the ecology and conservation of migratory species and strategies for designing efficient conservation plans and he has published over 260 peer-reviewed scientific publications. Prof. Fuller serves on the Australian Government's Ecosystem Research and Monitoring Panel and frequently advises the Australian Government on migratory species conservation.

3.0 OFFSET ASSESSMENT METHOD

3.1 BACKGROUND

Eastern Curlews use two types of habitat on their non-breeding grounds in Australia: foraging habitat and roosting habitat, and their use of these two habitats alternates with the tide cycle. During the low tide phase of the tide cycle, Eastern Curlews forage on tidal areas exposed at low tide, including soft sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near mangroves, saltflats, saltmarsh, rockpools and among rubble on coral reefs, and ocean beaches near the tideline (Department of the Environment 2015). During the high tide phase of the tide cycle when the preferred foraging habitat becomes flooded by the rising tide, Eastern Curlews move to rest at roosting habitat on sandy spits, sandbars and islets, especially on beach sand near the high-water mark, and among coastal vegetation including low saltmarsh or mangroves, occasionally on reef-flats, in the shallow water of lagoons and other near-coastal wetlands (Department of the Environment 2015). The ecological requirements of Eastern Curlews differ between foraging habitat and roosting habitat.

3.1.1 Factors influencing foraging habitat quality

The suitability of feeding habitat for migratory shorebirds, including Eastern Curlew depend on a variety of factors, which include:

- Abundance and availability of preferred benthic invertebrate foods (Rogers *et al.* 2013);
- Substrate type hardness hardness/penetrability; Eastern Curlew prefer tidal flats with low substrate resistance and substrate resistance is an important predictor of the foraging density of Eastern Curlew and their invertebrate prey (Finn *et al.* 2008, Finn and Catterall 2023);
- Predation and disturbance risk; for example, the presence of dogs reduced shorebird use of foraging habitat by 20% in Moreton Bay (Fuller *et al.* 2021); and
- Distance from roost sites, preferring sites close to preferred roost sites since that reduces their energy expenditure flying between roosting and feeding sites (Rogers *et al.* 2006a); distance to high tide roost sites can constrain shorebird use of foraging habitats (Dias *et al.* 2006, Rogers *et al.* 2006b).

3.1.2 Factors influencing roosting habitat quality

The suitability of roost sites for migratory shorebirds, including Eastern Curlew depend on a variety of factors, which include:

- distance from feeding areas, preferring sites close to feeding areas since that reduces their energy expenditure flying between roosting and feeding sites (Rogers *et al.* 2006a);
- distance from tall cover, preferring sites with little cover to ensure a clear view of approaching predators (Rogers *et al.* 2006a, Lilleyman *et al.* 2020);
- climate, preferring sites at the water's edge or with a wet substrate to stay cool (Ryeland *et al.* 2020, Lilleyman *et al.* 2020);
- height of the tide (whether the site will be inundated) (Rogers *et al.* 2006a);
- background colour of the roost site, preferring sites that provide camouflage against predators (Rogers *et al.* 2006a);
- predation and disturbance risk, preferring sites with lower risk of predation and disturbance (Peters and Otis 2007, van der Kolk *et al.* 2022); and
- wind speed and the ability of the roost to provide shelter from the wind (Peters and Otis 2007).

Migratory shorebirds are particularly sensitive to the risk of predation and disturbance at roost sites because they are concentrated into small areas closer to land where the risk of predation is greater

and often with substantially greater distances to the nearest suitable alternative sites than is relevant in foraging habitat (Fuller *et al.* 2021).

3.2 SELECTION OF PROTECTED MATTER ATTRIBUTE FOR USE IN THE OFFSET CALCULATOR

As outlined in **Sections 3.1.1** and **3.1.2** above, a wide variety of variables influence the suitability or quality of shorebird habitats, including for Eastern Curlew. The number of individuals using the habitat can be viewed as the net result of the influence of these various factors on the decisions of shorebirds to use an area of habitat. Furthermore, the various factors influencing habitat suitability are typically difficult to quantify and their individual influence on habitat suitability is difficult to estimate. Consequently, the number of individuals using the habitat provides a more suitable and direct measure or indicator of habitat quality for most shorebirds.

The EPBC Act offset assessment guide notes that the type and quality of the data available should inform the decision regarding the protected matter attribute that is used to calculate the quantum of impact and associated suitable offset, citing the example that if the number of individuals can be counted or accurately estimated from sampling then *number of individuals* should be used. Shorebirds that use intertidal habitats, including Eastern Curlew are easily censused at both low tide (to measure the number of individuals using a given area of foraging habitat) and high tide (to measure the number of individuals using roost sites). Thus, they are particularly amenable to the use of the number of individuals as a measure of the magnitude of impact and offset value in the EPBC Act offsets calculator. This is particularly the case in the context of comparing the impact and offset values of foraging habitat versus roosting habitat; foraging habitat supports lower densities of shorebirds over larger areas whereas roosting habitat supports high densities in sometimes very small areas. When comparing a roost site offset that compensates for an impact on foraging habitat, habitat area performs poorly as a metric for offset assessment.

Since the number of individuals using the habitat integrates the influence of a variety of factors that affect habitat quality and the number of individuals can be easily counted, the *number of individuals* is the most appropriate protected matter attribute for the Eastern Curlew offset assessment method.

3.3 EASTERN CURLEW OFFSET CALCULATOR

The value of an Eastern Curlew offset is calculated using the formula:

$$\text{Offset value (number of individuals)} = \frac{[(Nfo-Ns)-(Nf-Ns)] \times Co}{(1+S)^{To}}$$

where:

*N*fo = Future number of individuals with offset;

*N*s = Start number of individuals;

*N*f = Future number of individuals without offset;

*C*o = Confidence in offset result (probability);

S = Conservation significance score (probability), which is 0.068 (6.8%) for a critically endangered species; and

*T*o = Time to ecological benefit (years).

3.3.1 Discounting the future number of individuals

The population of Eastern Curlew migrating to Australia has undergone a severe population decline of 77% over the 28 years 1993 to 2021; however, the annual rate of population decline has reduced to an average rate of -1.46% over the most recent period 2012-2021 (Rogers *et al.* 2023). This decline is strongly linked to the loss of intertidal feeding habitat at key migration staging sites in the Yellow Sea that Eastern Curlew is highly reliant on (Studds *et al.* 2017). Consequently, both the start number and future number of Eastern Curlew should be discounted by the most recent available estimate of annual rate of population change for the duration of the time to ecological benefit in the calculation of offset value. Rigorous methods have been developed to estimate the annual rate of population change for Eastern Curlew from extensive national shorebird monitoring datasets, for example Studds *et al.* (2017) and Rogers *et al.* (2023). Consequently, the most recent applicable estimate from such analysis is preferred to the approach of using a reference area in the vicinity of the offset area that may be unpredictably influenced by local factors.

3.3.2 Using an equivalency factor for comparing impact and offset

Foraging habitat and roosting habitat perform different functions for a coastal migratory shorebird such as Eastern Curlew. While they are expected to use the two different habitat types for a similar amount of time each day, foraging habitat is critical for energy intake whereas roosting habitat is critical for conserving energy and ensuring safety from predation during the resting period over high tide. The two habitat types are not directly comparable. This creates a complication for determining the equivalency between a roost site offset to compensate for an impact on foraging habitat. Yet, a roost site offset may provide a better overall conservation outcome for Eastern Curlew than a foraging habitat offset in many situations (Fuller *et al.* 2021), including in Port Curtis (see **Appendix 2**).

Comparability between the two habitat types in the context of comparing impact and offset can be achieved using an equivalency factor to adjust the offset target relative to the impact value (number of individuals). **Table 3.1** outlines the proposed equivalency factors for an impact on foraging habitat, which vary depending on whether the offset is foraging habitat, roosting habitat or a mixture of the two.

Table 3.1. Proposed equivalency factors for calculating offset targets for an impact on foraging habitat, depending on whether the offset is foraging habitat, roosting habitat or a mixture of the two.

Number impacted	Equivalency factor	Offset target
1	1	1 (foraging habitat offset)
1	10	10 (roost site offset)
1	5	5 (mixed foraging and roost offset)

When the offset includes only roosting habitat to compensate for an impact on foraging habitat, for example creating an artificial roost site or restoring a roost site, the effective impact value is ten times the impact value. Thus, for every 1 Eastern Curlew using the impacted foraging habitat, the offset must accommodate 10 Eastern Curlews, on average, before accounting for the influence of conservation significance score, time to ecological benefit and confidence in the offset result.

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APPENDIX 2

Eastern Curlew survey data

Table A2.1. Summary of low tide surveys of the total numbers of Eastern Curlew foraging within the NLEP-SRA impact footprint.

Date	LT height (m)	Eastern Curlews	Source
09/02/2022	2.02	6	BAAM unpublished
11/02/2022	1.69	5	BAAM unpublished
13/02/2022	1.33	4	BAAM unpublished
16/02/2022	0.95	2	BAAM unpublished
01/03/2023	1.84	1	BAAM (2023)
02/03/2023	1.59	1	BAAM (2023)
07/03/2023	0.99	0	BAAM (2023)
17/01/2024	1.41	1	BAAM (2024)
02/02/2024	2.06	1	BAAM (2024)
22/02/2024	1.12	2	BAAM (2024)
Average ±1SD		2.3±2.0	

Table A2.2. Summary of low tide surveys of the density of Eastern Curlews in foraging habitat on north Curtis Island.

Month	Year	Foraging density (birds per 10 ha)	Source
October	2019	1.7	Wildlife Unlimited (2020)
August	2019	0.7	Wildlife Unlimited (2020)
March	2019	0.4	Wildlife Unlimited (2020)
February	2019	0.9	Wildlife Unlimited (2020)
January	2019	0.7	Wildlife Unlimited (2020)
February	2018	0.5	Wildlife Unlimited (2018)
Average summer ±1SD		0.84±0.52	

Table A2.3. Summary of high tide surveys of the number of Eastern Curlews roosting within the Western Basin Reclamation Area.

Year	Date	Eastern Curlews	Source
2011/12	10/02/2012	0	ERMP database
2011/12	20/03/2012	0	ERMP database
2012/13	03/10/2012	0	ERMP database
2012/13	14/02/2013	0	ERMP database
2013/14	18/02/2014	0	ERMP database
2014/15	08/02/2015	0	ERMP database
2015/16	12/02/2016	0	ERMP database
2016/17	15/02/2017	0	ERMP database
2017/18	01/02/2018	0	ERMP database
2018/19	10/01/2019	0	ERMP database
2018/19	08/02/2019	0	ERMP database
2018/19	11/03/2019	3	ERMP database
2019/20	05/08/2019	0	ERMP database
2019/20	17/10/2019	0	ERMP database
2019/20	15/01/2020	2	ERMP database
2019/20	13/02/2020	74	ERMP database
2020/21	06/08/2020	0	ERMP database
2020/21	06/10/2020	72	ERMP database
2020/21	17/02/2021	85	Wildlife Unlimited (2021a)
2021/22	09/07/2021	25	Wildlife Unlimited (2021b)
2021/22	11/03/2021	2	ERMP database
2021/22	09/02/2022	133	BAAM unpublished
2021/22	15/02/2022	13	BAAM unpublished

Year	Date	Eastern Curlews	Source
2022/23	01/03/2023	64*	BAAM (2023)
2022/23	02/03/2024	59*	BAAM (2023)
2023/24	17/01/2024	23*	BAAM (2024)
2023/24	02/02/2024	87*	BAAM (2024)
2023/24	20/02/2024	92	BAAM (2024)

* Counts conducted approximately 3.5 hours after low tide, prior to the high tide window; therefore, these represent minimum counts since further birds could arrive at the roost closer to high tide.

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APPENDIX 3

Fuller (2021) Technical advice for development of Eastern Curlew offsets for EPBC2012/6558

Appendix A

TECHNICAL MEMORANDUM

To: Gladstone Ports Corporation
From: Professor Richard Fuller, University of Queensland
Date: 25th March 2021
Subject: Technical Advice for development of Eastern Curlew Offsets for EPBC2012/6558

This technical memorandum develops scientific reasoning for the design and implementation of Eastern Curlew offsets that will enable GPC to meet the offset requirements for the project. Importantly, *this advice only covers Stage 1, additional offsets may be required to meet the conditions for Stage 3*. It outlines the following three options, which could be undertaken separately or in any combination. They are listed approximately in order of the strength of their capacity to offset project impact.

Option 1 – Construct an artificial roost suitable for Eastern Curlews: A roosting area similar to the existing "wetland" could be incorporated into the construction of the southern reclamation area. A comprehensive literature review by Jackson (2017) contains a number of important principles and case studies that could specifically guide the design and construction of the roost. Previous experience with similar projects elsewhere, and I recommend that Port of Gladstone engages in discussions with staff from the Port of Darwin and the Port of Brisbane about their experiences with shorebirds roosting on artificial habitats within those ports. By way of example, the Port of Brisbane roost measures approximately 500 m x 200 m (Figure 1), and I think this should be considered a minimum size. At the Port of Darwin, the roosting pond favoured by Eastern Curlews measures approximately 400 m x 200 m (Figure 2). My assessment of the critical characteristics of a constructed roost site are as follows:

(i) predominantly marine environment, i.e. ability to flush with sea water, some tidal influence on water level is useful, but it is important that the roost site does not become fully inundated at high tide;
(ii) easily accessible to roosting birds and unobstructed from the seaward side – in practice, the long edge of a rectangular roost site should be adjacent to the sea wall;
(iii) as few obstructions as possible in the surrounding area, such that an uninterrupted view of the vicinity can be had by birds that are inside the roost. In particular ensuring that surrounding dredge spoil heaps are not so high as to disrupt sightlines and bird access;
(iv) extensive shallow water of varying depths;
(v) marshy or wet edges (controlled by varying the water level, in particular flooding the roost ahead of major migration periods, and then drawing down the water to create softer edges);
(vi) several islands, which allow for roosting even when the water level in the roost is high (e.g. after heavy rainfall, king tides) and;
(vii) vegetation succession control (achieved through flooding with sea water).

I consider these design principles to be sufficient to create suitable habitat for Eastern Curlews. One cannot be fully certain that the roost site will actually be used by large numbers of Eastern Curlews. The amount of tidal flat in the surrounding area is going to be reduced by the reclamation, possibly reducing the number of curlews that are looking for a roost site in this part of Port Curtis. However, if a shorebird roost site is created according to the above parameters, I think it can be interpreted as a best effort to create roosting habitat suitable for Eastern Curlews, regardless of whether they actually end up using it. This said, if curlews appear to be avoiding the roost after its establishment, it would be worth investigating whether any alterations could be made.

The existing wetland area is used as a roosting site by migratory shorebirds, albeit in relatively small numbers. However, the construction of the southern reclamation area will nearly cut off the wetland from the seawall, with only the eastern end of the wetland remaining in contact with the sea wall. Also, the accumulation of dredge spoil next to the wetland is likely to reach more than 10 metres in height, creating a significant obstruction in the view of the area surrounding the roost. These factors are likely to reduce the attractiveness of the roost for migratory shorebirds, and my conclusion is that instead, a roost site would have to be incorporated ito the design of the southern reclamation area. In future, should the northern reclamation area be added, it is possible at that point that the roost site would need to be relocated again.

Under the *Working with Nature* project, an option under active consideration is to have mangroves growing on the seawall. From the perspective of shorebirds using the roost site, it is important that the mangroves do not significantly overtop the seawall and create an obstruction to the birds accessing the roost site, or having a view of the area surrounding the roost while they are on the site. Advice from the Working with Nature project indicates that mangroves are unlikely to overtop the seawall, instead they are projected to approximately reach the level of the top of the seawall after about 20 years of growth.

Finally, it is important that there is a funding and management mechanism for ongoing maintenance of the roost site, including vegetation control (*Phragmites* and mangroves might emerge as significant issues). This involves foreseeing regulatory hurdles that might be associated with removal of mangrove seedlings and approval from fisheries.

The number of Eastern Curlews using the roost site can be used to index the magnitude of the offset.

Figure 1 An aerial view of the Port of Brisbane Shorebird Roost. The three islands are 45 m x 20 m, 65 m x 15 m, and 80 m x 25 m. Also note the sinuous shoreline, which has created mini bays and peninsulas within the roost. Some mangroves are visible growing on the outer edge of the seawall, although these do not overtop the seawall, and are barely visible from inside the roost. Notice also the two birdwatching hides (small white buildings), which are visited by keyholders from time to time.

Figure 2 An aerial view of the Port of Darwin, with the reclamation areas favoured by Eastern Curlews shown by the black arrows. The white arrow shows a reclamation pond that has become too vegetated, and is no longer used by large numbers of roosting migratory shorebirds.

Option 2 – Enhanced protection for remaining intertidal habitat: Gladstone Ports Corporation could explore securing areas of nearby intertidal flats and / or linked supratidal roosting areas as protected areas as a mechanism for averting future loss of foraging and roosting habitats suitable for Eastern Curlews. This operation of such a mechanism would depend on a legal analysis, but could entail placing hectares of intertidal habitat into protected trust at some ratio (e.g. 1:10) to that of the impacted area. Over time, this measure could measurably avert further loss of intertidal habitat.

Initial steps would need to include identifying intertidal areas that support foraging Eastern Curlews, or supratidal lands where Eastern Curlews roost. For example, Gladstone Ports Corporation has some land potentially available for securing as offset on Balaclava Island (Port Alma). Surveys of any potential Eastern Curlew foraging or roosting habitat could be commissioned to assess their suitability for offsetting. Such a survey could include dividing up the area into spatial units that could be surveyed in one visit, and covering each area 3-4 times at spring tides and neap tides to count the numbers of birds using them for foraging and / or roosting. Potential intertidal areas should be visited two hours either side of low tide, and surveyed at spring tides and neap tides. Likewise, potential roosting sites should be visited two hours either side of high tide, and surveyed at spring tides and neap tides. Any areas that are found to constitute Eastern Curlew habitat could then be offered

as offsets, and a legal mechanism for affording them indefinite protection would need to be explored.

Option 3 – On-ground activities to aid long term conservaton of foraging areas: Disturbance is one of the greatest threats to foraging migratory shorebirds that is readily amenable to management intervention. For example, data from Moreton Bay suggest that the presence of dogs in intertidal foraging areas reduces shorebird numbers by about 20% (Dhanjal-Adams *et al.* 2016). A number of measures could be implemented aimed at reducing disturbance to foraging migratory shorebirds in any publicly accessible area in Port Curtis where Eastern Curlews occur, and thus create an offset for project impact (Stigner *et al.* 2016). These could include (i) public awareness campaigns about the importance of not disturbing shorebirds at low tide, (ii) working with local authorities to tighten regulations around permitted activities, (iii) co-investing in enforcement capability. A simple before-after study could be used to measure the change in disturbance levels and estimate the size of the achieved offset.

This approach could be expanded to reduce a number of other threats to the birds. While direct data on these threats are sparse for the project area, they could be readily collected to conduct a formal prioritisation assessment. An exercise of this type was recently conducted in Moreton Bay (Fuller *et al.* 2019), and is now being implemented through a $1.2M on-ground management project being run by Healthy Land and Water. The prioritisation identified five groups of threats to migratory shorebirds on roosting sites (development, disturbance, erosion, mangrove encroachment, land management). In total, 95% of the roost sites in Moreton Bay were affected by one or more of the threats. Moreover, many of these threats are readily amenable to management, and could be the target of investment by Gladstone Ports Corporation to generate offsets that could be measured quantitatively using simple before/after studies. For example, disturbance at roost sites in Moreton Bay was primarily recreational disturbance (e.g., from boats, kite surfers, dogs, or anglers). Threats from land management primarily encompassed issues such as weeds (e.g., at Manly Harbour) or overgrowth of other non-mangrove vegetation. An assessment of which threats are operating at which roost sites in the project area will enable the design of a management plan together with an assessment of the size of the offset.

Background and logic for development of options

The major impact of the development to shorebird habitat is the removal of over 300 hectares of intertidal foraging area. Perhaps the most obvious and like-for-like offset is to attempt to create new intertidal flat. Indeed, there are examples of intertidal flat recreation in Australia (Botany Bay - https://www.portauthoritynsw.com.au/media/1084/pehep_report_execsummary.pdf) but these require very specific flow conditions and have only been attempted in relatively small areas. The risk of failure for these sorts of projects is very high, and it would likely be many years before curlews began foraging in any created habitat. Analysis of benthic prey availability suggests that sufficient intertidal carrying capacity exists in the Gladstone region for Eastern Curlews (Choi *et al.* 2017), and thus it is my assessment that tidal flat

creation or enhancement would not deliver a significant increase in Eastern Curlew numbers.

Instead, given the paucity of roosting sites available on the mainland coast around the Port of Gladstone, and the fact that the northern reclamation area will extend to within a few hundred metres of the Friend Point Roost, my assessment is that a constructed artificial roost is the form of offset most likely to address the limiting factor for the local Eastern Curlew population, and therefore to benefit displaced eastern curlews in the project impact area. Additionally, this sort of project (i) has a higher likelihood of success than tidal flat creation, (ii) can build on successful examples from other ports around Australia (e.g. Darwin, Brisbane), and (iii) is scalable and somewhat moveable as the reclamation area increases in size.

Migratory shorebirds, including Eastern Curlews frequently use artificial habitats in Australia (Jackson *et al.* in press), and dozens of curlews roost in reclamation ponds in the Ports of Darwin (Lilleyman *et al.* 2020) and Brisbane (https://www.portbris.com.au/Sustainability/Planet/Environment/Shorebirds/). This evidence indicates a satisfactory likelihood that Eastern Curlews would use a constructed artificial roost, although it might take several years for the site to settle down and become attractive for the birds.

Given these considerations, I conclude that a like-for-like offset is not appropriate in this case, and in fact that offsetting the loss of intertidal area with the creation of a roost is the course of action most likely to benefit Eastern Curlews.

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APPENDIX 4

Balaclava Island offset option assessment

BAAM
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4 July 2024

Anjana Singh
Environment Specialist
Gladstone Ports Corporation Limited
Email: SinghAA@gpcl.com.au

Dear Anjana

RE: Technical Memorandum
Balaclava Island Eastern Curlew Offset Advice

Please find attached our technical memorandum to provide advice on whether Balaclava Island would be a suitable offset option to offset significant residual impacts of the Northern Land Expansion Project - Southern Reclamation Area on Eastern Curlew.

Yours sincerely

Penn Lloyd

Dr Penn Lloyd
Principal Ecologist and Director
Biodiversity Assessment and Management Pty Ltd

File No	Author	Reviewer
0570-002 Draft A	PL	AMJ

1.0 BACKGROUND

Gladstone Ports Corporation Limited (GPC) is proposing to construct a new reclamation area outer bund wall, referred to as the Northern Land Expansion Project - Southern Reclamation Area (NLEP-SRA or Project), which has received the following Queensland and Commonwealth Government approvals as part of the Port of Gladstone Gatcombe and Golding Cutting Channel Project (CD Project):

- 'Coordinated project' approval on 8 July 2020 under the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act)
- 'Controlled action' approval on 24 December 2020, under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) (EPBC 2012/6558).

The EPBC Act approval for the construction of the NLEP-SRA associated with the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (EPBC 2012/6558) requires GPC to comply with several conditions with regards to offsets for significant residual impacts on Eastern Curlew (*Numenius madagascariensis*), which is listed as a critically endangered threatened bird species under the EPBC Act. The relevant conditions are outlined in **Table 1.1**.

Table 1.1. Outline of the Project conditions of approval (EPBC 2012/6558) relevant to the critically endangered Eastern Curlew.

Approval condition
(31) Each Project Stage Offset Strategy must propose offsets for that Project Stage and include the following:
a. details of how the proposed offsets align with the broader strategies and programs for the Great Barrier Reef, including but not limited to the Reef 2050 Long-term Sustainability Plan and will provide a net benefit to the Great Barrier Reef World Heritage Area (GBRWHA);
b. details to demonstrate how the proposed offsets will compensate for significant residual impacts on the relevant protected matters in accordance with the principles of the Environmental Offsets Policy;
c. evidence of how the proposed offsets take into account relevant approved conservation advices, relevant recovery plans and threat abatement plans, or other relevant contributions to species recovery and conservation;
d. a process to update the Offset Strategy and confirm the offset requirements for protected matters based on the report prepared under condition 19;
e. a process for, at the minimum, a biannual review of the Offset Strategy and the performance of offsets for the period of effect of the approval including timeframes for conducting the re-views and for publishing the findings of each review on the website;
f. where direct offsets are proposed, offset information for each offset site must be provided in the offset strategy;
g. if indirect compensatory measures such as research are proposed, details of how the proposed offsets will be developed, the timeframe over which they would be undertaken and the expected outcomes of the compensatory measures. Indirect compensatory measures must be prepared in accordance with the Environmental Offsets Policy; and
h. if a financial contribution is proposed (e.g. for the amount of fine-grained sediment returned to the marine environment that was not previously available for resuspension before commencement of any Project Stage, and/or for lethal or sub-lethal impacts to seagrass and macroalgae), the Offset Strategy must: i. explain the purpose of the financial contribution and demonstrate how it will result in a net benefit to the protected matter(s);

Approval condition
ii. provide details of and justification for the organisation(s) to which a contribution will be made; iii. explain how the financial contribution will be calculated; iv. specify the proportion of the offset obligation that would be met by any financial contribution; and v. specify the proposed amount of the financial contribution (where known).
(32) To compensate for impacts to Eastern Curlew habitat[1], the approval holder must provide an environmental offset consistent with the Environmental Offsets Policy. This offset must be in accordance with the approved Project Stage 1 Offset Strategy and implemented within 12 months from the date that the Project Stage 1 Offset Strategy is approved in writing by the Minister. The quantum of impacts to Eastern Curlew habitat must be confirmed in the Project Stage 1 Offset Strategy and based on the detailed design for the southern reclamation area.
(33) The environmental offset to compensate for impacts to Eastern Curlew habitat must deliver direct on-ground benefits to the species and must include at a minimum:
a. activities to create or improve foraging habitat for the Eastern Curlew within the Port Curtis area;
b. on-the-ground activities to aid the long-term conservation of areas of foraging habitat for the Eastern Curlew, which may be within the entirety of the GBRWHA and/or within the Australian range of the species;
c. creation of a migratory shorebird roost, appropriate for the Eastern Curlew, on part of the WB reclamation area and/or WBE reclamation area. The design and construction of the migratory shorebird roost must be undertaken with advice from a suitably qualified ecologist, and the roost must be maintained for the period of the effect of the approval; and
d. management of threats to the Eastern Curlew within the Port of Gladstone area, such as invasive plant and animal control within or adjacent to Eastern Curlew habitat as part of a regionalised approach to threat abatement.

GPC commissioned a technical memorandum prepared by Professor Richard Fuller, a shorebird expert at the University of Queensland, to provide technical advice for development of Eastern Curlew offsets for EPBC2012/6558. This technical advice, included as **Appendix 1**, identified three options for meeting the offset requirements of the project:

- Option 1 – Construct an artificial roost suitable for Eastern Curlews;
- Option 2 – Enhanced protection for remaining intertidal habitat; and
- Option 3 – On-ground activities to aid long term conservation of foraging areas.

Under Option 2, Professor Fuller recommended that GPC "*could explore securing areas of nearby intertidal flats and / or linked supratidal roosting areas as protected areas as a mechanism for averting future loss of foraging and roosting habitats suitable for Eastern Curlews. This operation of such a mechanism would depend on a legal analysis, but could entail placing hectares of intertidal habitat into protected trust at some ratio (e.g. 1:10) to that of the impacted area. Over time, this measure could measurably avert further loss of intertidal habitat*". Furthermore, Professor Fuller mentioned Balaclava Island at Port Alma as a potential site for such an averted loss offset option. In the past, a portion of Balaclava Island had been identified as a site for the construction of a new coal port terminal.

[1] Eastern Curlew habitat means roosts such as claypans, sandbars, islands, creek banks, mangroves, beaches and ash ponds or foraging habitat such as inter-tidal mudflats, sandflats, salt flats, saltmarsh, rock pools, coral reefs, and beaches identified as being utilised by Eastern Curlew at any time.

2.0 ASSESSMENT OF BALACLAVA ISLAND

Balaclava Island forms a portion of Lot 18/DS727 that is located to the east of Port Alma (**Figure 2.1**). The tenure of the lot is Reserve 80 for Harbour purposes – Port Alma.

Figure 2.1. Location of Balaclava Island within Lot 18/DS727 (contains material © CNES reproduced under licence from Airbus DS, © 2023, Planet Labs PBC, © 21AT © Earth-I, all rights reserved, © State of Queensland 2024).

The entirety of Lot 18/DS727 is protected as a declared fish habitat area under the Fisheries Act 1994 (Fish Habitat Areas), a matter of State environmental significance (MSES; see **Appendix 2**). Balaclava Island is also identified as a MSES high ecological significance wetland. The majority of Balaclava Island is vegetated by two different vegetation communities (see **Appendix 3**):

- RE 11.1.2 Samphire forbland or bare mud-flats on marine clay plains (mainly saltpans and mudflats with clumps of saltbush); and
- RE 11.1.4 Mangrove low open forest and/or woodland on marine clay plains.

The extensive areas of RE 11.1.2 on Balaclava Island provide suitable habitat for Eastern Curlew (Department of Climate Change, Energy, the Environment and Water 2023).

2.1 SHOREBIRD SURVEYS

GPC commissioned three surveys for shorebirds roosting in the south-western portion of Balaclava Island at high tide over the period October-December 2021 (Wnorowski 2022). These surveys confirmed that the surveyed area of Balaclava Island comprises large claypans and fringing mangrove shrubland to low, closed forest with fringing tidal mudflats. The surveys also reported up to 137 Eastern Curlew (as well as other migratory shorebirds) roosting in the area surveyed, confirming the suitability of habitats on Balaclava Island for Eastern Curlew. The surveys did not identify the presence of any threats to Eastern Curlew or any evidence of degradation of Eastern Curlew habitat.

2.2 Risk of Future Loss of Eastern Curlew Habitat on Balaclava Island

The land tenure of Balaclava Island is Reserve 80 for Harbour purposes – Port Alma and a portion of Balaclava Island had been identified as a site for the construction of a new coal port terminal in the past. However, the *Sustainable Ports Development Act 2015* (Ports Act) prohibits such development. The purpose of the Ports Act is to provide for the protection of the Great Barrier Reef World Heritage Area (GBRWHA) through managing port-related development in and adjacent to the area. The Ports Act:

- restricts new port development in and adjoining the GBRWHA to within current port limits and outside Commonwealth and state marine parks; and
- prohibits major capital dredging for the development of new or expansion of existing port facilities in the GBRWHA outside the priority ports of Gladstone, Townsville, Hay Point/Mackay and Abbot Point.

Port Alma has not been identified as a priority port under the Ports Act; therefore, major capital dredging for the development of new or expansion of existing port facilities at Port Alma is prohibited. Consequently, GPC has no current plans to develop a new port terminal on Balaclava Island (A. Singh, personal communication).

The risk of future loss of Eastern Curlew habitats on Balaclava Island appears to be negligible at the present time due to:

- new port development on Balaclava Island being prohibited by the Ports Act;
- protection of the area as a declared fish habitat area under the *Fisheries Act 1994* (Fish Habitat Areas), a MSES;
- protection of the area as a high ecological significance wetland, a MSES; and
- protection of the area as habitat for Eastern Curlew, listed as a critically endangered species under the EPBC Act.

2.3 Threats to Eastern Curlew Habitat on Balaclava Island

Balaclava Island comprises mostly intertidal habitats in a remote area distant from human settlement that is isolated from the mainland by permanent estuarine channels (see **Figure 2.**1). Consequently, the risk of feral animal and weed presence in intertidal habitats is likely to be negligible and the risk of degradation to intertidal habitats from human activities is likely to be low. Certainly, three shorebird surveys of a portion of Balaclava Island did not identify the presence of any threats to Eastern Curlew or any evidence of degradation of Eastern Curlew habitat (Wnorowski 2022).

2.4 Suitability of Balaclava Island as an Offset for Eastern Curlew

Balaclava Island is assessed as being unsuitable as an option for the delivery of an offset to compensate for significant residual impacts on Eastern Curlew habitat for two main reasons.

First, there are no identified threats to Eastern Curlew or any evidence of degradation of Eastern Curlew habitat on Balaclava Island. Consequently, there is no supported mechanism for improving habitat quality for Eastern Curlew to enable delivery of an overall conservation outcome that improves or maintains the viability of Eastern Curlew.

Second, the risk of future loss of Eastern Curlew habitats on Balaclava Island appears to be negligible at the present time due to a variety of existing protections to Eastern Curlew habitats

on Balaclava Island. Consequently, there appears to be no unequivocal mechanism for enhancing the protection of Eastern Curlew habitats on Balaclava Island.

Balaclava Island shares a boundary with the Great Barrier Reef Coast Marine Park. An argument could be made that transfer of land tenure to include Balaclava Island in the Great Barrier Reef Coast Marine Park would enhance the protection status of Eastern Curlew habitats on Balaclava Island. However, there is no relevant information to guide or support the selection of an offset ratio in this context, the latter being required to demonstrate the equivalency of the magnitude of offset in comparison to the magnitude of impact. Consequently, the Department of Climate Change, Energy, the Environment and Water would need to advise on the relevant offset ratio if an offset option of this type were to be pursued. Furthermore, the feasibility of transferring tenure of Balaclava Island to the Great Barrier Reef Coast Marine Park would need to be confirmed with the Queensland Government.

3.0 REFERENCES

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APPENDIX 1: Fuller (2021) Technical advice for development of Eastern Curlew offsets for EPBC2012/6558

Appendix A

TECHNICAL MEMORANDUM

To: Gladstone Ports Corporation
From: Professor Richard Fuller, University of Queensland
Date: 25th March 2021
Subject: Technical Advice for development of Eastern Curlew Offsets for EPBC2012/6558

This technical memorandum develops scientific reasoning for the design and implementation of Eastern Curlew offsets that will enable GPC to meet the offset requirements for the project. Importantly, *this advice only covers Stage 1, additional offsets may be required to meet the conditions for Stage 3*. It outlines the following three options, which could be undertaken separately or in any combination. They are listed approximately in order of the strength of their capacity to offset project impact.

Option 1 – Construct an artificial roost suitable for Eastern Curlews: A roosting area similar to the existing "wetland" could be incorporated into the construction of the southern reclamation area. A comprehensive literature review by Jackson (2017) contains a number of important principles and case studies that could specifically guide the design and construction of the roost. Previous experience with similar projects elsewhere, and I recommend that Port of Gladstone engages in discussions with staff from the Port of Darwin and the Port of Brisbane about their experiences with shorebirds roosting on artificial habitats within those ports. By way of example, the Port of Brisbane roost measures approximately 500 m x 200 m (Figure 1), and I think this should be considered a minimum size. At the Port of Darwin, the roosting pond favoured by Eastern Curlews measures approximately 400 m x 200 m (Figure 2). My assessment of the critical characteristics of a constructed roost site are as follows:

(i) predominantly marine environment, i.e. ability to flush with sea water, some tidal influence on water level is useful, but it is important that the roost site does not become fully inundated at high tide;
(ii) easily accessible to roosting birds and unobstructed from the seaward side – in practice, the long edge of a rectangular roost site should be adjacent to the sea wall;
(iii) as few obstructions as possible in the surrounding area, such that an uninterrupted view of the vicinity can be had by birds that are inside the roost. In particular ensuring that surrounding dredge spoil heaps are not so high as to disrupt sightlines and bird access;
(iv) extensive shallow water of varying depths;
(v) marshy or wet edges (controlled by varying the water level, in particular flooding the roost ahead of major migration periods, and then drawing down the water to create softer edges);
(vi) several islands, which allow for roosting even when the water level in the roost is high (e.g. after heavy rainfall, king tides) and;
(vii) vegetation succession control (achieved through flooding with sea water).

I consider these design principles to be sufficient to create suitable habitat for Eastern Curlews. One cannot be fully certain that the roost site will actually be used by large numbers of Eastern Curlews. The amount of tidal flat in the surrounding area is going to be reduced by the reclamation, possibly reducing the number of curlews that are looking for a roost site in this part of Port Curtis. However, if a shorebird roost site is created according to the above parameters, I think it can be interpreted as a best effort to create roosting habitat suitable for Eastern Curlews, regardless of whether they actually end up using it. This said, if curlews appear to be avoiding the roost after its establishment, it would be worth investigating whether any alterations could be made.

The existing wetland area is used as a roosting site by migratory shorebirds, albeit in relatively small numbers. However, the construction of the southern reclamation area will nearly cut off the wetland from the seawall, with only the eastern end of the wetland remaining in contact with the sea wall. Also, the accumulation of dredge spoil next to the wetland is likely to reach more than 10 metres in height, creating a significant obstruction in the view of the area surrounding the roost. These factors are likely to reduce the attractiveness of the roost for migratory shorebirds, and my conclusion is that instead, a roost site would have to be incorporated ito the design of the southern reclamation area. In future, should the northern reclamation area be added, it is possible at that point that the roost site would need to be relocated again.

Under the *Working with Nature* project, an option under active consideration is to have mangroves growing on the seawall. From the perspective of shorebirds using the roost site, it is important that the mangroves do not significantly overtop the seawall and create an obstruction to the birds accessing the roost site, or having a view of the area surrounding the roost while they are on the site. Advice from the Working with Nature project indicates that mangroves are unlikely to overtop the seawall, instead they are projected to approximately reach the level of the top of the seawall after about 20 years of growth.

Finally, it is important that there is a funding and management mechanism for ongoing maintenance of the roost site, including vegetation control (*Phragmites* and mangroves might emerge as significant issues). This involves foreseeing regulatory hurdles that might be associated with removal of mangrove seedlings and approval from fisheries.

The number of Eastern Curlews using the roost site can be used to index the magnitude of the offset.

Figure 1 An aerial view of the Port of Brisbane Shorebird Roost. The three islands are 45 m x 20 m, 65 m x 15 m, and 80 m x 25 m. Also note the sinuous shoreline, which has created mini bays and peninsulas within the roost. Some mangroves are visible growing on the outer edge of the seawall, although these do not overtop the seawall, and are barely visible from inside the roost. Notice also the two birdwatching hides (small white buildings), which are visited by keyholders from time to time.

Figure 2 An aerial view of the Port of Darwin, with the reclamation areas favoured by Eastern Curlews shown by the black arrows. The white arrow shows a reclamation pond that has become too vegetated, and is no longer used by large numbers of roosting migratory shorebirds.

Option 2 – Enhanced protection for remaining intertidal habitat: Gladstone Ports Corporation could explore securing areas of nearby intertidal flats and / or linked supratidal roosting areas as protected areas as a mechanism for averting future loss of foraging and roosting habitats suitable for Eastern Curlews. This operation of such a mechanism would depend on a legal analysis, but could entail placing hectares of intertidal habitat into protected trust at some ratio (e.g. 1:10) to that of the impacted area. Over time, this measure could measurably avert further loss of intertidal habitat.

Initial steps would need to include identifying intertidal areas that support foraging Eastern Curlews, or supratidal lands where Eastern Curlews roost. For example, Gladstone Ports Corporation has some land potentially available for securing as offset on Balaclava Island (Port Alma). Surveys of any potential Eastern Curlew foraging or roosting habitat could be commissioned to assess their suitability for offsetting. Such a survey could include dividing up the area into spatial units that could be surveyed in one visit, and covering each area 3-4 times at spring tides and neap tides to count the numbers of birds using them for foraging and / or roosting. Potential intertidal areas should be visited two hours either side of low tide, and surveyed at spring tides and neap tides. Likewise, potential roosting sites should be visited two hours either side of high tide, and surveyed at spring tides and neap tides. Any areas that are found to constitute Eastern Curlew habitat could then be offered

as offsets, and a legal mechanism for affording them indefinite protection would need to be explored.

Option 3 – On-ground activities to aid long term conservaton of foraging areas: Disturbance is one of the greatest threats to foraging migratory shorebirds that is readily amenable to management intervention. For example, data from Moreton Bay suggest that the presence of dogs in intertidal foraging areas reduces shorebird numbers by about 20% (Dhanjal-Adams *et al.* 2016). A number of measures could be implemented aimed at reducing disturbance to foraging migratory shorebirds in any publicly accessible area in Port Curtis where Eastern Curlews occur, and thus create an offset for project impact (Stigner *et al.* 2016). These could include (i) public awareness campaigns about the importance of not disturbing shorebirds at low tide, (ii) working with local authorities to tighten regulations around permitted activities, (iii) co-investing in enforcement capability. A simple before-after study could be used to measure the change in disturbance levels and estimate the size of the achieved offset.

This approach could be expanded to reduce a number of other threats to the birds. While direct data on these threats are sparse for the project area, they could be readily collected to conduct a formal prioritisation assessment. An exercise of this type was recently conducted in Moreton Bay (Fuller *et al.* 2019), and is now being implemented through a $1.2M on-ground management project being run by Healthy Land and Water. The prioritisation identified five groups of threats to migratory shorebirds on roosting sites (development, disturbance, erosion, mangrove encroachment, land management). In total, 95% of the roost sites in Moreton Bay were affected by one or more of the threats. Moreover, many of these threats are readily amenable to management, and could be the target of investment by Gladstone Ports Corporation to generate offsets that could be measured quantitatively using simple before/after studies. For example, disturbance at roost sites in Moreton Bay was primarily recreational disturbance (e.g., from boats, kite surfers, dogs, or anglers). Threats from land management primarily encompassed issues such as weeds (e.g., at Manly Harbour) or overgrowth of other non-mangrove vegetation. An assessment of which threats are operating at which roost sites in the project area will enable the design of a management plan together with an assessment of the size of the offset.

Background and logic for development of options

The major impact of the development to shorebird habitat is the removal of over 300 hectares of intertidal foraging area. Perhaps the most obvious and like-for-like offset is to attempt to create new intertidal flat. Indeed, there are examples of intertidal flat recreation in Australia (Botany Bay - https://www.portauthoritynsw.com.au/media/1084/pehep_report_execsummary.pdf) but these require very specific flow conditions and have only been attempted in relatively small areas. The risk of failure for these sorts of projects is very high, and it would likely be many years before curlews began foraging in any created habitat. Analysis of benthic prey availability suggests that sufficient intertidal carrying capacity exists in the Gladstone region for Eastern Curlews (Choi *et al.* 2017), and thus it is my assessment that tidal flat

creation or enhancement would not deliver a significant increase in Eastern Curlew numbers.

Instead, given the paucity of roosting sites available on the mainland coast around the Port of Gladstone, and the fact that the northern reclamation area will extend to within a few hundred metres of the Friend Point Roost, my assessment is that a constructed artificial roost is the form of offset most likely to address the limiting factor for the local Eastern Curlew population, and therefore to benefit displaced eastern curlews in the project impact area. Additionally, this sort of project (i) has a higher likelihood of success than tidal flat creation, (ii) can build on successful examples from other ports around Australia (e.g. Darwin, Brisbane), and (iii) is scalable and somewhat moveable as the reclamation area increases in size.

Migratory shorebirds, including Eastern Curlews frequently use artificial habitats in Australia (Jackson *et al.* in press), and dozens of curlews roost in reclamation ponds in the Ports of Darwin (Lilleyman *et al.* 2020) and Brisbane (https://www.portbris.com.au/Sustainability/Planet/Environment/Shorebirds/). This evidence indicates a satisfactory likelihood that Eastern Curlews would use a constructed artificial roost, although it might take several years for the site to settle down and become attractive for the birds.

Given these considerations, I conclude that a like-for-like offset is not appropriate in this case, and in fact that offsetting the loss of intertidal area with the creation of a roost is the course of action most likely to benefit Eastern Curlews.

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APPENDIX 2: Matters of State Environmental Significance Report for Lot 18 on Plan DS727

Queensland Government

Department of Environment, Science and Innovation

Environmental Reports

Matters of State Environmental Significance

For the selected area of interest

Lot: 18 Plan: DS727

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and a field survey may be required to validate values on the ground.

Please direct queries about these reports to: Planning.Support@des.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

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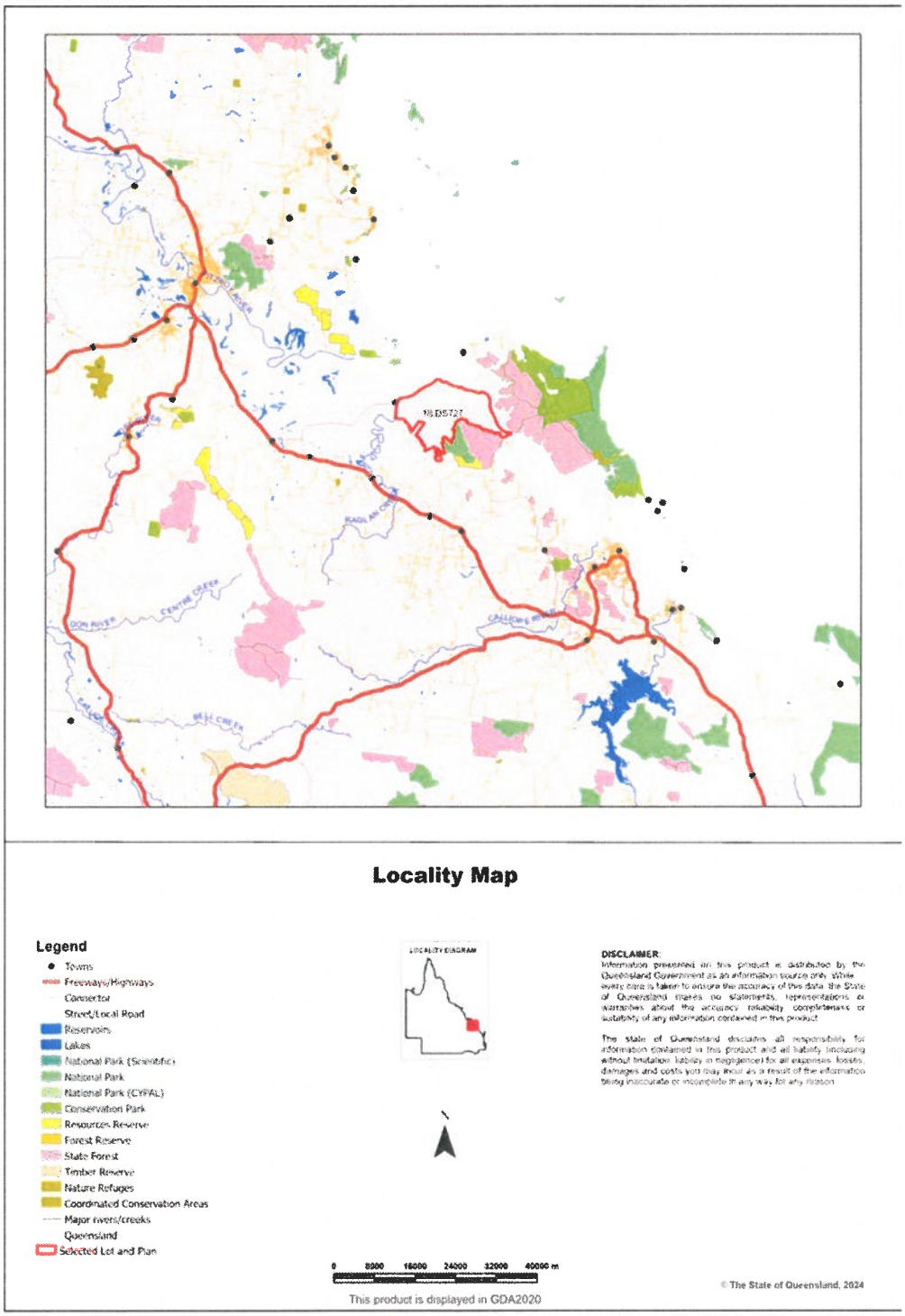
Assessment Area Details

The following table provides an overview of the area of interest (AOI) with respect to selected topographic and environmental values.

Table 1: Summary table, details for AOI: Lot: 18 Plan: DS727, with area 15002.5 ha

Local Government(s)	Catchment(s)	Bioregion(s)	Subregion(s)
Gladstone Regional	Coral Sea	Brigalow Belt	Marlborough Plains
	Calliope		
	Fitzroy		



Matters of State Environmental Significance (MSES)

MSES Categories

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states:

'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset.'

The MSES mapping product is a guide to assist implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations.

The SPP defines matters of state environmental significance as:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992;*

- *Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the Marine Parks Act 2004 ;*

- *Areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008;*

- *Threatened wildlife under the Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006;

- Regulated vegetation under the *Vegetation Management Act 1999* that is:

  - Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;
  - Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;
  - Category R areas on the regulated vegetation management map;
  - Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse and drainage feature map;
  - Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map;

- Strategic Environmental Areas under the *Regional Planning Interests Act 2014* ;

- Wetlands in a wetland protection area of wetlands of high ecological significance shown on the Map of Queensland Wetland Environmental Values under the Environment Protection Regulation 2019;

- Wetlands and watercourses in high ecological value waters defined in the Environmental Protection (Water) Policy 2009, schedule 2;
- Legally secured offset areas.

MSES Values Present

The MSES values that are present in the area of interest are summarised in the table below:

Table 2: Summary of MSES present within the AOI

1a Protected Areas- estates	0 ha	0.0%
1b Protected Areas- nature refuges	0 ha	0.0%
1c Protected Areas- special wildlife reserves	0 ha	0.0%
2 State Marine Parks- highly protected zones	0 ha	0.0%
3 Fish habitat areas (A and B areas)	14930.3 ha	99.5%
4 Strategic Environmental Areas (SEA)	0 ha	0.0%
5 High Ecological Significance wetlands on the Map of Queensland Wetland Environmental Values	4636.77 ha	30.9%
6a High Ecological Value (HEV) wetlands	0.08 ha	0.0%
6b High Ecological Value (HEV) waterways	0 km	Not applicable
7a Threatened (endangered or vulnerable) wildlife	2077.44 ha	13.8%
7b Special least concern animals	1502.71 ha	10.0%
7c i Koala habitat area - core (SEQ)	0 ha	0.0%
7c ii Koala habitat area - locally refined (SEQ)	0 ha	0.0%
7d Sea turtle nesting areas	0 km	Not applicable
8a Regulated Vegetation - Endangered/Of concern in Category B (remnant)	53.09 ha	0.4%
8b Regulated Vegetation - Endangered/Of concern in Category C (regrowth)	0 ha	0.0%
8c Regulated Vegetation - Category R (GBR riverine regrowth)	0 ha	0.0%
8d Regulated Vegetation - Essential habitat	1612.27 ha	10.7%
8e Regulated Vegetation - intersecting a watercourse	157.7 km	Not applicable
8f Regulated Vegetation - within 100m of a Vegetation Management Wetland	0 ha	0.0%
9a Legally secured offset areas- offset register areas	0 ha	0.0%
9b Legally secured offset areas- vegetation offsets through a Property Map of Assessable Vegetation	0 ha	0.0%

Additional Information with Respect to MSES Values Present

MSES - State Conservation Areas

1a. Protected Areas - estates

(No results)

1b. Protected Areas - nature refuges

(No results)

1c. Protected Areas - special wildlife reserves

(No results)

2. State Marine Parks - highly protected zones

(No results)

3. Fish habitat areas (A and B areas)

Type	Type abbreviated	Declared plan link
Fish Habitat Area	FHAA	http://www.nprsr.qld.gov.au/managing/pdf/fitzroy.pdf

Refer to **Map 1 - MSES - State Conservation Areas** for an overview of the relevant MSES.

MSES - Wetlands and Waterways

4. Strategic Environmental Areas (SEA)

(No results)

5. High Ecological Significance wetlands on the Map of Queensland Wetland Environmental Values

Natural wetlands that are 'High Ecological Significance' (HES) on the Map of Queensland Wetland Environmental Values are present.

6a. Wetlands in High Ecological Value (HEV) waters

Natural wetlands that occur in HEV (maintain) freshwater and estuarine areas under the Environmental Protection (water) Policy are present.

6b. Waterways in High Ecological Value (HEV) waters

(no results)

Refer to **Map 2 - MSES - Wetlands and Waterways** for an overview of the relevant MSES.

MSES - Species

7a. Threatened (endangered or vulnerable) wildlife

Values are present

7b. Special least concern animals

Values are present

7c i. Koala habitat area - core (SEQ)

Not applicable

7c ii. Koala habitat area - locally refined (SEQ)

Not applicable

7d. Wildlife habitat (sea turtle nesting areas)

Not applicable

Threatened (endangered or vulnerable) wildlife habitat suitability models

Species	Common name	NCA status	Presence
Boronia keysii	Keys boronia	V	None
Calyptorhynchus lathami	Glossy black cockatoo	V	None
Casuarius casuarius johnsonii	Sthn population cassowary	E	None
Crinia tinnula	Wallum froglet	V	None
Denisonia maculata	Ornamental snake	V	None
Euastacus bindal	Mount Elliot crayfish	CR	None
Euastacus binzayedi		CR	None
Euastacus eungella		E	None
Euastacus hystricosus		E	None
Euastacus jagara	Jagara hairy crayfish	CR	None
Euastacus maidae		CR	None
Euastacus monteithorum		E	None
Euastacus robertsi		E	None
Taudactylus pleione	Kroombit tinkerfrog	E	None
Litoria freycineti	Wallum rocketfrog	V	None
Litoria olongburensis	Wallum sedgefrog	V	None
Macadamia integrifolia		V	None
Melaleuca irbyana	swamp tea-tree	E	None
Macadamia ternifolia		V	None
Macadamia tetraphylla	bopple nut	V	None
Petrogale penicillata	brush-tailed rock-wallaby	V	None
Petrogale coenensis	Cape York rock-wallaby	V	None
Petrogale purpureicollis	purple-necked rock-wallaby	V	None
Petrogale sharmani	Sharmans rock-wallaby	V	None
Petrogale xanthopus celeris	yellow-footed rock-wallaby (Qld subspecies)	V	None
Petaurus gracilis	Mahogany Glider	E	None
Petrogale persephone	Proserpine rock-wallaby	E	None
Phascolarctos cinereus	Koala - outside SEQ*	E	None
Pezoporus wallicus wallicus	Eastern ground parrot	V	None
Xeromys myoides	Water Mouse	V	None

*For koala model, this includes areas outside SEQ. Check 7c SEQ koala habitat for presence/absence.

Threatened (endangered or vulnerable) wildlife species records

Scientific name	Common name	NCA status	EPBC status	Migratory status
Charadrius mongolus	lesser sand plover	E	E	M-C/J/R/B/E
Numenius madagascariensis	eastern curlew	E	CE	M-C/J/R/B/E
Limosa lapponica baueri	Western Alaskan bar-tailed godwit	V	V	M-C/J/R/B/E
Charadrius leschenaultii	greater sand plover	V	V	M-C/J/R/B/E
Calidris tenuirostris	great knot	CR	CE	M-C/J/R/B/E
Calidris canutus	red knot	E	E	M-C/J/R/B/E
Calidris ferruginea	curlew sandpiper	CR	CE	M-C/J/R/B/E
Crocodylus porosus	estuarine crocodile	V	None	M-B/E
Geophaps scripta scripta	squatter pigeon (southern subspecies)	V	V	None
Petauroides armillatus	central greater glider	E	E	None
Nyctophilus corbeni	eastern long-eared bat	V	V	None

Special least concern animal species records

Scientific name	Common name	Migratory status
Tringa brevipes	grey-tailed tattler	M-C/J/R/B/E
Calidris ruficollis	red-necked stint	M-C/J/R/B/E
Calidris acuminata	sharp-tailed sandpiper	M-C/J/R/B/E
Numenius phaeopus	whimbrel	M-C/J/R/B/E
Tringa nebularia	common greenshank	M-C/J/R/B/E
Pluvialis squatarola	grey plover	M-C/J/R/B/E
Calidris falcinellus	broad-billed sandpiper	M-C/J/R/B/E
Tringa stagnatilis	marsh sandpiper	M-C/J/R/B/E
Xenus cinereus	terek sandpiper	M-C/J/R/B/E
Limosa limosa	black-tailed godwit	M-C/J/R/B/E
Charadrius bicinctus	double-banded plover	M-B/E
Actitis hypoleucos	common sandpiper	M-C/J/R/B/E

Shorebird habitat (critically endangered/endangered/vulnerable)

Not applicable

Shorebird habitat (special least concern)

Not applicable

**Nature Conservation Act 1992 (NCA) Status- Endangered (E), Vulnerable (V) or Special Least Concern Animal (SL). Environment Protection and Biodiversity Conservation Act 1999 (EPBC) status: Critically Endangered (CE) Endangered (E), Vulnerable (V)*

Migratory status (M) - China and Australia Migratory Bird Agreement (C), Japan and Australia Migratory Bird Agreement (J), Republic of Korea and Australia Migratory Bird Agreement (R), Bonn Migratory Convention (B), Eastern Flyway (E)

To request a species list for an area, or search for a species profile, access Wildlife Online at:

https://www.qld.gov.au/environment/plants-animals/species-list/

Refer to **Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals** and **Map 3b - MSES - Species - Koala habitat area (SEQ)** and **Map 3c - MSES - Wildlife habitat (sea turtle nesting areas)** for an overview of the relevant MSES.

MSES - Regulated Vegetation

For further information relating to regional ecosystems in general, go to:

https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/

For a more detailed description of a particular regional ecosystem, access the regional ecosystem search page at:

https://environment.ehp.qld.gov.au/regional-ecosystems/

8a. Regulated Vegetation - Endangered/Of concern in Category B (remnant)

Regional ecosystem	Vegetation management polygon	Vegetation management status
11.11.14	E-dom	rem_end
11.2.3	O-dom	rem_oc
11.3.25/11.3.4	O-subdom	rem_oc
11.3.4	O-dom	rem_oc
11.3.4/11.3.1	E-subdom	rem_end

8b. Regulated Vegetation - Endangered/Of concern in Category C (regrowth)

Not applicable

8c. Regulated Vegetation - Category R (GBR riverine regrowth)

Not applicable

8d. Regulated Vegetation - Essential habitat

Values are present

8e. Regulated Vegetation - intersecting a watercourse**

A vegetation management watercourse is mapped as present

8f. Regulated Vegetation - within 100m of a Vegetation Management wetland

Not applicable

Refer to **Map 4 - MSES - Regulated Vegetation** for an overview of the relevant MSES.

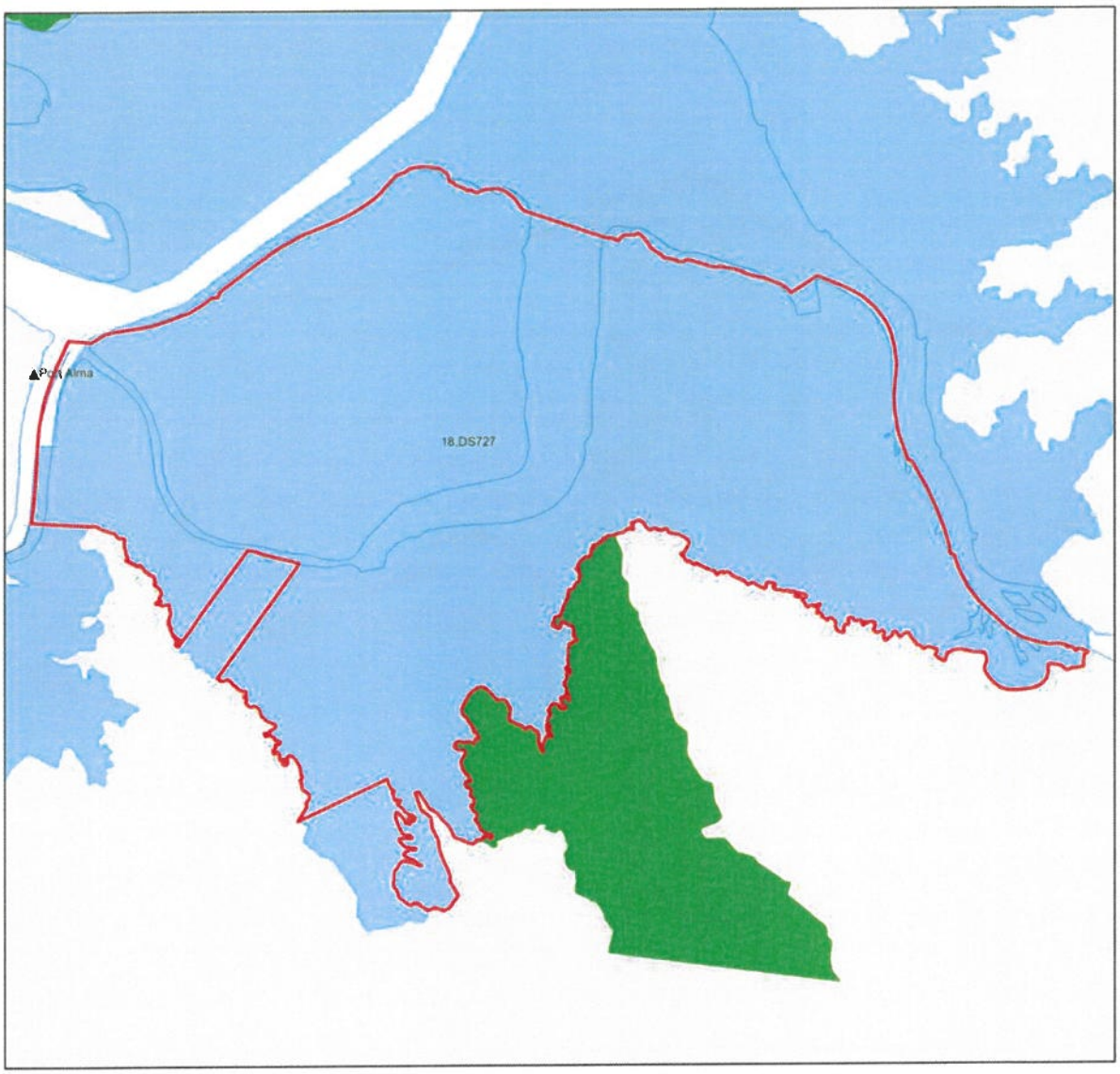
MSES - Offsets

9a. Legally secured offset areas - offset register areas
(No results)

9b. Legally secured offset areas - vegetation offsets through a Property Map of Assessable Vegetation
(No results)

Refer to **Map 5 - MSES - Offset Areas** for an overview of the relevant MSES.

Map 1 - MSES - State Conservation Areas



MSES - State Conservation Areas

- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Protected area (estates, nature refuges, special wildlife reserves)
- Declared fish habitat area (A and B areas)
- Marine park (highly protected)
- Selected Lot and Plan

LOCALITY DIAGRAM

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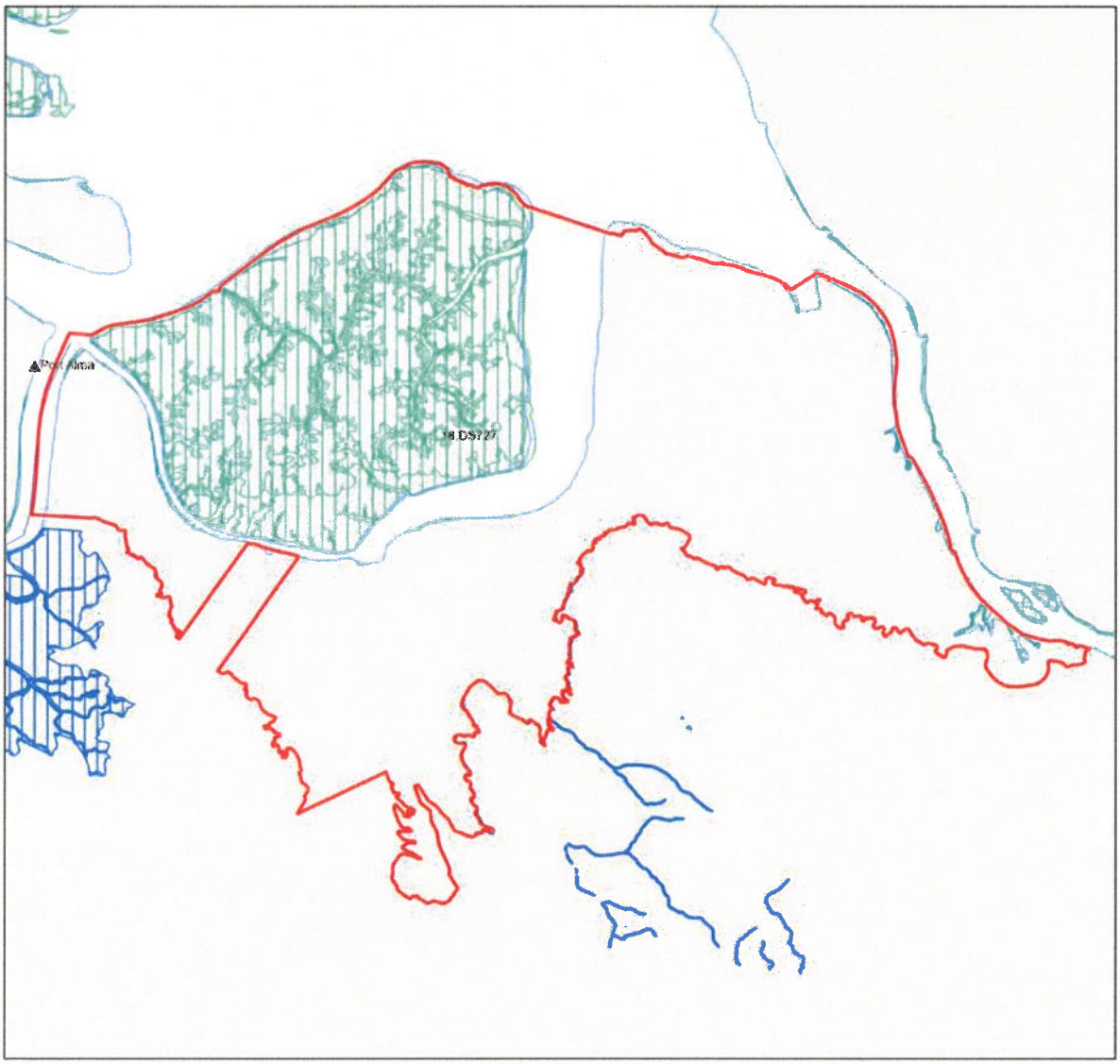
Map 2 - MSES - Wetlands and Waterways



MSES - Wetlands and Waterways

- ▲ Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Declared high ecological value waters (watercourse)
- Strategic environmental area (designated precinct)
- Declared high ecological value waters (wetland)
- High ecological significance wetlands
- Selected Lot and Plan

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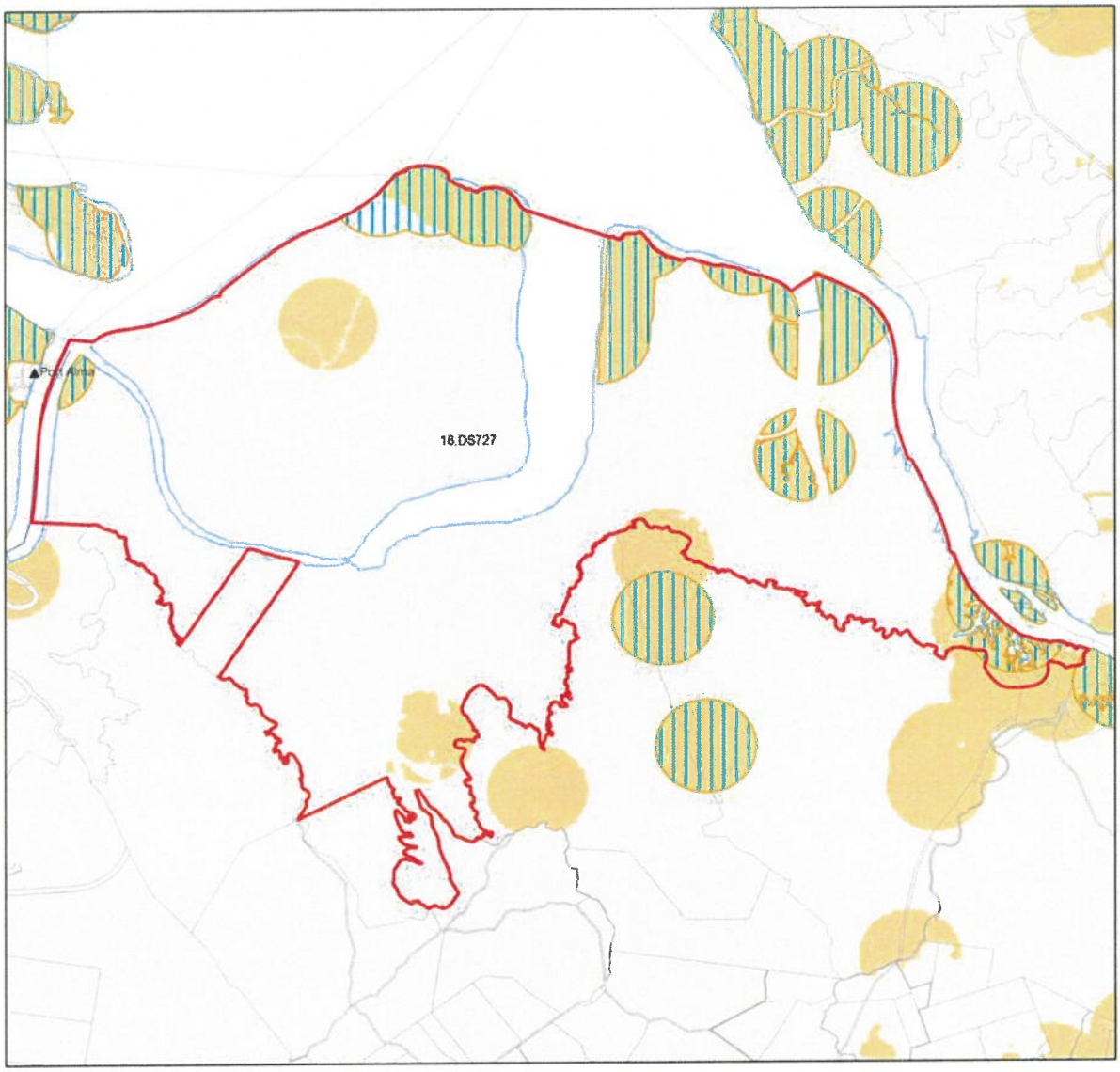
Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals



MSES - Species
Threatened (endangered or vulnerable) wildlife and special least concern animals

- ▲ Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Wildlife habitat (special least concern)
- Wildlife habitat (endangered or vulnerable)
- Selected Lot and Plan

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Map 3b - MSES - Species - Koala habitat area (SEQ)

MSES - Species
Koala habitat area (SEQ)

- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Koala habitat area (core)
- Koala habitat area (locally refined)
- Selected Lot and Plan

LOCALITY DIAGRAM

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The represented layers for SEQ 'koala habitat area-core' and 'koala habitat area- locally refined' in MSES are sourced directly from the regulatory mapping under the Nature Conservation (Koala) Conservation Plan 2017. Whilst every effort is made to ensure the information remains current, there may be delays between updating versions. Please refer to the original mapping for the most recent version. See https://environment.des.qld.gov.au/wildlife/animals/living-with/koalas/mapping

The koala habitat mapping within South East Queensland uses regional ecosystem linework compiled at a scale varying from 1:25,000 to 1:100,000. Linework should be used as a guide only. The positional accuracy of regional ecosystem data mapped at a scale of 1:100,000 is +/- 100 metres

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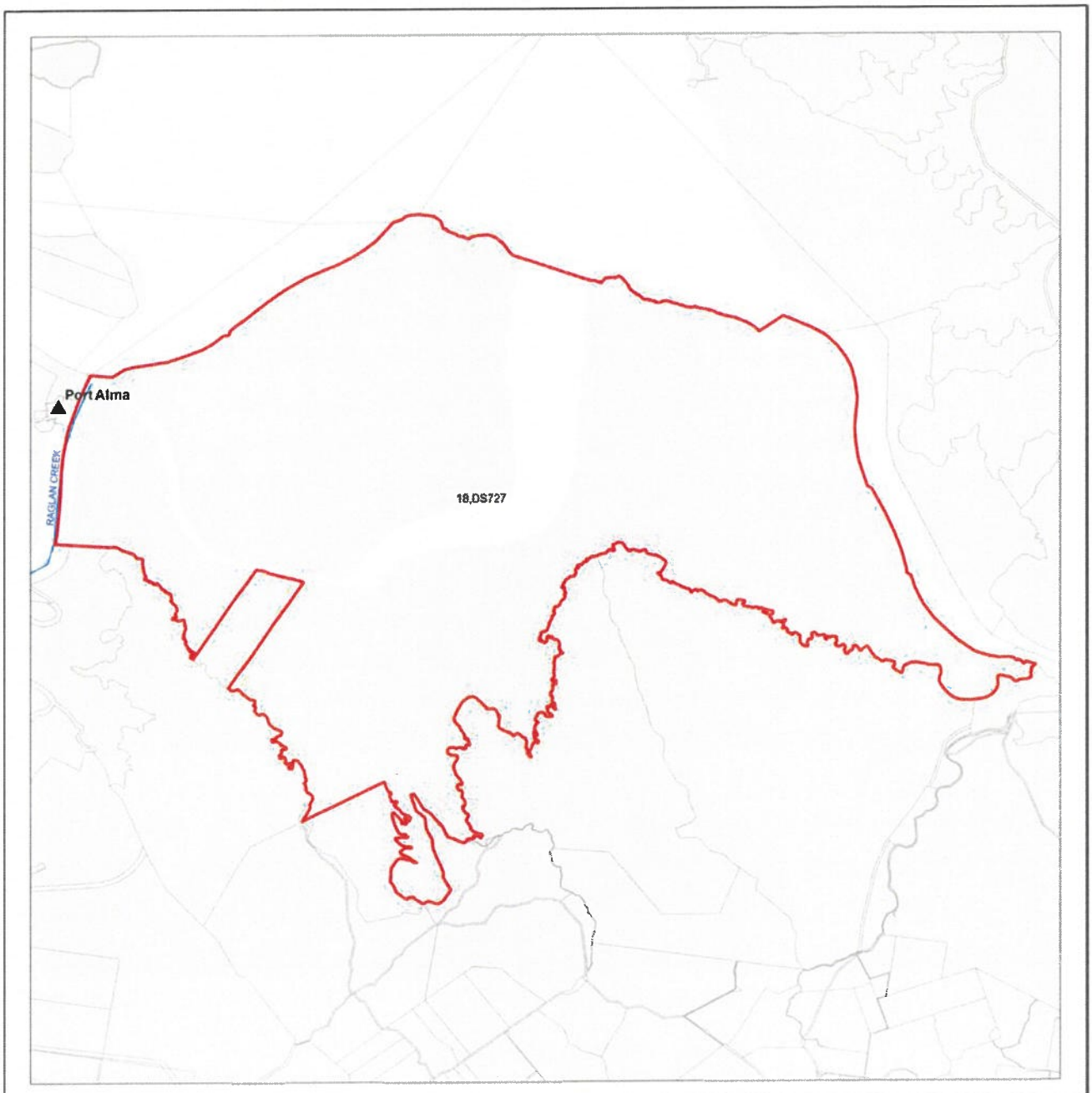
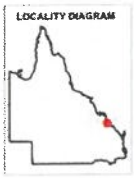
Map 3c - MSES - Species - Wildlife habitat (sea turtle nesting areas)



MSES - Wildlife habitat (sea turtle nesting areas)

- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Wildlife habitat (sea turtle nesting areas)
- Selected Lot and Plan



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MSES mapping of sea turtle nesting areas identifies beaches where the recorded number of turtle nests are over 1% of the turtle species or genetic stock. The linework is also deliberately extended along nearby rocky coastlines and headlands to recognise that significant numbers of nesting adults and hatchlings can become disoriented by light pollution from development on rocky coastlines and headlands while navigating offshore from nesting beaches

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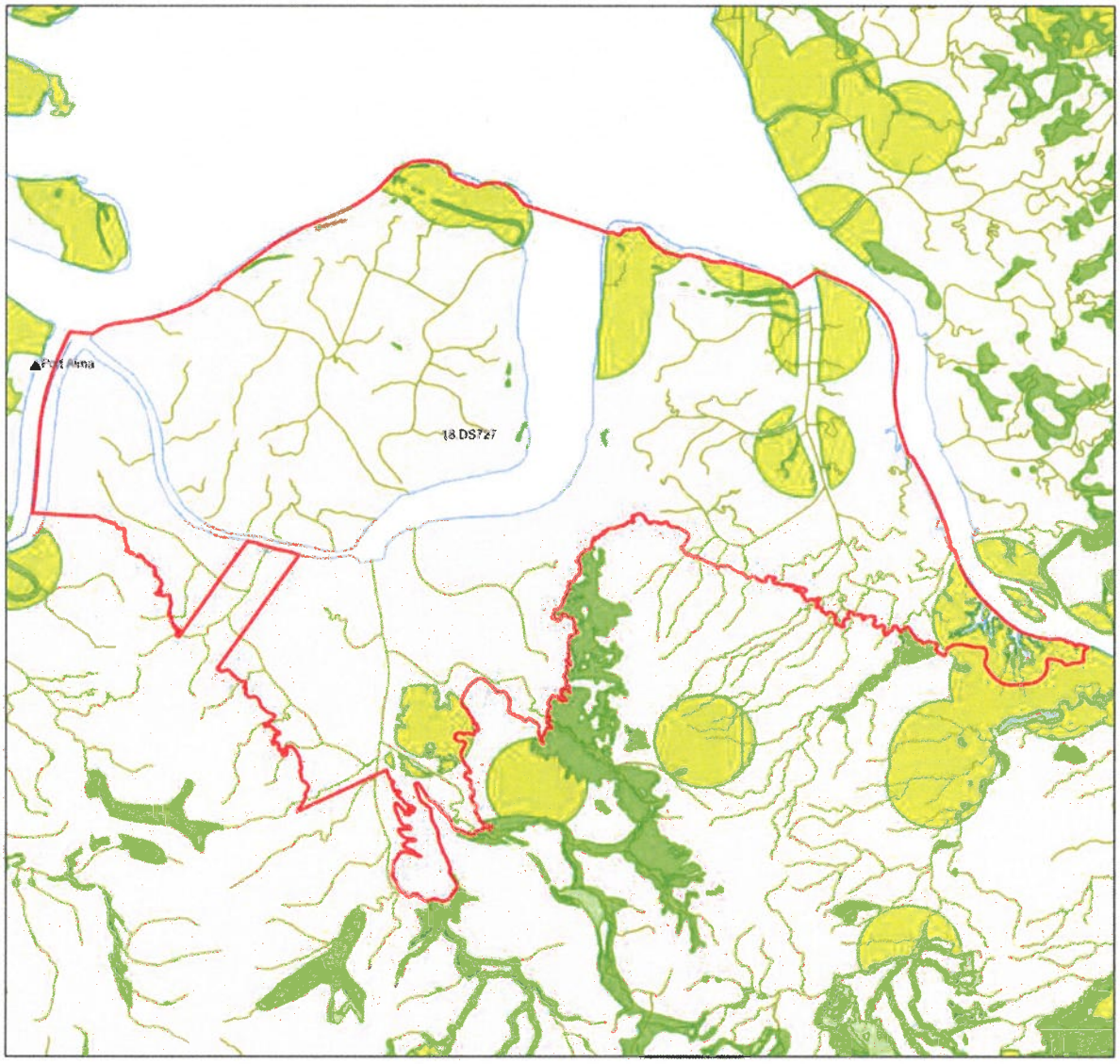
Map 4 - MSES - Regulated Vegetation



MSES - Regulated Vegetation

- ▲ Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Regulated vegetation (intersecting a watercourse)
- Regulated vegetation (100m from wetland)
- Regulated vegetation (category B - endangered or of concern)
- Regulated vegetation (category C - endangered or of concern)
- Regulated vegetation (category R - GBR riverine)
- Regulated vegetation (essential habitat)
- Selected Lot and Plan

LOCALITY DIAGRAM

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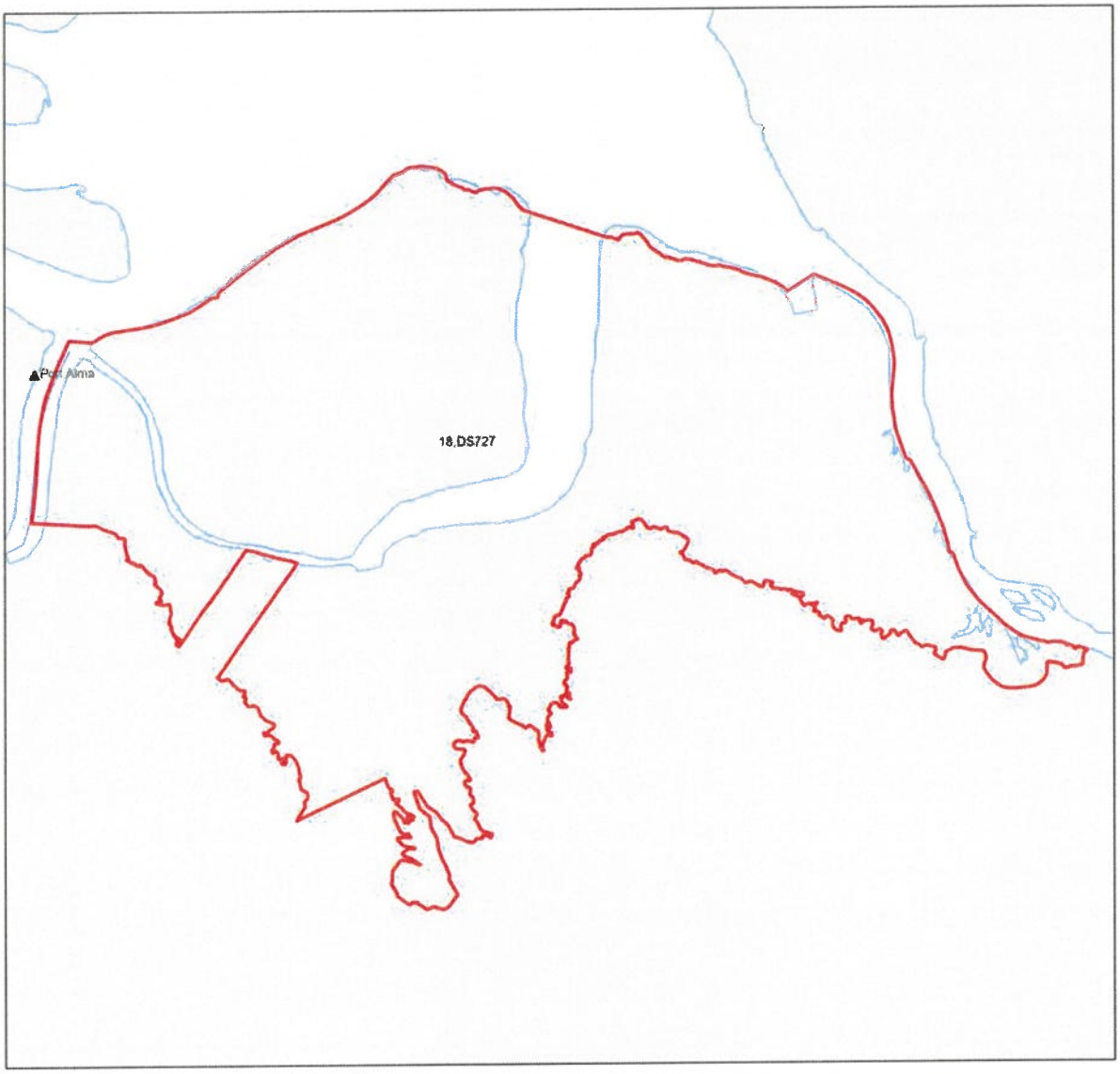
Map 5 - MSES - Offset Areas



MSES - Offsets

- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Legally secured offset area (offset register)
- Legally secured offset area (vegetation offsets)
- Selected Lot and Plan

N

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Appendices

Appendix 1 - Matters of State Environmental Significance (MSES) methodology

MSES mapping is a regional-scale representation of the definition for MSES under the State Planning Policy (SPP). Its primary purpose is to support implementation of the SPP biodiversity policy.

MSES mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations.

MSES mapping does not determine whether state or local development assessment is required. For state assessment triggers refer to the Development Assessment Mapping System (DAMS). For local assessment triggers, refer to the relevant local planning scheme.

The Queensland Government's "Method for mapping - matters of state environmental significance can be downloaded from:

http://www.ehp.qld.gov.au/land/natural-resource/method-mapping-mses.html .

Appendix 2 - Source Data

The datasets listed below are available on request from:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

- Matters of State environmental significance

Note: MSES mapping is not based on new or unique data. The primary mapping product draws data from a number of underlying environment databases and geo-referenced information sources. MSES mapping is a versioned product that is updated generally on a twice-yearly basis to incorporate the changes to underlying data sources. Several components of MSES mapping made for the current version may differ from the current underlying data sources. To ensure accuracy, or proper representation of MSES values, it is strongly recommended that users refer to the underlying data sources and review the current definition of MSES in the State Planning Policy, before applying the MSES mapping.

Individual MSES layers can be attributed to the following source data available at QSpatial:

MSES layers	**current QSpatial data (http://qspatial.information.qld.gov.au)**
Protected Areas-Estates, Nature Refuges, Special Wildlife Reserves	- Protected areas of Queensland - Nature Refuges - Queensland - Special Wildlife Reserves- Queensland
Marine Park-Highly Protected Zones	Moreton Bay marine park zoning 2008
Fish Habitat Areas	Queensland fish habitat areas
Strategic Environmental Areas-designated	Regional Planning Interests Act - Strategic Environmental Areas
HES wetlands	Map of Queensland Wetland Environmental Values
Wetlands in HEV waters	HEV waters: - EPP Water intent for waters Source Wetlands: - Queensland Wetland Mapping (Current version 5) Source Watercourses: - Vegetation management watercourse and drainage feature map (1:100000 and 1:250000)
Wildlife habitat (threatened and special least concern)	-WildNet database species records - habitat suitability models (various) - SEQ koala habitat areas under the Koala Conservation Plan 2019
VMA regulated regional ecosystems	Vegetation management regional ecosystem and remnant map
VMA Essential Habitat	Vegetation management - essential habitat map
VMA Wetlands	Vegetation management wetlands map
Legally secured offsets	Vegetation Management Act property maps of assessable vegetation. For offset register data-contact DES
Regulated Vegetation Map	Vegetation management - regulated vegetation management map

Appendix 3 - Acronyms and Abbreviations

AOI	- Area of Interest
DESI	- Department of Environment, Science and Innovation
EP Act	- Environmental Protection Act 1994
EPP	- Environmental Protection Policy
GDA94	- Geocentric Datum of Australia 1994
GEM	- General Environmental Matters
GIS	- Geographic Information System
MSES	- Matters of State Environmental Significance
NCA	- Nature Conservation Act 1992
RE	- Regional Ecosystem
SPP	- State Planning Policy
VMA	- Vegetation Management Act 1999

APPENDIX 3: Regional Ecosystems Report for Lot 18 on Plan DS727

Queensland Government

Department of Environment, Science and Innovation

Environmental Reports

Regional Ecosystems

Biodiversity Status

For the selected area of interest
Lot: 18 Plan: DS727

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the input coordinates.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 2020). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Important Note to User

Information presented in this report is based upon the Queensland Herbarium & Biodiversity Science's Regional Ecosystem framework. The Biodiversity Status has been used to depict the extent of "Endangered", "Of Concern" and "No Concern at Present" regional ecosystems in all cases, rather than the classes used for the purposes of the *Vegetation Management Act 1999* (VMA). Mapping and figures presented in this document reflect the Queensland Herbarium & Biodiversity Science's Remnant and Pre-clearing Regional Ecosystem Datasets, and not the certified mapping used for the purpose of the VMA.

For matters relevant to vegetation management under the VMA, please refer to the Department of Resources website https://www.resources.qld.gov.au/

Please direct queries about these reports to: Queensland.Herbarium@qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

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Summary Information

The following table provides an overview of the AOI with respect to selected topographic and environmental themes. Refer to **Map 1** for locality information.

Table 1: Details for area of interest:
Lot: 18 Plan: DS727, with area 15002.5 ha

Local Government(s)	Catchment(s)	Bioregion(s)	Subregion(s)
Gladstone Regional	Coral Sea	Brigalow Belt	Marlborough Plains
	Calliope		
	Fitzroy		

The table below summarizes the extent of remnant vegetation classed as "Endangered", "Of concern" and "No concern at present" regional ecosystems classified by Biodiversity Status within the area of interest (AOI).

Table 2: Summary table, biodiversity status of regional ecosystems within the AOI

Biodiversity Status	Area (Ha)	% of AOI
Endangered	1.52	0.01
Of concern	51.57	0.34
No concern at present	12,109.38	80.72
Total remnant vegetation	12,162.47	81.07

Refer to **Map 2** for further information.

Regional Ecosystems

1. Introduction

Regional ecosystems are vegetation communities in a bioregion that are consistently associated with particular combinations of geology, landform and soil (Sattler and Williams 1999). Descriptions of Queensland's Regional ecosystems are available online from the Regional Ecosystem Description Database (REDD). Descriptions are compiled from a broad range of information sources including vegetation, land system and geology survey and mapping and detailed vegetation site data. The regional ecosystem classification and descriptions are reviewed as new information becomes available. A number of vegetation communities may form a single regional ecosystem and may be distinguished by differences in structure or sub-dominant species in the ecologically dominant layer. Vegetation communities with different dominant species in the ecologically dominant layer may be amalgamated in to a regional ecosystem if they are not mappable and predictable in the landscape at 1:100 000 scale. Vegetation communities may be mappable at a scale larger than 1:100 000. Vegetation communities within a regional ecosystem are denoted by a letter following the regional ecosystem code (e.g. a, b, c). Vegetation communities and regional ecosystems are amalgamated into a higher level classification of broad vegetation groups (BVGs).

A published methodology for survey and mapping of regional ecosystems across Queensland (Neldner et al 2023) provides further details on regional ecosystem concepts and terminology.

This report provides information on the type, status, and extent of vegetation communities, regional ecosystems and broad vegetation groups present within a user specified area of interest. Please note, for the purpose of this report, the Biodiversity Status is used. This report has not been developed for application of the *Vegetation Management Act 1999* (VMA). Additionally, information generated in this report has been derived from the Queensland Herbarium & Biodiversity Science's Regional Ecosystem Mapping, and not the regulated mapping certified for the purposes of the VMA. If your interest/matter relates to regional ecosystems and the VMA, users should refer to the Department of Resources website https://www.resources.qld.gov.au/.

With respect to the Queensland Biodiversity Status,

"Endangered" regional ecosystems are described as those where:

- remnant vegetation is less than 10 per cent of its pre-clearing extent across the bioregion; or 10-30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 hectares, or
- less than 10 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss*, or
- 10-30 percent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000 hectares; or
- it is a rare** regional ecosystem subject to a threatening process.***

"Of concern" regional ecosystems are described as those where:

- the degradation criteria listed above for 'Endangered' regional ecosystems are not met and,
- remnant vegetation is 10-30 per cent of its pre-clearing extent across the bioregion; or more than 20 per cent of its pre-clearing extent remains and the remnant extent is less than 10,000 hectares, or
- 10-30 percent of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.****

and "No concern at present" regional ecosystems are described as those where:

- remnant vegetation is over 30 percent of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 hectares, and
- the degradation criteria listed above for 'Endangered' or 'Of concern' regional ecosystems are not met.

**Severe degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 50 years even with the removal of threatening processes; or soil surface is severely degraded, for example, by loss of A horizon, surface expression of salinity; surface compaction, loss of organic matter or sheet erosion.*

***Rare regional ecosystem: pre-clearing extent (<1000 ha); or patch size (<100 ha and of limited total extent across its range).*

****Threatening processes are those that are reducing or will reduce the biodiversity and ecological integrity of a regional ecosystem. For example, clearing, weed invasion, fragmentation, inappropriate fire regime or grazing pressure, or infrastructure development.*

*****Moderate degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 20 years even with the removal of threatening processes; or soil surface is moderately degraded.*

2. Remnant Regional Ecosystems

The following table identifies the remnant regional ecosystems and vegetation communities mapped within the AOI and provides their short descriptions, Biodiversity Status, and remnant extent within the selected AOI. Please note, where heterogeneous vegetated patches (mixed patches of remnant vegetation mapped as containing multiple regional ecosystems) occur within the AOI, they have been split and listed as individual regional ecosystems (or vegetation communities where present) for the purposes of the table below. In such instances, associated area figures have been generated based upon the estimated proportion of each regional ecosystem (or vegetation community) predicted to be present within the larger mixed patch.

Table 3: Remnant regional ecosystems, description and status within the AOI

Regional Ecosystem	Short Description	BD Status	Area (Ha)	% of AOI
11.1.1	Sporobolus virginicus grassland on marine clay plains	No concern at present	2.89	0.02
11.1.2a	Samphire forbland on marine clay plains	No concern at present	6,804.97	45.36
11.1.2b	Samphire forbland on marine clay plains	No concern at present	4.38	0.03
11.1.4a	Mangrove low open forest and/or woodland on marine clay plains	No concern at present	3,413.12	22.75
11.1.4b	Mangrove low open forest and/or woodland on marine clay plains	No concern at present	204.74	1.36
11.1.4d	Mangrove low open forest and/or woodland on marine clay plains	No concern at present	1,569.45	10.46
11.11.14	Acacia harpophylla open forest on deformed and metamorphosed sediments and interbedded volcanics	Endangered	1.44	less than 0.01
11.11.15	Eucalyptus crebra woodland to open woodland on deformed and metamorphosed sediments and interbedded volcanics	No concern at present	23.31	0.16
11.11.15a	Eucalyptus crebra woodland to open woodland on deformed and metamorphosed sediments and interbedded volcanics	No concern at present	29.91	0.20
11.11.5	Microphyll vine forest +/- Araucaria cunninghamii on old sedimentary rocks with varying degrees of metamorphism and folding	No concern at present	13.44	0.09
11.11.5a	Microphyll vine forest +/- Araucaria cunninghamii on old sedimentary rocks with varying degrees of metamorphism and folding	No concern at present	42.47	0.28
11.2.3	Microphyll vine forest ("beach scrub") on sandy beach ridges and dune swales	Of concern	50.66	0.34
11.3.1	Acacia harpophylla and/or Casuarina cristata open forest on alluvial plains	Endangered	0.09	less than 0.01

11.3.25	Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines	Of concern	0.49	less than 0.01
11.3.4	Eucalyptus tereticornis and/or Eucalyptus spp. woodland on alluvial plains	Of concern	0.42	less than 0.01
11.5.9d	Eucalyptus crebra and other Eucalyptus spp. and Corymbia spp. woodland on Cainozoic sand plains and/or remnant surfaces	No concern at present	0.71	less than 0.01
estuary	None	None	2,838.28	18.92
non-remnant	None	None	0.75	less than 0.01
ocean	None	None	1.00	less than 0.01

Refer to **Map 2** for further information. **Map 3** also provides a visual estimate of the distribution of regional ecosystems present before clearing.

Table 4 provides further information in regards to the remnant regional ecosystems present within the AOI. Specifically, the extent of remnant vegetation remaining within the bioregion, the 1:1,000,000 broad vegetation group (BVG) classification, whether the regional ecosystem is identified as a wetland, and extent of representation in Queensland's Protected Area Estate. For a description of the vegetation communities within the AOI and classified according to the 1:1,000,000 BVG, refer to **Table 6**.

Table 4: Remnant regional ecosystems within the AOI, additional information

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
11.1.1	Pre-clearing 38000 ha; Remnant 2021 32000 ha	35b	Intertidal	Medium
11.1.2a	Pre-clearing 117000 ha; Remnant 2021 104000 ha	35b	Intertidal	High
11.1.2b	Pre-clearing 117000 ha; Remnant 2021 104000 ha	35b	Intertidal	High
11.1.4a	Pre-clearing 84000 ha; Remnant 2021 84000 ha	35a	Intertidal	High
11.1.4b	Pre-clearing 84000 ha; Remnant 2021 84000 ha	35a	Intertidal	High
11.1.4d	Pre-clearing 84000 ha; Remnant 2021 84000 ha	35a	Intertidal	High
11.11.14	Pre-clearing 37000 ha; Remnant 2021 4000 ha	25a	Not a Wetland	Low
11.11.15	Pre-clearing 892000 ha; Remnant 2021 519000 ha	13c	Not a Wetland	Low

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
11.11.15a	Pre-clearing 892000 ha; Remnant 2021 519000 ha	13c	Not a Wetland	Low
11.11.5	Pre-clearing 81000 ha; Remnant 2021 32000 ha	7a	Not a Wetland	Medium
11.11.5a	Pre-clearing 81000 ha; Remnant 2021 32000 ha	7a	Not a Wetland	Medium
11.2.3	Pre-clearing 3000 ha; Remnant 2021 2000 ha	3a	Not a Wetland	High
11.3.1	Pre-clearing 785000 ha; Remnant 2021 80000 ha	25a	Not a Wetland	Low
11.3.25	Pre-clearing 813000 ha; Remnant 2021 531000 ha	16a	Riverine	Low
11.3.4	Pre-clearing 684000 ha; Remnant 2021 178000 ha	16c	Not a Wetland	Low
11.5.9d	Pre-clearing 366000 ha; Remnant 2021 238000 ha	10a	Not a Wetland	Low
estuary	None	None	None	None
non-remnant	None	None	None	None
ocean	None	None	None	None

Representation in Protected Area Estate: High greater than 10% of pre-clearing extent is represented; Medium 4 - 10% is represented; Low less than 4% is represented, No representation.

The distribution of mapped wetland systems within the area of interest is displayed in **Map 6**.

The following table lists known special values associated with a regional ecosystem type.

Table 5: Remnant regional ecosystems within the AOI, special values

Regional Ecosystem	Special Values
11.1.1	11.1.1: Provides estuarine wetland habitat.
11.1.2a	11.1.2: Provides estuarine wetland habitat. 11.1.2b: Some areas of this ecosystem form habitat for the Capricorn Yellow Chat (Epthianura crocea macgregrori).

Regional Ecosystem	Special Values
11.1.2b	11.1.2: Provides estuarine wetland habitat. 11.1.2b: Some areas of this ecosystem form habitat for the Capricorn Yellow Chat (Epthianura crocea macgregrori).
11.1.4a	11.1.4: Provides estuarine wetland habitat.
11.1.4b	11.1.4: Provides estuarine wetland habitat.
11.1.4d	11.1.4: Provides estuarine wetland habitat.
11.11.14	11.11.14: Potential habitat for NCA listed species: Cadellia pentastylis, Denhamia parvifolia, Macropteranthes leiocaulis.
11.11.15	11.11.15: Potential habitat for NCA listed species: Capparis humistrata, Corymbia clandestina, Corymbia xanthope, Cycas megacarpa, Cycas ophiolitica.
11.11.15a	11.11.15: Potential habitat for NCA listed species: Capparis humistrata, Corymbia clandestina, Corymbia xanthope, Cycas megacarpa, Cycas ophiolitica.
11.11.5	11.11.5: Potential habitat for NCA listed species: Atalaya collina, Corchorus hygrophilus, Dansiea elliptica, Decaspermum struckoilicum, Graptophyllum excelsum, Hernandia bivalvis, Macropteranthes leiocaulis, Macrozamia serpentina, Solanum sporadotrichum, Zieria verrucosa.
11.11.5a	11.11.5: Potential habitat for NCA listed species: Atalaya collina, Corchorus hygrophilus, Dansiea elliptica, Decaspermum struckoilicum, Graptophyllum excelsum, Hernandia bivalvis, Macropteranthes leiocaulis, Macrozamia serpentina, Solanum sporadotrichum, Zieria verrucosa.
11.2.3	11.2.3: Potential habitat for NCA listed species: Xylosma ovata.
11.3.1	11.3.1: Habitat for threatened fauna species including painted honeyeater, Grantiella picta particularly in subregion 35 (Oliver et al. 2003).
11.3.25	11.3.25: Shown to be associated with a high fauna species richness in the Taroom area (Venz et al. 2002). Within parts of the Fitzroy catchment, this RE is known habitat for the threatened freshwater turtle Rheodytes leukops. Known to be important habitat for other riparian freshwater turtle species. This ecosystem is also known to provide suitable habitat for koalas (Phascolarctos cinereus).
11.3.4	11.3.4: Potential habitat for NCA listed species: Acacia pedleyi, Callicarpa thozetii, Cycas megacarpa, Cycas ophiolitica, Digitaria porrecta, Eriocaulon carsonii subsp. orientale, Livistona nitida, Rhaponticum australe, Samadera bidwillii, Sannantha brachypoda. This ecosystem is also known to provide suitable habitat for koalas (Phascolarctos cinereus).
11.5.9d	11.5.9: Potential habitat for NCA listed species: Cerbera dumicola, Cossinia australiana, Cycas ophiolitica, Solanum elachophyllum.
estuary	None
non-remnant	None

Regional Ecosystem	Special Values
ocean	None

3. Remnant Regional Ecosystems by Broad Vegetation Group

BVGs are a higher-level grouping of vegetation communities. Queensland encompasses a wide variety of landscapes across temperate, wet and dry tropics and semi-arid climatic zones. BVGs provide an overview of vegetation communities across the state or a bioregion and allow comparison with other states. There are three levels of BVGs which reflect the approximate scale at which they are designed to be used: the 1:5,000,000 (national), 1:2,000,000 (state) and 1:1,000,000 (regional) scales.

A comprehensive description of BVGs is available at: https://publications.qld.gov.au/dataset/redd/resource/

The following table provides a description of the 1:1,000,000 BVGs present and their associated extent within the AOI.

Table 6: Broad vegetation groups (1 million) within the AOI

BVG (1 Million)	Description	Area (Ha)	% of AOI
None	None	2,840.03	18.93
10a	Dry woodlands to open woodlands dominated by Corymbia citriodora (spotted gum).	0.71	less than 0.01
13c	Woodlands of Eucalyptus crebra (sens. lat.) (narrow-leaved red ironbark), E. drepanophylla (grey ironbark), E. fibrosa (dusky-leaved ironbark), E. shirleyi (shirley's silver-leaved ironbark) on granitic and metamorphic ranges.	53.22	0.35
16a	Open forest and woodlands dominated by Eucalyptus camaldulensis (river red gum) (or E. tereticornis (blue gum)) and/or E. coolabah (coolabah) (or E. microtheca (coolabah)) fringing drainage lines. Associated species may include Melaleuca spp., Corymbia tessellaris (carbeen), Angophora spp., Casuarina cunninghamiana (riveroak). Does not include alluvial areas dominated by herb and grasslands or alluvial plains that are not flooded.	0.49	less than 0.01
16c	Woodlands and open woodlands dominated by Eucalyptus coolabah (coolabah) or E. microtheca (coolabah) or E. largiflorens (black box) or E. tereticornis (blue gum) or E. chlorophylla on floodplains. Does not include alluvial areas dominated by herb and grasslands or alluvial plains that are not flooded.	0.42	less than 0.01
25a	Open forests to woodlands dominated by Acacia harpophylla (brigalow) sometimes with Casuarina cristata (belah) on heavy clay soils. Includes areas co-dominated with A. cambagei (gidgee) and/or emergent eucalypts.	1.52	0.01
35a	Closed forests and low closed forests dominated by mangroves.	5,187.31	34.58
35b	Bare saltpans ± areas of Tecticornia spp. (samphire) sparse forbland and/or Xerochloa imberbis or Sporobolus virginicus (sand couch) tussock grassland.	6,812.24	45.41

BVG (1 Million)	Description	Area (Ha)	% of AOI
3a	Evergreen to semi-deciduous, notophyll to microphyll vine forest/ thicket on beach ridges and coastal dunes, occasionally Araucaria cunninghamii (hoop pine) microphyll vine forest on dunes. Pisonia grandis on coral cays.	50.66	0.34
7a	Semi-evergreen vine thickets on wide range of substrates.	55.91	0.37

Refer to **Map 4** for further information. **Map 5** also provides a representation of the distribution of vegetation communities as per the 1:5,000,000 BVG believed to be present prior to European settlement.

4. Technical and BioCondition Benchmark Descriptions

Technical descriptions provide a detailed description of the full range in structure and floristic composition of regional ecosystems (e.g. 11.3.1) and their component vegetation communities (e.g. 11.3.1a, 11.3.1b). See: http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

The descriptions are compiled using site survey data from the Queensland Herbarium & Biodiversity Science's QBEIS database. Distribution maps, representative images (if available) and the pre-clearing and remnant extent (hectares) of each vegetation community derived from the regional ecosystem mapping data are included. The technical descriptions should be used in conjunction with the fields from the regional ecosystem description database (REDD) for a full description of the regional ecosystem.

Technical descriptions include data on canopy height, canopy cover and native plant species composition of the predominant layer, which are attributes relevant to assessment of the remnant status of vegetation under the *Vegetation Management Act 1999*. However, as technical descriptions reflect the full range in structure and floristic composition across the climatic, natural disturbance and geographic range of the regional ecosystem, local reference sites should be used for remnant assessment where possible (Neldner et al. 2023 (PDF)* section 3.3 of: https://www.qld.gov.au/__data/assets/pdf_file/0033/459186/methodology-mapping-surveying-v7.pdf

The technical descriptions are subject to review and are updated as additional data becomes available.

When conducting a BioCondition assessment, these technical descriptions should be used in conjunction with BioCondition benchmarks for the specific regional ecosystem, or component vegetation community. http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

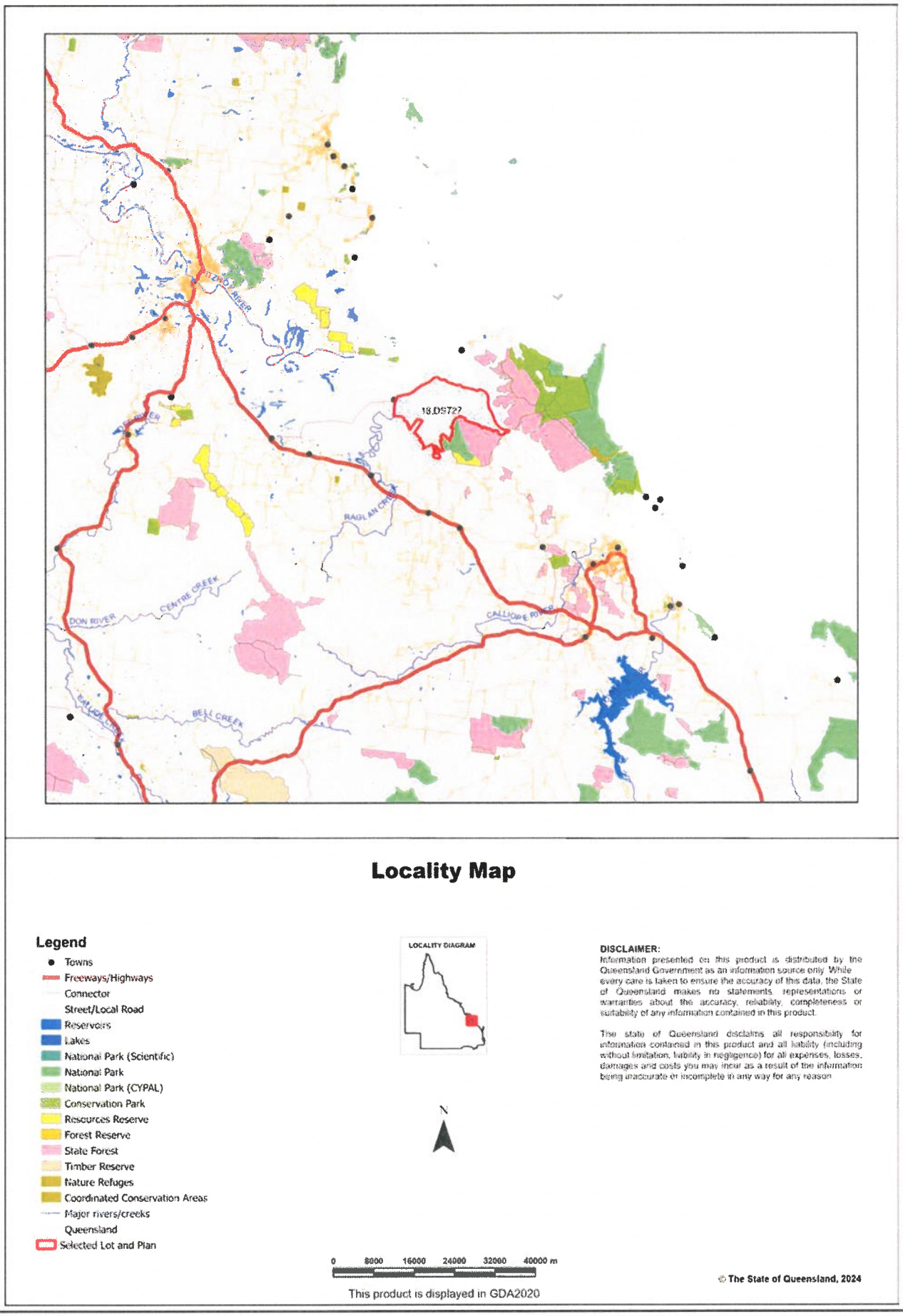
Benchmarks are based on a combination of quantitative and qualitative information and should be used as a guide only. Benchmarks are specific to one regional ecosystem vegetation community, however, the natural variability in structure and floristic composition under a range of climatic and natural disturbance regimes has been considered throughout the geographic extent of the regional ecosystem. Local reference sites should be used for this spatial and temporal (seasonal and annual) variability.

Table 7: List of remnant regional ecosystems within the AOI for which technical and biocondition benchmark descriptions are available

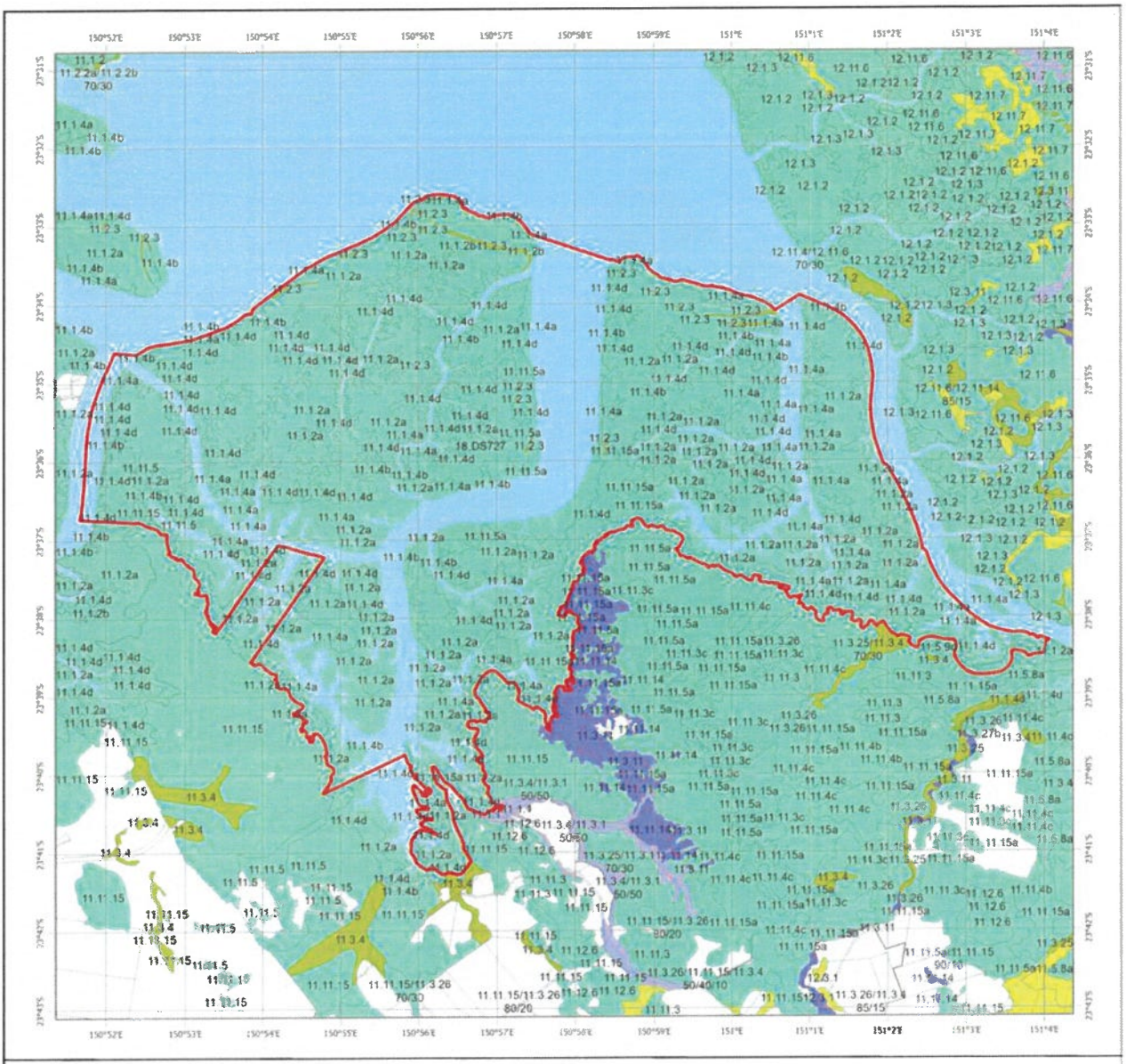
Regional ecosystems mapped as within the AOI	Technical Descriptions	Biocondition Benchmarks
11.1.1	Available	Not currently available
11.1.2a	Available	Not currently available
11.1.2b	Available	Not currently available
11.1.4a	Available	Not currently available
11.1.4b	Available	Not currently available
11.1.4d	Available	Not currently available
11.11.14	Available	Not currently available
11.11.15	Available	Available
11.11.15a	Available	Available
11.11.5	Available	Available
11.11.5a	Available	Not currently available
11.2.3	Available	Available
11.3.1	Available	Available
11.3.25	Available	Available
11.3.4	Available	Available
11.5.9d	Not currently available	Not currently available
estuary	Not currently available	Not currently available
non-remnant	Not currently available	Not currently available
ocean	Not currently available	Not currently available

Maps

Map 1 - Location



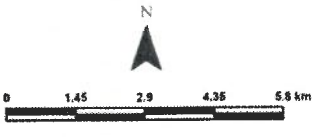
Map 2 - Remnant 2021 regional ecosystems



Remnant 2021 Regional Ecosystems

Biodiversity Status

- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Non-remnant vegetation, cultivated or built environment
- Plantation
- Water
- Cadastral Boundaries
- Selected Lot and Plan



This product is projected into GDA2020

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

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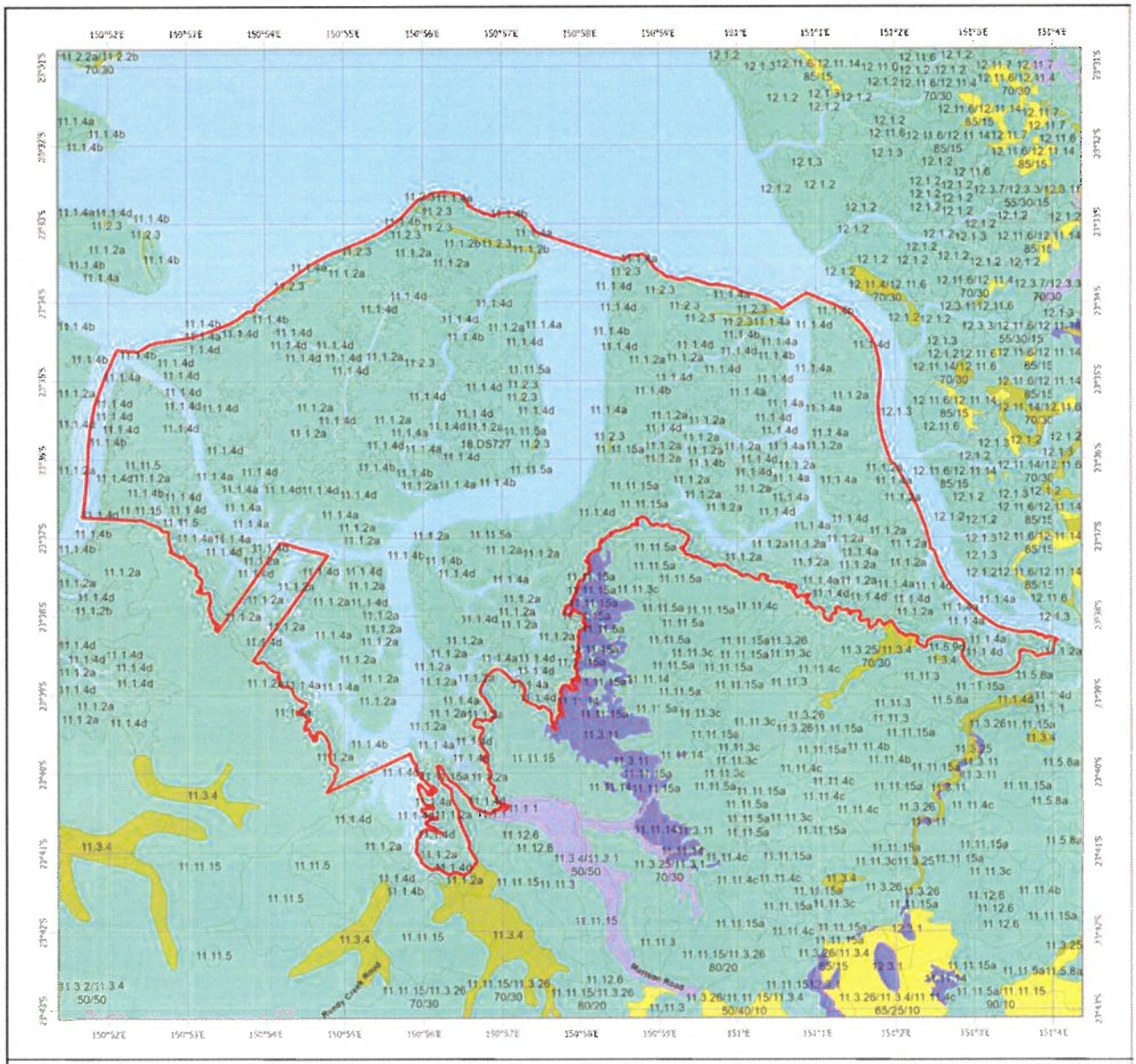
Map 3 - Pre-clearing regional ecosystems



Pre-clearing Regional Ecosystems

Biodiversity Status

- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Water
- Cadastral Boundaries
- Selected Lot and Plan

LOCALITY DIAGRAM

N

0 1.45 2.9 4.35 5.8 km

This product is displayed in GDA2020

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.

Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g : RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".

Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

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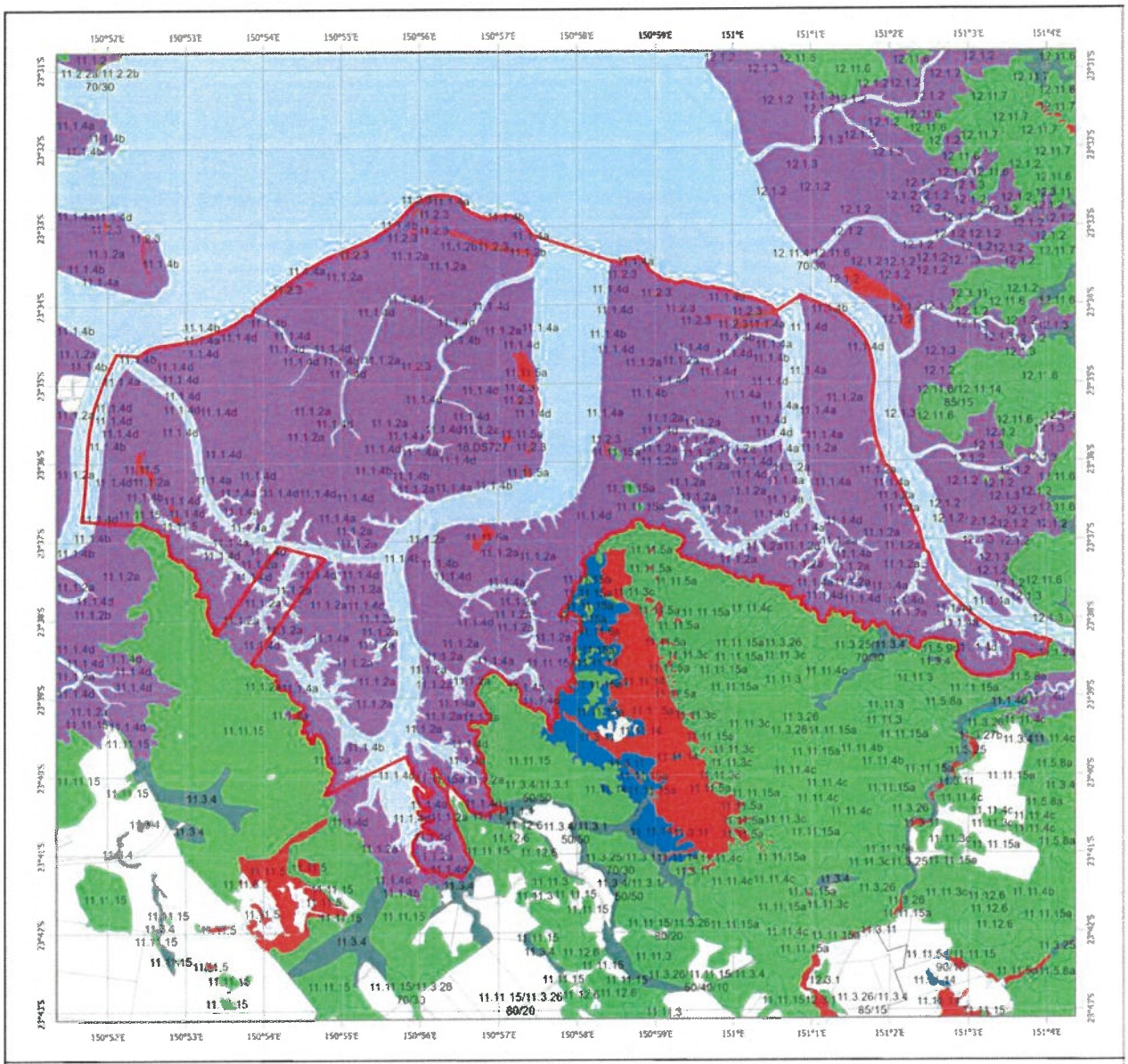
Map 4 - Remnant 2021 regional ecosystems by BVG (5M)

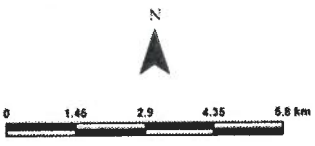


Remnant 2021 Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

1. Rainforests and scrubs (1-7b)
2. Wet eucalypt open forests (8-8b)
3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
4. Eucalypt open forests to woodlands on floodplains (16-16d)
5. Eucalypt dry woodlands on inland depositional plains (17-18d)
6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
7. Callitris woodland - open forests (20a)
8. Melaleuca open woodlands on depositional plains (21-22c)
9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
12. Other coastal communities or heaths (28-29b)
13. Tussock grasslands, forblands (30-32b)
14. Hummock grasslands (33-33b)
15. Wetlands (swamps and lakes) (34-34g)
16. Mangroves and saltmarshes (35-35b)

Non-remnant vegetation, cultivated or built environment
Water
Cadastral Boundaries
Selected Lot and Plan



This product is displayed in GDA2020

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species, e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.
Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.
Non-remnant vegetation includes regrowth and disturbed native vegetation.

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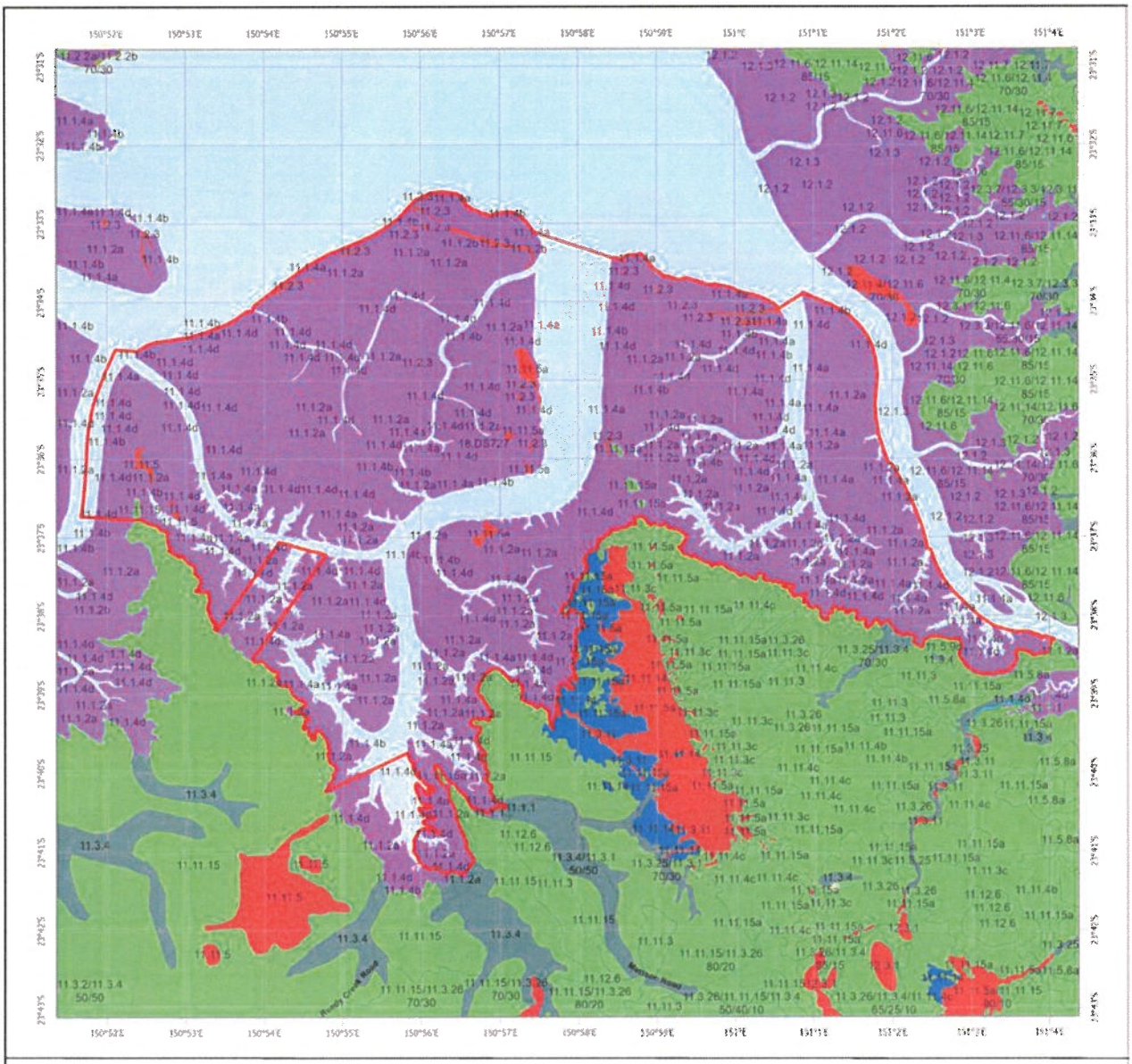
Map 5 - Pre-clearing regional ecosystems by BVG (5M)



Pre-clearing Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

1. Rainforests and scrubs (1-7b)
2. Wet eucalypt open forests (8-8b)
3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
4. Eucalypt open forests to woodlands on floodplains (16-16d)
5. Eucalypt dry woodlands on inland depositional plains (17-18d)
6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
7. Callitris woodland - open forests (20a)
8. Melaleuca open woodlands on depositional plains (21-22c)
9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
12. Other coastal communities or heaths (28-29b)
13. Tussock grasslands, forblands (30-32b)
14. Hummock grasslands (33-33b)
15. Wetlands (swamps and lakes) (34-34g)
16. Mangroves and saltmarshes (35-35b)

Water
Cadastral Boundaries
Selected Lot and Plan

LOCALITY DIAGRAM

N

0 1.5 3 4.5 6 km

This product is displayed in GDA2020

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The label consists of 3 components: bioregion, land zone, and vegetation community - the dominant canopy species e.g. RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

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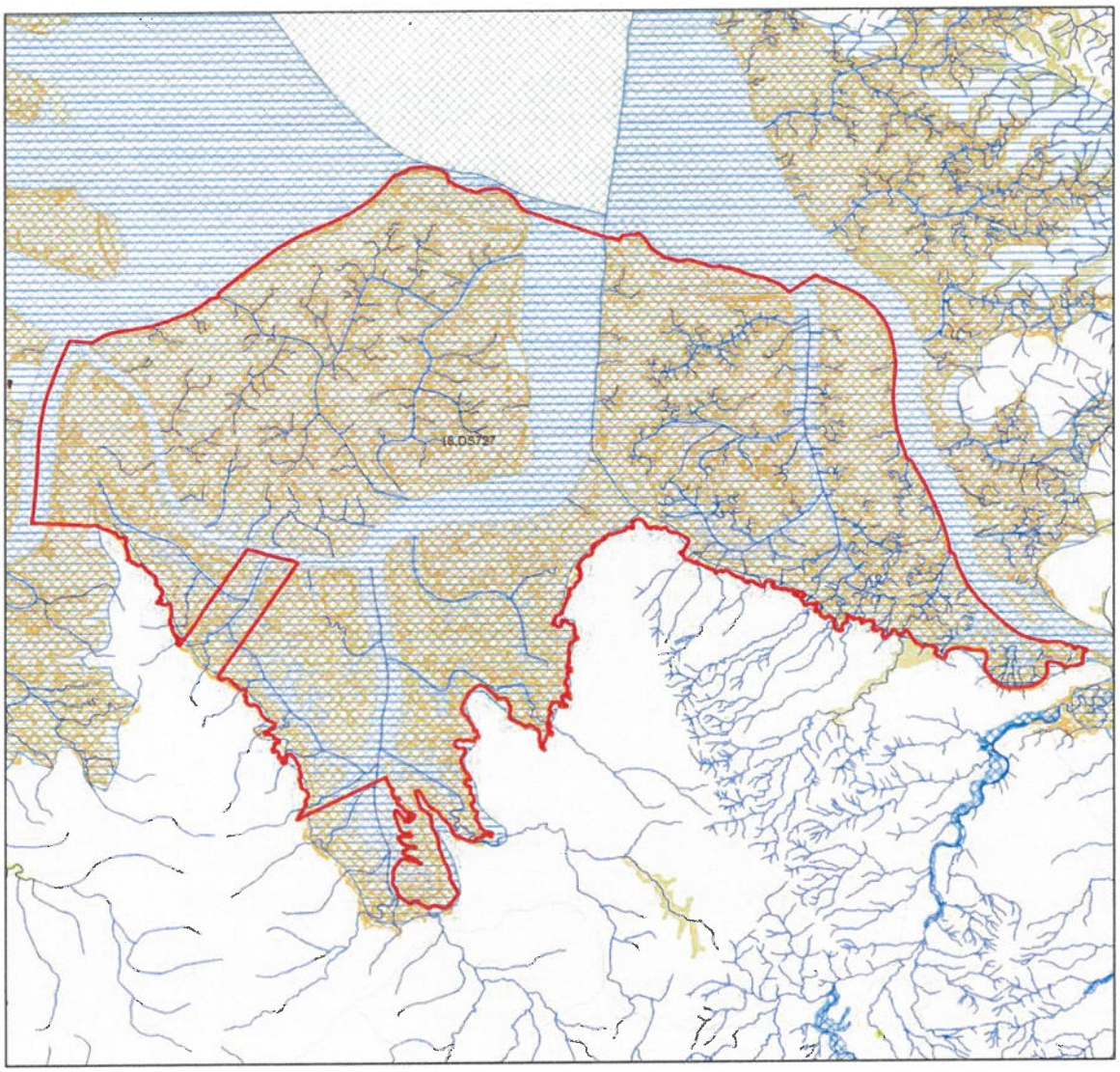
Map 6 - Wetlands and waterways



Wetlands and Waterways

- Towns
- Roads
- Springs
- Rivers/Creeks
- Directory of Important Wetlands
- Ramsar Sites - QLD

Wetland Type

Hydrologically natural Wetlands
- Lacustrine Wetlands (hydrologically natural)
- Palustrine Wetlands (hydrologically natural)
- Riverine Wetlands (hydrologically natural)
- Intertidal Wetlands (hydrologically natural)
- Subtidal Wetlands (hydrologically natural)
- Intertidal/Subtidal Wetlands (hydrologically natural)

Hydrologically Modified and Artificial Wetlands
- Lacustrine Wetlands (hydrologically modified or artificial)
- Palustrine Wetlands (hydrologically modified or artificial)
- Riverine Wetlands (hydrologically modified or artificial)
- Intertidal Wetlands (hydrologically modified or artificial)
- Subtidal Wetlands (hydrologically modified or artificial)
- Intertidal/Subtidal Wetlands (hydrologically modified or artificial)

Subdominant Wetlands
- Subdominant Wetlands (51 - 80%)

Contains Wetlands
- Contains Wetlands (1 - 50%)
- Queensland
- Selected Lot and Plan

LOCALITY DIAGRAM

N

0 1000 2000 3000 4000 5000 m

This product is displayed in GDA2020

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Links and Other Information Sources

The Department of Environment, Science and Innovation's Website - http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/ provides further information on the regional ecosystem framework, including access to links to the Regional Ecosystem Database, Broad Vegetation Group Definitions, Regional Ecosystem and Land zone descriptions.

Descriptions of the broad vegetation groups of Queensland can be downloaded from: https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/broad-vegetation

The methodology for mapping regional ecosystems can be downloaded from: https://www.qld.gov.au/__data/assets/pdf_file/0033/459186/methodology-mapping-surveying-v7.pdf

Technical descriptions for regional ecosystems can be obtained from: http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

Benchmarks can be obtained from: http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

For further information associated with the remnant regional ecosystem dataset used by this report, refer to the metadata associated with the Biodiversity status of pre-clearing and Remnant Regional Ecosystems of Queensland dataset (version listed in **Appendix 1**) which is available through the Queensland Spatial Catalogue, Queensland Spatial Catalogue : Queensland Government (information.qld.gov.au)

The Queensland Globe is a mapping and data application. As an interactive online tool, Queensland Globe allows you to view and explore Queensland maps, imagery (including up-to-date satellite images) and other spatial data, including regional ecosystem mapping. To further view and explore regional ecosystems over an area of interest, access the Biota Globe (a component of the Queensland Globe). The Queensland Globe can be accessed via the following link: https://qldglobe.information.qld.gov.au/

References

Neldner, V.J., Niehus, R.E., Wilson, B.A., McDonald, W.J.F., Ford, A.J. and Accad, A. (2023). The Vegetation of Queensland. Descriptions of Broad Vegetation Groups. Version 6.0. Queensland Herbarium, Department of Environment and Science. (https://publications.qld.gov.au/dataset/redd/resource/78209e74-c7f2-4589-90c1-c33188359086)

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S., Butler, D.W., McDonald, W.J.F, Richter,D., Addicott, E.P. and Appelman, C.N. (2023) Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland. Version 7.0. Updated December 2023. Queensland Herbarium, Queensland Department of Environment, Science and Innovation, Brisbane. (https://www.qld.gov.au/__data/assets/pdf_file/0033/459186/methodology-mapping-surveying-v7.pdf).

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems.* Environmental Protection Agency, Brisbane.

Appendices

Appendix 1 - Source Data

The dataset listed below is available for download from:
http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/download/

- Regional Ecosystem Description Database

The datasets listed below are available for download from:
Queensland Spatial Catalogue : Queensland Government (information.qld.gov.au)

- Biodiversity status of pre-clearing and 2021 remnant regional ecosystems of Queensland
- Pre-clearing Vegetation Communities and Regional Ecosystems of Queensland
- Queensland Wetland Data Version - Wetland lines
- Queensland Wetland Data Version - Wetland points
- Queensland Wetland Data Version - Wetland areas
- Pre-clearing broad vegetation groups of Queensland
- Remnant 2021 broad vegetation groups of Queensland

Appendix 2 - Acronyms and Abbreviations

AOI - Area of Interest
GIS - Geographic Information System
RE - Regional Ecosystem
REDD - Regional Ecosystem Description Database
VMA - *Vegetation Management Act 1999*

APPENDIX 5

Evidence of feral animal impacts on Curtis Island

Photo 1. Example of feral pig abundance on Curtis Island prior to feral pig control (source: State of Queensland 2017).

Photo 2. Pig damage to wetlands on the marine plain prior to feral pig control, Curtis Island (source: State of Queensland 2022).

Photo 3. Curtis Island wetland in 2017 before feral control: pugging, collapsed banks, turbid water, lack of aquatic plants (source: QPWS supplied).

Photo 4. Curtis Island wetland in 2021 after feral control: restored grass growth on banks, improved water quality, abundant aquatic plants (source: QPWS supplied).

Photo 4. Condition of fore dune and beach dune communities on Curtis Island before (2016) and after (2021) feral animal control in areas managed by QPWS (source: QPWS supplied).

2016

- Turtle researchers report high numbers of feral livestock in flatback turtle nesting area and hoofprints on top of turtle nests; potential for damage to turtle eggs and hatchlings via trampling of nests
- Grazing of beach spinifex that is the primary sand trapping plant for dune stabilisation. Beach spinifex is considered critical for restoration of flatback turtle nesting habitat following cyclone and storm events
- Grazing and trampling of other dune plant species impacting dune stability of turtle nesting area
- Beaches in fore dune crest in flatback turtle nesting area caused by feral livestock traversing via dune slope. Ongoing wind erosion develops breaches into small blowouts impacting dune stability.

2021

- Turtle researchers report nil observations of feral livestock in turtle nesting area and nil incubating nests impacted by feral livestock
- Nil evidence of livestock presence e.g. grazing, hoofprints, manure
- Substantial increase in grass height and grass cover of beach spinifex and other dune plants in turtle nesting area
- Repair of breaches in frontal dune.

2016 before control: abundant feral horses in beach communities

2021 after control: no feral horses detected in beach communities

APPENDIX 6

Risk assessment approach

Risk Assessment Approach

The risk assessment was undertaken for each potential risk to the successful implementation of the Easter Curlew offset strategy by estimating the likelihood (Table A6.1) and consequence (Table A6.2) of each potential risk and then combining them using Table A6.3 to generate a risk rating of low, medium, high or severe.

Table A6.1. Qualitative measures of likelihood i.e. how likely is it that this event/issue will occur after control strategies have been put in place.

Likelihood	Explanation
Highly likely	Is expected to occur in most circumstances
Likely	Will probably occur during the life of the project
Possible	Might occur during the life of the project
Unlikely	Could occur but considered unlikely or doubtful
Rare	May occur in exceptional circumstances

Table A6.2. Qualitative measures of consequences i.e. what will be the consequence/result if this issue does occur.

Consequence	Explanation
Minor	Minor impact or incident of environmental damage that can be reversed
Moderate	Isolated but substantial impact or instances of environmental damage that could be reversed with intensive efforts
High	Substantial impact or instances of environmental damage that could be reversed with intensive efforts
Major	Major impact or loss of environmental amenity and real danger of continuing
Critical	Severe impact or widespread loss of environmental amenity and irrecoverable environmental damage

Table A6.3. Qualitative measures of risk rating.

Risk rating	Explanation
Low	Low probability and consequence, involving a minor effect on the project.
Medium	Risk combinations ranging from minor consequence/highly likely likelihood to major consequence/rare likelihood, involving minor to major consequences for the project.
High	Risk combinations ranging from moderate consequence/highly likely likelihood to critical consequence/unlikely likelihood, typically requiring the implementation and close monitoring of planned additional measures to reduce the level of risk.
Severe	Relatively high probabilities of occurring and with major to critical consequences for the project, requiring urgent and immediate attention to identifying and implementing additional measures to reduce the level of risk.

Table A6.3. Risk rating table.

	Consequence				
	Minor	**Moderate**	**High**	**Major**	**Critical**
Highly Likely	Medium	High	High	**Severe**	**Severe**
Likely	**Low**	Medium	High	High	**Severe**
Possible	**Low**	Medium	Medium	High	**Severe**
Unlikely	**Low**	**Low**	Medium	High	High
Rare	**Low**	**Low**	**Low**	Medium	High

DOCSCQPA-#1908378-v5A-NLEP_EPBC_2012_6558-_Eastern_Curlew_Offset_Stratgey

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11 Appendix B: NLEP SRA Seagrass and Macroalgae Offset Strategy

NORTHERN LAND EXPANSION PROJECT: ENVIRONMENTAL OFFSETS STRATEGY FOR SEAGRASS AND MACROALGAE

COASTAL MARINE ECOSYSTEMS RESEARCH CENTRE

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Cover Page and Declaration of Accuracy (Proponent)

EPBC number: 2012/6558

Project name: Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (CD Project) Stage 1 (Project Stage 1 means any aspect of the construction of the barge unloading facility and the southern reclamation area), Gladstone, Queensland

Approval holder and ABN: Gladstone Ports Corporation Limited, ABN: 96 263 788 242

Approved action: To duplicate the existing Gatcombe and Golding Cutting shipping channel, disposal of capital dredge spoil to land reclamation, and upgrade associated infrastructure in the Port of Gladstone, Queensland (see EPBC Act referral 2012/6558 approved by the Minister on December 2020).

Location of the action: Port of Gladstone, Queensland

Declaration of accuracy

In making this declaration, I am aware that section 491 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

This offset is not required under any other EPBC approvals or programs.

Signed	
Full name (please print)	Richard Haward
Organisation (please print)	Gladstone Ports Corporation Limited
Date	17/02/2025

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Acronyms

CD Project	Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project
CMERC	Coastal Marine Ecosystems Research Centre
CHIRP	Compressed High-Intensity Radiated Pulse
DAF	Department of Agriculture and Fisheries
DCCEEW	Department of Climate Change Energy Environment and Water
DES	Department of Environment and Science
DNA	Deoxyribonucleic acid
EIS	Environmental Impact Statement
EPBC Act	Environment Protection and Biodiversity Conservation Act
ERMP	Ecosystem Research and Monitoring Program
GBRWHA	Great Barrier Reef World Heritage Area
GHHP	Gladstone Healthy Harbour Partnership
GPC	Gladstone Ports Corporation
MNES	Matter of national environmental significance
MSES	Matter of state environmental significance
NG	Net gain
NNL	No net loss
NLEP	The Northern Land Expansion Project
NPI	Net positive impact
NRM	Natural Resource Managers
OUV	Outstanding Universal Value
PCCC	Port Curtis Coral Coast
SDAP	State Development Assessment Provisions
SRA	Southern Reclamation Area
SRI	Significant Residual Impact
TUMRA	Traditional Use of Marine Resources Agreement

EXECUTIVE SUMMARY

The Gladstone Ports Corporation (GPC) has received approval from the Department of Climate Change Energy Environment and Water (DCCEEW) to proceed with the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project. This requires the establishment of seagrass and macroalgal habitat as an offset due to the permanent loss of 55 hectares of seagrass and 1.06 hectares of macroalgae from the associated reclamation area.

Recent surveys (October 2023) show that the seagrass meadow at the Northern Land Expansion Project (Meadow 8) has been stable for over five years but exhibits significant variability over 20 years. The site is primarily dominated by *Z. muelleri,* especially during low disturbance periods. The offset goal is to enhance 55.04 hectares of intertidal *Z. muelleri* to achieve a biomass of over 5 g DW/m^2. Additionally, macroalgae were identified in Meadow 8 and the NLEP SRA footprint, with filamentous algae being the most prevalent, found at 41 sites but covering less than 5%. Erect macrophytes were recorded at 14 sites, with higher cover (10-40%) noted at the bund wall and northern tip. To offset losses, 1.1 hectares of macroalgal habitat will be created near the new bund wall, targeting 90% coverage of at least 5% and 10% reaching 40%. Focus will be on erect and turfing macroalgae due to the ephemeral nature of filamentous algae and its association with poor water quality.

Gladstone Harbour is home to dugongs and green turtles. Dugong surveys in the harbour provide data for Meadow 43, but do not extend to the NLEP SRA due to low seagrass biomass and high turbidity. Green turtles rely on seagrass and macroalgae for foraging, thus informing the offset strategy to enhance macroalgal cover in the Western Basin and seagrass in Pelican Banks. While dolphins have not been sighted in the area, seagrass beds are also crucial for supporting fish populations, providing habitats for life cycles, nurseries, and food sources. Although there is limited data on fish nursery use, studies show seagrass meadows support higher densities of benthic invertebrates compared to other substrates. The proposed offset is expected to increase seagrass biomass and benthic fauna, creating additional nursery habitats for juvenile fish. However, there is no evidence that the proposed sites serve as foraging areas for dolphins, with Snubfin dolphins absent from surveys and Humpback dolphins favouring deeper waters.

Three projects are proposed to offset seagrass and macroalgal impacts as part of the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project, including a direct seagrass offset, a direct macroalgae offset, and an indirect offset investigating the co-benefits of seagrass restoration (research component)

Direct Offset Proposal: Enhancing Resilience of Degraded Seagrass at Pelican Banks

This project aims to restore the degraded seagrass meadow at Pelican Banks, the primary offset site, by enhancing seedbanks. Monitoring shows the area has not recovered from 2014 flood events. The initiative will focus on regions with low biomass and seedbanks to promote recovery and improve resilience against future disturbances.

The project aims to promote seagrass recovery through seed enhancement, expecting a more stable cover over time. Monitoring will focus on changes in area, landscape connectivity (aggregated vs. isolated patches), and seagrass persistence (enduring vs. transitory). Increased

persistence and connectivity are anticipated to enhance biodiversity, improve sediment trapping, and boost carbon capture. Given the variability in seagrass cover, a robust sampling design will be employed using a Before-After Control-Impact (BACI) approach for effective assessment.

Key stages of this project include:

- Year 1: Obtain permits, establish governance, collect seagrass spathes (flowers), extend SeaGrow nursery, and map baseline seagrass cover at target locations;
- Year 2: Collect baseline data on fish and bird habitats, initiate annual seed dispersal;
- Years 2-10: Annual seed dispersal and seagrass spathe collection;
- Years 3, 5, 7, 9: Conduct biannual monitoring and provide progress reports; and
- Year 5: Conduct a five-year review.

Completion of the offset will be achieved when the following criteria are met:

- By Year 20: At least 55.04 ha of intertidal *Z. muelleri* and mixed species must be rehabilitated, increasing biomass from ≤ 0.64 g DW/m² to ≥ 5 g DW/m² at the offset site (Meadow 43, Pelican Banks), compared to reference sites through repeated sowing.
- Monitoring Requirements: Over five years of biannual monitoring, rehabilitated areas must show increased persistence (transitioning from transitory to enduring) and biomass growth from <0.64 to 5 g DW/m².
- Dugong Habitat: Rehabilitated sites should also exhibit dugong feeding trails and have enough biomass to support two dugongs over one year.

A risk analysis and management strategy are in place to address potential risks to the successful implementation of the environmental offset and timely achievement of these criteria.

Direct Offset Proposal: Integrating Macroalgal Habitat into Seawall Design

This project aims to create 1.1 ha of macroalgal habitat on the NLEP seawalls, specifically for brown algae, *Sargassum,* and red seaweed, *Asparagopsis taxiformis*. The goal is for 90% of this area (1 ha) to achieve at least 5% cover, while 10% (0.1 ha) should reach 40% cover.

The key project stages include: 1) identify the optimal substrate to enhance macroalgal growth, 2) cultivate seeded tiles in a controlled area to strengthen plants and select suitable strains for the NLEP environment, 3) apply algal-seeded substrate along the new NLEP SRA seawall, and 4) conduct annual monitoring. In the third year, recruitment to unseeded tiles will be assessed to inform the decision on whether to continue lab inoculation or rely on natural recruitment.

Completion of the offset will be achieved when the following criteria are met:

- By Year 5: Establish 0.1 ha of macroalgal habitat on the living seawall, and
- By Year 10: Achieve 1 ha of macroalgal habitat, with 80% of the area having at least 5% cover and 20% having 40% cover.

These targets signify a net gain in both area and coverage.

Indirect Offset Proposal: Co-Benefits of Restoration (Research Component)

This project aims to investigate blue carbon sequestration and other benefits arising from seagrass restoration. Large-scale seagrass restoration currently relies on funding from biodiversity offsets. Gathering data on the co-benefits of these restoration efforts is essential for attracting alternative funding sources, such as blue carbon credits, nature credits, reef credits, and sustainable seafood initiatives. The lack of specific data for the Great Barrier Reef (GBR) presents a significant challenge for seagrass restoration.

To address this, it is proposed that GPC fund a PhD project to study changes in co-benefits from years two to five of the program. This research aims to provide insights into how restored seagrass ecosystems contribute to vital services, including carbon sequestration, nutrient cycling, habitat provision, and coastal protection. The findings will support the case for seagrass restoration as a conservation strategy, highlighting its socio-economic importance and offering evidence-based recommendations for future investments in conservation initiatives. Understanding these benefits is crucial for guiding conservation and management decisions to protect coastal habitats.

Indirect Offset Proposal: Seaweed substrate optimisation (Research Component)

The proposed project seeks to identify optimal substrates to support the settlement, survival, and growth of local macroalgal species as a means to offset the ecological impact of seaweed loss. By fostering macroalgal establishment on artificial marine structures like seawalls, wharves, and breakwaters, this initiative aims to create new habitats that boost biodiversity and ecosystem resilience. Effective substrate selection is essential for successful macroalgal attachment and growth, helping restore lost ecological functions and biomass.

Macroalgae play a vital role in coastal ecosystems, providing habitat, food, and nutrient cycling services. To advance this work, GPC proposes funding a PhD project focused on identifying optimal substrate conditions for maximizing germling settlement and growth in the Gladstone area and the Great Barrier Reef region.

Alignment with broader strategies

These proposed offsets are the first to specifically target seagrass rehabilitation and seaweed habitat creation, utilizing established methodologies and supported by significant investments in research, partnerships (including First Nations, industry, and community stakeholders), and infrastructure. The goal is to achieve a net gain in habitat quality, which will benefit fish, migratory shorebirds, and vulnerable species such as dugongs and green turtles. The proposed offsets also align with the broader strategies and programs for the Great Barrier Reef, including but not limited to the Reef 2050 Plan. Ultimately, these strategies will provide a net benefit to the GBRWHA, for example, through expanding Indigenous land and sea ranger programs to deliver on-ground activities, including compliance, marine monitoring, and species protection and management.

1. INTRODUCTION

The Gladstone Ports Corporation Limited (GPC) has received approval conditions from the Department of Climate Change Energy Environment and Water (DCCEEW) to progress with the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project (CD Project). With this comes a legal obligation to establish seagrass restoration and macroalgal habitat creation as an offset.

The associated reclamation area for receiving the capital dredge from the CD Project, The Northern Land Expansion Project (NLEP) Southern Reclamation Area (SRA) results in the permanent loss of seagrass. Under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999. No. 91 as habitat for a threatened species, the seagrass is afforded protection and triggers *State Planning Policy* 2017(SPP) for plans to 'avoid-mitigate-offset'. Given the impact is permanent, therefore the responsibility for offset implementation is with the approval holder for the duration of the impact.

Moilanen and Kotiaho (2018) identify fundamental operational design decisions for Biodiversity Offsetting, the first of which is the degree of adherence to the mitigation hierarchy. Offsets are considered the fourth option after avoidance, mitigation and local restoration or rehabilitation (Bos et al. 2014, Niner et al. 2017). In this offset strategy, for directly impacted seagrass and macroalgae, the proposed approach is local rehabilitation of seagrass meadows through the enhancement of resilience and the creation of macroalgal beds. While both restoration and rehabilitation aim to improve habitats, restoration typically involves more intensive efforts to return ecosystems to a previous state, while rehabilitation focuses on improving degraded habitats to meet specific objectives without necessarily aiming for full restoration to a previous or natural state, often before it was degraded or altered by human activities. Improvements could include enhancing the habitat by increasing cover and species composition to a healthier state, or increasing the resilience of the habitat to disturbance pressures.

Changes in the condition of seagrass meadows in central Queensland have been primarily linked to flood and storm events (McKenzie et al. 2023)which are becoming increasingly frequent and intense with climate change (Walsh et al. 2002). The proposed approach recognises the limited ability to remove this "*exogenic unmanaged pressure*" (Elliott 2011) through an averted loss approach (i.e. actions taken to prevent or minimize negative impacts on a habitat), and focuses on an adaptive management approach utilising seed-based restoration techniques to facilitate rehabilitation and build resilience for these meadows. Habitat creation through the beneficial reuse of dredge material was explored as an option in 2020, however replacement of an existing habitat through the creation of seagrass would require additional approval and offsets. One exception is the area within 20 m of the existing and new seawall. However, establishing seagrass in these created habitats is extremely novel and requires research which is proposed in this strategy. Restoration of an existing degraded meadow and enhancing the meadows resilience to future disturbance events was identified as the preferred option.

Few offsets have been applied to seagrass restoration due to a lack of large-scale projects demonstrating confidence (Bell et al. 2014). The lack of attempts to address seagrass loss leaves coastal development continuing to diminish seagrass populations, weakening connectivity between meadows and the resilience of the wider metapopulation.

The following three projects are being recommended under this Strategy:

- Direct (Major)Project: Enhancing resilience of degraded seagrass at Pelican Banks (Figure 1);
- Direct Project: Incorporating macroalgal habitat creation into seawall design;
- Indirect/research option: Co-benefits of restoration.

The proposed offsets will take an adaptive management for ecosystem restoration approach. Adaptive management can commence with the early stages of a restoration initiative when scientific and programmatic uncertainties about the ecosystem and restoration process exist.

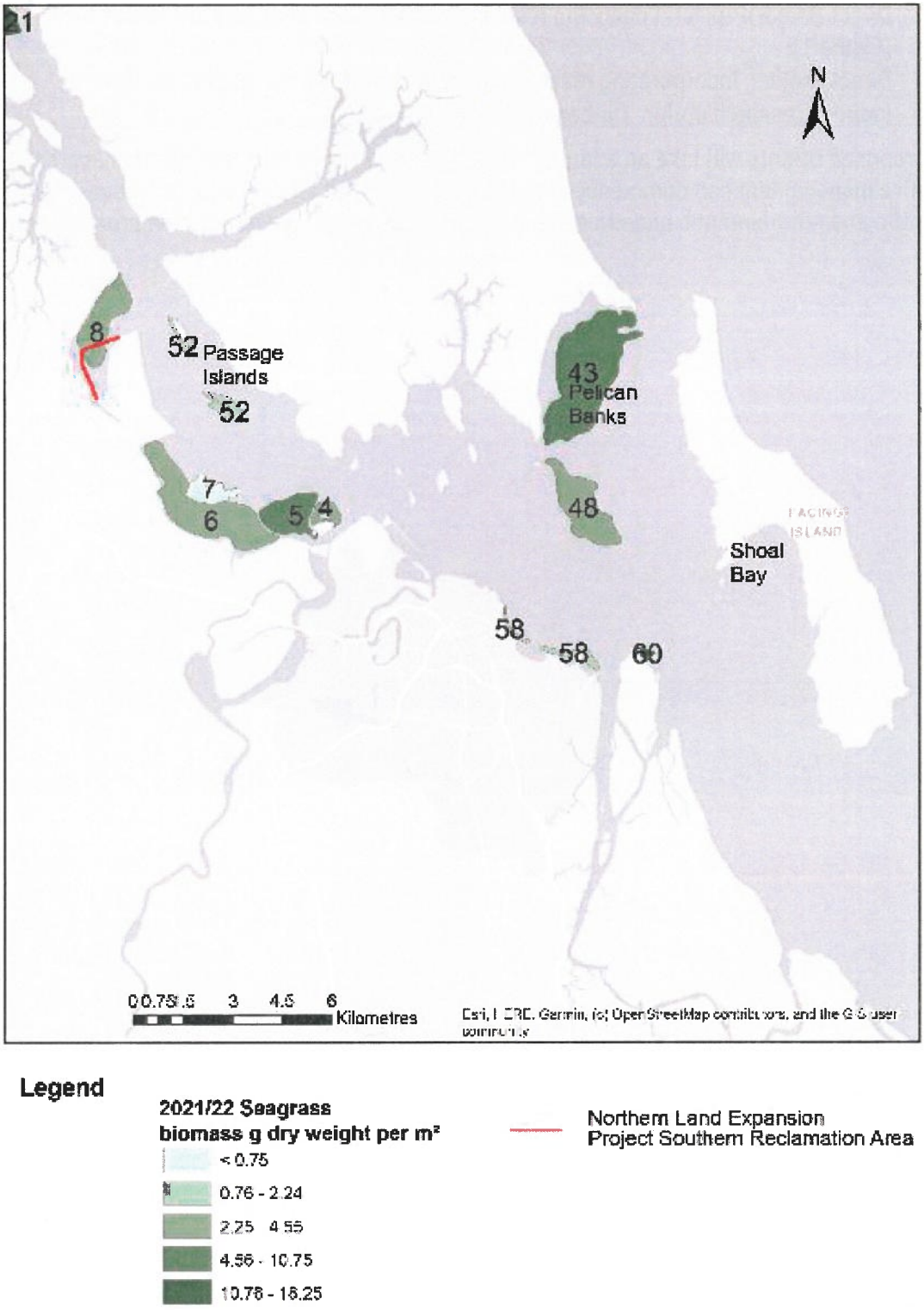

Figure 1 Overview map of the Port of Gladstone area, showing the NLEP and location of Meadow 8 (the impacted site within the NLEP footprint) and Meadow 43, Pelican Banks (the degraded meadow proposed for enhancement). Biomass is from the 2021/22 reporting [Source TropWater and GPC].

1.1. Project background and requirement for Biodiversity Offsets

Seagrasses and macroalgae hold significant importance as foundational species, primarily due to their high productivity and ability to sustain intricate food webs. Additionally, they play a crucial role in enhancing water quality for various marine species and habitats by filtering out nutrients and fine sediments from the water column.

Seagrass is both a matter of state environmental significance (MSES) and a matter of national environmental significance (MNES), contributing to the outstanding universal value (OUV) of the Great Barrier Reef World Heritage Area (GBRWHA). Seagrass is a foraging resource for listed threatened and migratory species under the EPBC Act. Therefore, maintaining or increasing the seagrass biomass directly benefits these species (Marsh et al. 2003). Damage to seagrass or macroalgae is a prescribed environmental matter that is an MSES under State legislation (i.e. subject to assessment under State Code 11 (Removal, destruction or damage of marine plants) of the State Development Assessment Provisions (SDAP) of the *Queensland Planning Act 2016*).

The EPBC Approval (2012/6558) issued for the CD Project has seagrass and macroalgae offsets that require adequate programs and activities addressing the following conditions:

> *To compensate for the significant residual impacts to seagrass and macroalgae within the Project Stage 1 direct impact area (based on survey results undertaken by condition 11a of the EPBC Approval), the approval holder must provide an environmental offset proportionate to the condition and density of seagrass and macroalgae impacted, consistent with the EPBC Act Environmental Offsets Policy. This offset must be in accordance with the approved Project Stage 1 offset Strategy and provided or commenced within 12 months from the date that the Project Stage 1 Offset Strategy is approved in writing by the Minster.*

In the Coordinator-General's evaluation report (July 2020), it was noted that commentators on the draft Environmental Impact Statement (EIS) for the NLEP were concerned that the estimated impact figures provided for seagrass were based on the area of seagrass habitat recorded in the Port of Gladstone during 2017 surveys, which with highly variable seagrass meadows was not representative (Figure 2). GPC revised the estimated impact figures based on the historical distribution of seagrass (i.e. between 2002 and 2018). Based on the revised estimates, in the construction of the NLEP SRA (referred to as the southern WBE reclamation area in the Coordinator-General's evaluation report July 2020), 110.48 ha of seagrass was stated as a Significant Residual Impact (SRI). Under the Environment Protection and Biodiversity Conservation (EPBC) Act, an SRI refers to an adverse effect on matters of national environmental significance that remains after all proposed mitigation measures have been implemented (i.e. permanent loss). This area represents a potential seagrass habitat, an appropriate conservative value for the SRI. The evaluation report notes that the area may be revised following an additional survey before the development application lodgement for marine plant removal, destruction, or damage to inform the project's final SRI and offset obligations.

A significant residual impact report is required in accordance with condition 19c and will be provided post completion of the seagrass and macroalgae monitoring report. This report will inform any requirements for additional offsets for impacts on seagrass or macroalgae as a result of Stage 1, for example if seagrass is impacted by the changes in hydrodynamics directly adjacent to the bund walls, where erosion is likely to occur.

Surveys in 2021 showed that the direct impact of the construction of the Southern Reclamation Area is the destruction of 41.77 ha of seagrass and 0.64 ha of marine algae. More recently, a resurvey of the site in October 2023 estimated that the direct impact included 56.1 ha of Marine Plant, including 55.04 ha of seagrass (*consisting of Zostera muelleri, Halophila ovalis, H. spinulosa and H. decipiens*) and 1.06 ha of marine algae.

It is proposed that, ahead of the development, up to 50 cores (25 cm diameter) of seagrass from the site be salvaged and held as seagrass nursery stock for seed production to preserve some of the population.

Based on the current status (October 2023), a "like for like" offset would be to recover or enhance up to 55.04 ha of Light[1] *Halophila ovalis/decipiens*. Halophila is a colonising species showing rapid turnover and an eventual succession to *Halodule uninervis* and *Zostera muelleri* (as shown by long-term monitoring data for this site, Figure 2). Since the last survey, a perturbation has likely degraded the seagrass at the NLEP SRA site, and recovery has started with *Halophila sp.*. *Halophila* is fast growing and may expand over larger areas, which may account for the increase in area since the previous survey. Still, it is highly ephemeral compared to the more persistent *Zostera muelleri*. Based on the habitat for seagrass at the location, its recovery trajectory, and its previous distribution and composition, a goal to rehabilitate up to 55.04 ha of light to medium cover *Zostera muelleri* would be more appropriate for the SRA NLEP offset (see more in section 2.1.1. and Box 1).

[1] Light: *H. uninervis* <1 g DW.m^{-2}; *Z. muelleri* <20 g DW.m^{-2}; *H. ovalis* <1 g DW.m^{-2}

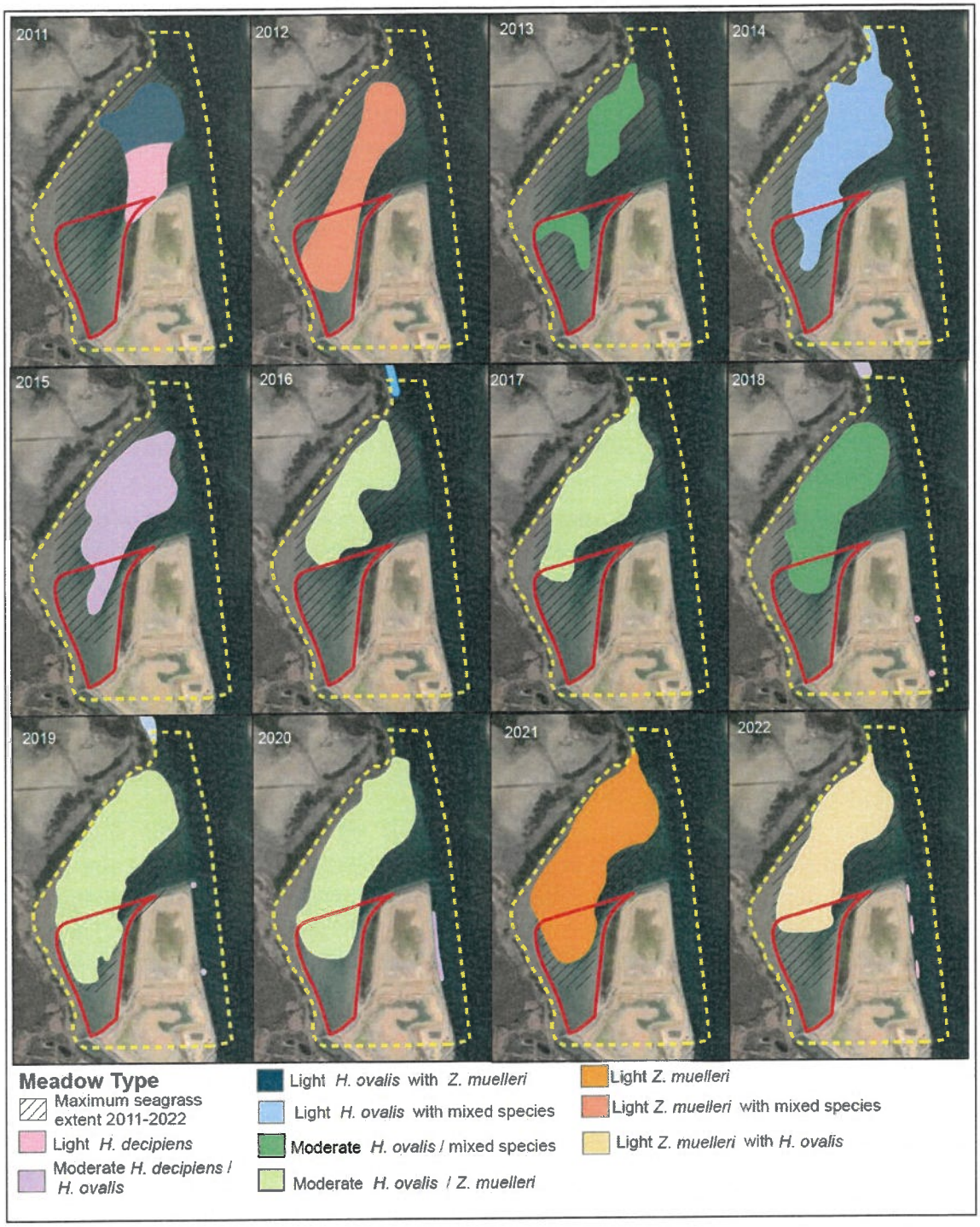

Figure 2 Seagrass meadow area and community composition in Meadow 8 between 2011 - 2022 within the NLEP site (red border). [Source Smith et al., 2022a]

Direct offsets for an SRI may be achieved by creating or improving habitat, reducing threats to the protected matter, increasing the heritage values of a heritage place, or averting the loss of a protected matter or its habitat under threat (Department of Environment and Science 2024). Compensatory measures are defined as indirect benefits (e.g. research funding or capacity

building), and only 10% of the offset may consist of compensatory measures. Therefore, the strategy presented here focuses on creating, restoring, and enhancing seagrass habitat (primarily *Zostera muelleri* subsp. *capricornii*[2] – referred to as *Z. muelleri* here on) and identifies compensatory measures in the form of research activities that will address knowledge gaps for seagrass restoration in the future. In addition, the strategy examines offsets concerning the EPBC Act's offset policy principles. Under these principles, suitable offsets must[3]:

- Deliver an overall conservation outcome that improves or maintains the viability of the protected matter.
- Be in proportion to the level of statutory protection that applies to the protected matter.
- Be of a size and scale proportionate to the residual impacts on the protected matter.
- Effectively account for and manage the risks of the offset failing.
- Be additional to what is already required by law.
- Be efficient, effective, timely, transparent, scientifically robust, and reasonable.
- Have transparent governance arrangements, including measurement, monitoring and enforcement.

The critical component of an offset program is identifying the biodiversity value to be offset, and the primary aim is to achieve "no net loss". For an offset policy to achieve "no net loss" usually requires that the values lost can be restored elsewhere with confidence (Bell et al. 2014). Often, the biodiversity value used in an offset is quantified by the area and condition of a particular habitat type, such as the area, density, or biomass of a seagrass meadow. The condition may also be quantified as a measure of a specific function of a seagrass meadow (e.g. carbon storage, fish habitat provision, foraging grounds for green turtles) (Bell et al. 2014). Therefore, this strategy proposes that seagrass offsets include an option to rehabilitate existing meadows and create new seagrass as part of the NLEP. Despite biodiversity offsets aiming to achieve "no net loss", few offsets have been applied to seagrass restoration due to a lack of large-scale projects demonstrating confidence (Bell et al., 2014; Bos et al.; 2014; May et al., 2017; Niner et al., 2017a; Niner et al. 2017b; Moilanen et al., 2018; Niner et al. 2021). DCCEEW advise that unless an offset is achieved, in full by the time impact occurs, then a loss is inherent until the offset is achieved. Therefore, the offset needs to be proportionally bigger than the impact and also account for the level of confidence in the result. Consequently, we propose reseeding to more than five times the biomass of seagrass impacted (Figure 3).

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[2] *Zostera muelleri* has recently been proposed to be renamed at *Nanozostera capricorni* (Ascherson) Tomlinson & Posluszny, 2001. It is left as *Zostera muelleri* in this document to avoid confusion with assessments of like for like with the offset criteria.

[3] Australian Government, Environment Protection and Biodiversity Conservation Act 1999: Environmental Offsets Policy (Department of Sustainability, Environment, Water, Population and Communities, 2012).

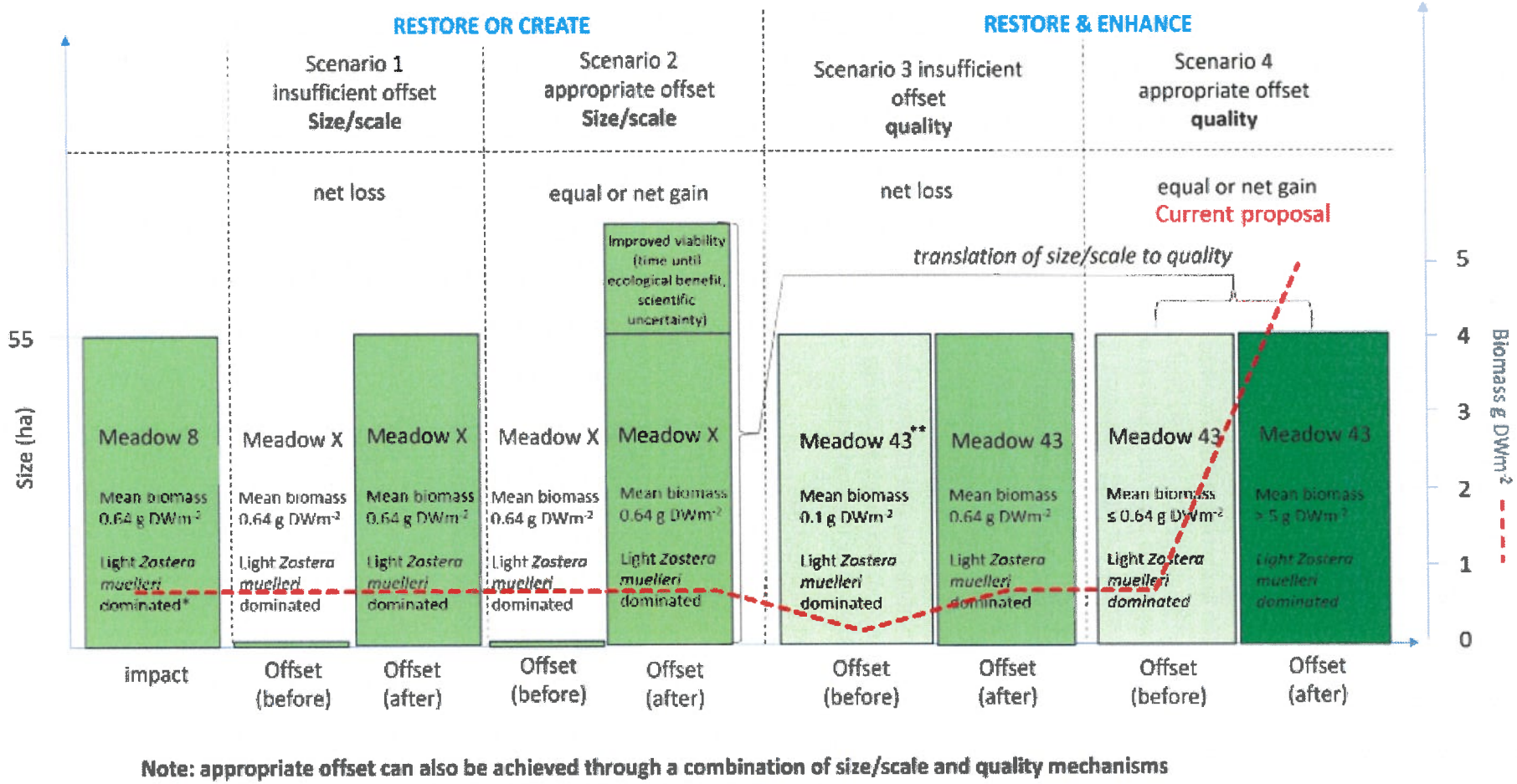


Figure 3 A schematic to illustrate the offset proportionality.

A global survival rate of 37% is estimated for seagrass restoration (van Katwijk et al. 2016), suggesting that the offset effort should aim for an area approximately 2.7 times larger than the area impacted. However, this statistic is averaged across restoration methods, seagrass species and locations. It is therefore proposed that following a review period (5 years), the success rate of the restoration will be assessed, and adjustments to the target area (i.e. increasing the area for rehabilitation and selecting more locations) will be applied where needed. Five years is selected based on the definition of enduring versus transitory meadow. See more details in section 2.1.1.

In addition, the EIS indicates that the construction of the NLEP has the potential to indirectly impact 99.41 ha of seagrass due to changed tidal velocities and subsequent erosion and sedimentation. However, the latter will be reassessed post-construction to determine any potential degradation of seagrass in the predicted indirect area. These determinations will take account of the dynamic nature of the transitory meadows in this location and review potential impact over five years.

1.2. Options considered before the presented strategy

The Environmental Protection and Conservation Act (EPC Act) provides various options for offsetting the loss of seagrass. These offsetting strategies aim to compensate for the environmental impact caused by activities that result in seagrass loss. Options available under the EPC Act to promote conservation gain (the benefit that a direct offset delivers to the protected matter, which maintains or increases its viability or reduces any threats of damage, destruction or extinction) considered by the team were:

1. Habitat Restoration and Enhancement:
    - This involves actively restoring or enhancing seagrass habitats in the impacted area or nearby locations.
    - Restoration efforts may include planting seagrass, improving water quality, or modifying the habitat to encourage natural recovery.
    - This option provides the most ecologically relevant and direct option where possible.
    - Local expertise, knowledgebase and facilities support this option.
2. Creation of Alternative Habitats:
    - Establishing new habitats that can support seagrass or serve as alternative ecosystems.
    - Sites were identified by the team (see section 3.8.1) and are included in the strategy as an alternative to the proposed site; for example, high habitat creation potential exists at Shoal Bay on Facing Island.
    - The creation of a seagrass habitat would result in the replacement of unvegetated mud flat at a site, and advice from DES (now known as DESI) when this was proposed was that the creation of seagrass in an area not previously recorded as seagrass would trigger a further offset.
3. Modifying environmental conditions to enhance the potential success of seagrass re-establishment and persistence.
    - Such interventions could, for example, help enhance substrate stability or create sheltered locations that would improve habitat suitability, promote natural recovery, increase the success of restoration efforts and ultimately increase the resilience of the local seagrass meadows.
    - As part of the feasibility studies for the Port of Gladstone Sustainable Sediment Management (SSM) Project, GPC commissioned a desktop feasibility study into beneficially reusing maintenance dredging sediment for 'Habitat Restoration, Creation

and Enhancement' as described in the Beneficial Reuse Options Assessment of the SMM Project (GHD 2019). The models described can be used in the SSM beneficial reuse feasibility study to identify potential sites where dredged sediment can be added to enhance habitat (slope, depth and sedimentation) for seagrass restoration (Jackson and Millar, 2020).
    - This option requires more large-scale trials to take it beyond proof of concept.
4. Averted Loss
    - Averting the loss of seagrass or seagrass habitats that are threatened and securing their future for conservation purposes.
    - The main driver of seagrass loss in the region is storm and flood events, along with de-vegetation and runoff of fine sediments from the catchment, beyond the management control of GPC.
5. Research and Monitoring Programs:
    - Investing in scientific research and monitoring programs can contribute to a better understanding of seagrass ecosystems, identifying threats, and developing effective conservation strategies.
    - These are incorporated into the strategy.
6. Community Engagement and Education:
    - Engaging local communities in seagrass conservation efforts and promoting awareness and education can be integral to offsetting strategies.
    - Community involvement can enhance the sustainability of seagrass ecosystems and foster long-term conservation efforts.
    - These are incorporated into the proposed strategy.

The choice of offsetting options was taken to align with the principles of ecological sustainability and contribute to the overall conservation goals outlined in the EPBC Act.

1.3. Applying seagrass restoration techniques for Biodiversity Offsets

Success rates for seagrass restoration have been improving over the years (Tan et al. 2020). The improvement is due to considering the most up-to-date research globally on restoration approaches, combined with a comprehensive knowledge of the local conditions and seagrass population dynamics to select the most appropriate intervention.

The lack of prior restoration ecology research at a location often undermines confidence in seagrass restoration under an offset policy. A considerable body of research on the ecology and distribution of local seagrasses within the Port of Gladstone exists, with assessments of sites that would benefit from restoration and methodologies that would support restoration interventions. Critical knowledge required for offsetting seagrass loss at the specific location is available in the Port of Gladstone, including:

- Long-term monitoring data on other meadows in the region to identify meadows in decline lost or those unable to recover naturally(Chartrand et al. 2019, Jackson et al. 2021, Smith et al. 2022a, Smith et al. 2024);
- Comprehensive data on the area of seagrass to be lost and a measure of its quality, e.g. density, biomass(Smith et al. 2022a, Smith et al. 2024);
- The connectivity between meadows is linked to recovery potential and identifying important sinks and sources in the population (Jackson et al. 2021, Aiken et al. 2022);

- Reproductive effort of different populations and local phenology (Bryant et al. 2016, Andrews et al. 2022, Lekammudiyanse et al. 2023);
- Data on the risk of disturbance of other meadows (including the potential for bi-stability);
- Ecosystem function of different meadows and the services provided (Connolly et al. 2006); and
- Restoration considerations and methodologies developed for the local conditions and ecosystems (Jackson et al. 2018a, Jackson et al. 2018b, Jackson and Irving 2018, Jackson et al. 2021, Aiken et al. 2022, Andrews et al. 2022, Lekammudiyanse et al. 2023, Tan et al. 2023).

Improving seagrass resilience can be a critical goal of seagrass restoration activities. Seagrass resilience refers to the ability of seagrass ecosystems to recover from disturbances and maintain their ecological functions over time. Restoring degraded or damaged seagrass habitats can help seagrass ecosystems become more resilient to future disturbances.

Seagrass meadows are often intrinsically patchy. The temporal delineation of patch configurations within a seascape is explicitly related to the disturbance regime (frequency, severity and predictability) and temporal variability in colonisation, competition and dieback (Jackson et al. 2017). Intertidal, sub-tropical seagrass meadows in a macro-tidal system are prone to high natural and (where relevant) anthropogenic disturbance. At its simplest, fragmentation is observed as a reduction in the area of seagrass cover, a decrease in patch size and an increase in the distance between patches (decreased connectivity). Seagrass loss often occurs through gradual fragmentation to a critical threshold, which causes large meadows to collapse quickly, releasing trapped carbon and fine sediments (Fonseca and Bell 1998, Jackson et al. 2017). Waiting until this collapse occurs to intervene is often too late, and reversing the fragmentation of large intertidal meadows with traditional methods such as core transplants to restore fragmented meadows (Ferretto et al. 2021) is not economically viable and can greatly disturb donor meadows when working at scale. Smart sowing of seagrass seeds to fill gaps in the meadow where the habitat is still suitable and getting the seeds there quickly and accurately can overcome this challenge, creating more robust and more resilient seagrass habitats (Livernois et al. 2017). Fonseca and Bell's (1998) results suggest that seagrass landscape contiguity, and not just the typical seagrass metrics such as biomass, shoot density, and canopy height, may be an appropriate measurement of vegetation persistence.

The predominant concern is that loss of seagrass may reduce the species diversity of associated fish and benthic invertebrate fauna. One of the main reasons for this prediction is based upon the general principle that species diversity is higher in seagrass compared with adjacent bare sand habitats (e.g. Arrivillaga and Baltz (1999), but see Jackson et al. (2002)). Improving the persistence of seagrass and reducing fragmentation through resowing can benefit many ecosystem services and OUVs of the Great Barrier Reef (GBR).

2. BASELINE DATA ON THE SEAGRASS MEADOWS AND MACGROALGAE IN THE PORT OF GLADSTONE

There is good historical data for both the impacted site, the proposed enhancement site and the wider seagrass population in the region. Seagrass meadows were first comprehensively surveyed in the Port of Gladstone in 1992 during the Department of Agriculture and Fisheries state-wide

seagrass surveys (Coles et al. 1992). Ongoing seagrass monitoring and mapping in the Port of Gladstone dates back to 1994 at some locations (Houston 1995, Walker and Houston 1996, Lewis et al. 1999, Small et al. 2000), with more standardised methodologies and annual monitoring dating back to 2002 (Chartrand et al. 2018, Chartrand et al. 2019, Smith et al. 2021). As a long-term monitoring programme, the Port of Gladstone seagrass record represents a unique and essential dataset and an example of commitment to managing this vital ecosystem. Such data allows for assessing current distribution (realised niche) concerning historical distribution and potentially unoccupied habitat (fundamental niche). The temporal data also provide information on the likelihood and attributes of recovery of individual meadows after perturbation.

The long-term mapping and monitoring record shows that in the Port of Gladstone and its surrounds, there are over 100 distinct seagrass meadows, which occur across a range of environmental gradients and vary in terms of configuration (patch size, species composition), environment (depth, wave and current exposure, turbidity) and disturbance pressures. Landscapes include multi-specific and mono-specific stands of seagrass from five different species: *H. spinulosa*, *H. ovalis*, *H. decipiens*, *Halodule uninervis* (narrow and broad-leaved forms) and *Z. muelleri*, of varying densities and configurations. Seagrasses in the Port are of regional significance, as they are the only significant stands between Shoalwater Bay and Hervey Bay (by more than 170 km). The Port of Gladstone and Rodds Bay lie within a Dugong Protection Area (declared in 1996). The Port of Gladstone seagrasses also contribute to the OUV of the GBRWHA, which is rated as providing a moderate local contribution based on the local expression of the OUV methodology (Adaptive Strategies et al. 2016). Meaning that "*The attribute occurs in moderate abundance or across a moderately large area but is not the prime occurrence or representation of the attribute within the GBRWHA. The attribute does however represent a feature for which the GBR was listed as World Heritage.*" (Sheppard et al. 2007, Aurecon 2017)

Methodologies for monitoring and scoring the health of the seagrass meadows in Gladstone were developed by the Queensland Department of Agriculture and Fisheries and the Department of Employment, Economic Development and Innovation and are widely used across Queensland and as established long-term indicators in the State, Federally and partner funded Gladstone Healthy Harbour Partnership's Annual Report Card.

Characteristics of seagrass at the NLEP SRA and Proposed Offset site are summarised in Table 1 and detailed in sections 2.1.1. and 3.2.1.

Table 1 Site characteristics of seagrass at the NLEP SRA and Proposed Offset site NLEP SRA

Attribute	Meadow 8 impacted site NLEP SRA (based on data from October 2023)	Meadow 43 current state (whole meadow average) (based on data from October 2023)	Meadow 43 proposed enhancement area 55 ha current status	Meadow 43 proposed enhancement area 55 ha enhancement following offset
Area	55.04 ± 1.78	632 ha	55 ha	55 ha
Biomass	0.64 ± 1.84 g DW. m^{-2} (estimated based on 22 ha <0.1 g DW m^{-2}, 33 ha between 0.1 and 5 g DW m^{-2} (Smith et al. 2024)	Average is 19 g DW. m^{-2} however there are degraded sections within the meadow where the biomass is <1 g DWm^{-2}.	≤ 0.64 g DWm^{-2}	≥ 5 g DWm^{-2}
Species composition (in order of dominance)*	*Halophila ovalis, Halophila decipiens, Halophila spinulosa, Zostera muelleri*	*Z. muelleri, Halodule uninervis and Halodule ovalis*	*Halophila ovalis, Halodule uninervis, Zostera muelleri*	*Z. muelleri, Halodule uninervis and Halodule ovalis*
Landscape contiguity	*Isolated patches*	*Aggregated patches*	*Isolated patches*	*Aggregated patches*
Meadow type	*Enduring*	*Enduring*	*Transitory*	*Enduring*
Connectivity	*Propagule source*	*Propagule source*	*Propagule source*	*Propagule source*
Dugong carrying capacity and In vitro dry matter digestibility (IVDMD)**	*1 dugong yr^{-1}* *67 IVDMD*	*102 dugong yr^{-1}* *71 IVDMD*	*0 dugong yr^{-1}* *71 IVDMD*	*2 dugong yr^{-1}* *71 IVDMD*
Green turtle carrying capacity	*69 green turtle yr^{-1}*	*263 green turtle yr^{-1}*	*14 green turtle yr^{-1}*	*114 green turtle yr^{-1}*

* *Halophila* is a colonising species showing rapid turnover and an eventual succession to *Halodule uninervis* and *Zostera muelleri* (as shown by long-term monitoring data for these sites)
** Dugong feeding behaviour is theorised to follow an optimal foraging strategy, in dugong select sites based on the maximum energy gained with minimal energy expended, i.e. areas with higher biomass of more digestible and nutrient rich species of seagrass

Characteristics of macroalgae at the NLEP SRA and Proposed Offset site are summarised in Table 2 and detailed in sections 2.1.2. and 4.

Table 2 Site characteristics of macroalgae at the NLEP SRA and Proposed Offset site NLEP SRA.

Attribute	Impacted site NLEP SRA	NLEP SRA bund wall macroalgae enhancement area current status	NLEP SRA bund wall macroalgae enhancement area following offset
Area	1.06 ha	0 ha	1.1 ha
Cover	<10 (11 out of 14 sites <5 % cover)	0	90% of the area with 5 % cover 10% of area with 40% cover
Species composition (in order of dominance)*	Filamentous; Turfing algae and Erect macroalgae on bunded wall.	None – not yet constructed	Filamentous algae; Turfing algae and Erect macroalgae on bunded wall.

2.1. Northern Land Expansion Project Southern Reclamation Area Site Habitat Quality

2.1.1. Seagrass

The seagrass meadow at the NLEP SRA site (Meadow 8) has been monitored since 2002 (Figure 2). Figure 2 illustrates the changes in the meadow area, biomass and species composition at Meadow 8 and indicates the changes in health scoring based on these measures relative to a site-specific baseline[4]. It is important to note that despite the low biomass, it has been classed as very good in the last seven years compared to the baseline of what would be expected at the site.

The seagrass area at Meadow 8 peaked in 2009, when the entire footprint of the NLEP was mapped as seagrass (Thomas et al. 2010), light *Zostera muelleri* in aggregated patches with mixed species of *Halophila*. The area has gradually increased since a significant disturbance in 2011 related to large-scale flooding concurrent with large-scale coastal development. Species composition also changes over time at the site. It indicates that the meadow shows species succession, with *Z. muelleri* dominating during periods of low disturbance when the biomass and area are suitable. After a disturbance event, less persistent species, such as the *Halophila*, dominate. Therefore, the site should be classified as a *Z. muelleri*-dominated meadow for offsets.

Based on the 2019 maps of seagrass distribution (meadow 8, Carter et al., 2019), the NLEP construction footprint would result in loss of intertidal, moderate density, isolated patches of *H. ovalis* with *Z. muelleri*. (Figure 2). Historically, the site has also been a suitable habitat for

[4] Baselines are set for monitoring purposes for GPC and are used in the Gladstone Healthy Harbour Report Card calculations, reviewed by an Independent Science Panel (Gladstone Healthy Harbour Partnership 2023). A condition index was developed for seagrass monitoring meadows based on changes in mean above ground biomass, total meadow area and species composition relative to a 10 year baseline. Baseline species composition is the composition of stable state species (i.e. *Zostera muelleri*) to mean meadow biomass. More details can be found in (Smith et al. 2022a)

Halophila spinulosa. In 2020, surveys of seagrass and macroalgae impacted by the NLEP found isolated patches of *H.ovalis* and *H. decipiens,* and approximately 41.77 ± 1.28 ha of Meadow 8 lay within the proposed NLEP SRA boundary.

In 2020, the biomass at the site was classed as good (1.77 ± 0.32 g DW m^{-2}), although significant areas were mapped as less than 0.1 g DW m-2 for the footprint area. *Z, muelleri* comprised 43% of seagrass biomass, showing that this site recovered from the 2010-12 La Niña event. The maps from 2021 identify the site of the proposed project as the community type "Light *Zostera muelleri* " (Smith et al. 2022a), with an impacted area of 39 ha (Figure 2).

Mapping carried out by TropWater in October 2022 (Smith et al. 2022b) found that the impacted area had declined to 19.36 ± 0.60 ha of seagrass that consisted of very low biomass *H. decipiens* (< 0.01 g DW m^{-2}). *Z. muelleri* still dominated the rest of Meadow 8 with an average of 1.68 ± 0.47 g DW m^{-2}.

The latest surveys (Smith et al., 2024) found that 55.04 ± 1.78 ha of Meadow 8 lies within the NLEP SRA footprint. Seagrass within the NLEP SRA has increased since recent surveys in January 2023 (22.63 ha) and October 2022 (19.36 ha) but is similar to the survey in 2020 (41.77 ha). Seagrass in the NLEP SRA comprised isolated patches of low-biomass *H. ovalis* and *H. decipiens*. Biomass within the NELP SRA section of meadow 8 was 0.64 ± 0.18 DW $m^{-2,}$ which is lower than the overall biomass in Meadow 8 (Figure 4), with 22 ha of the area having <0.1 g DW m^{-2}. All five surveys found that seagrass within the NLEP SRA was very patchy and had low biomass (< 5 g DW.m^{-2})(see Figure 5).

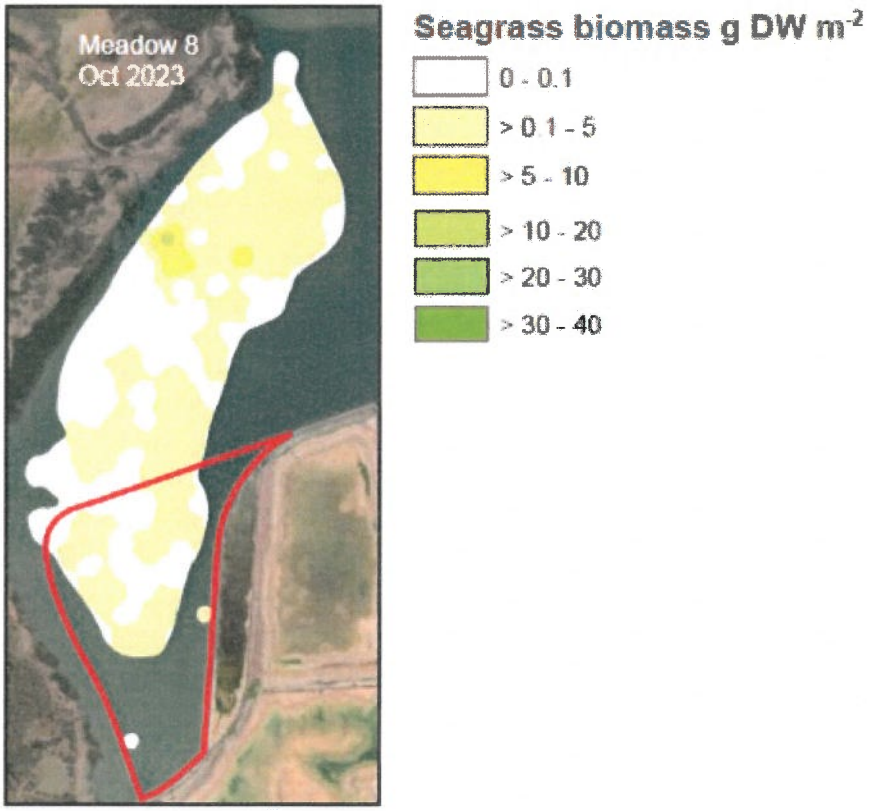


Figure 4 ***Seagrass biomass distribution across Meadow 8 in October 2023. [Source: Smith et al., 2024]***

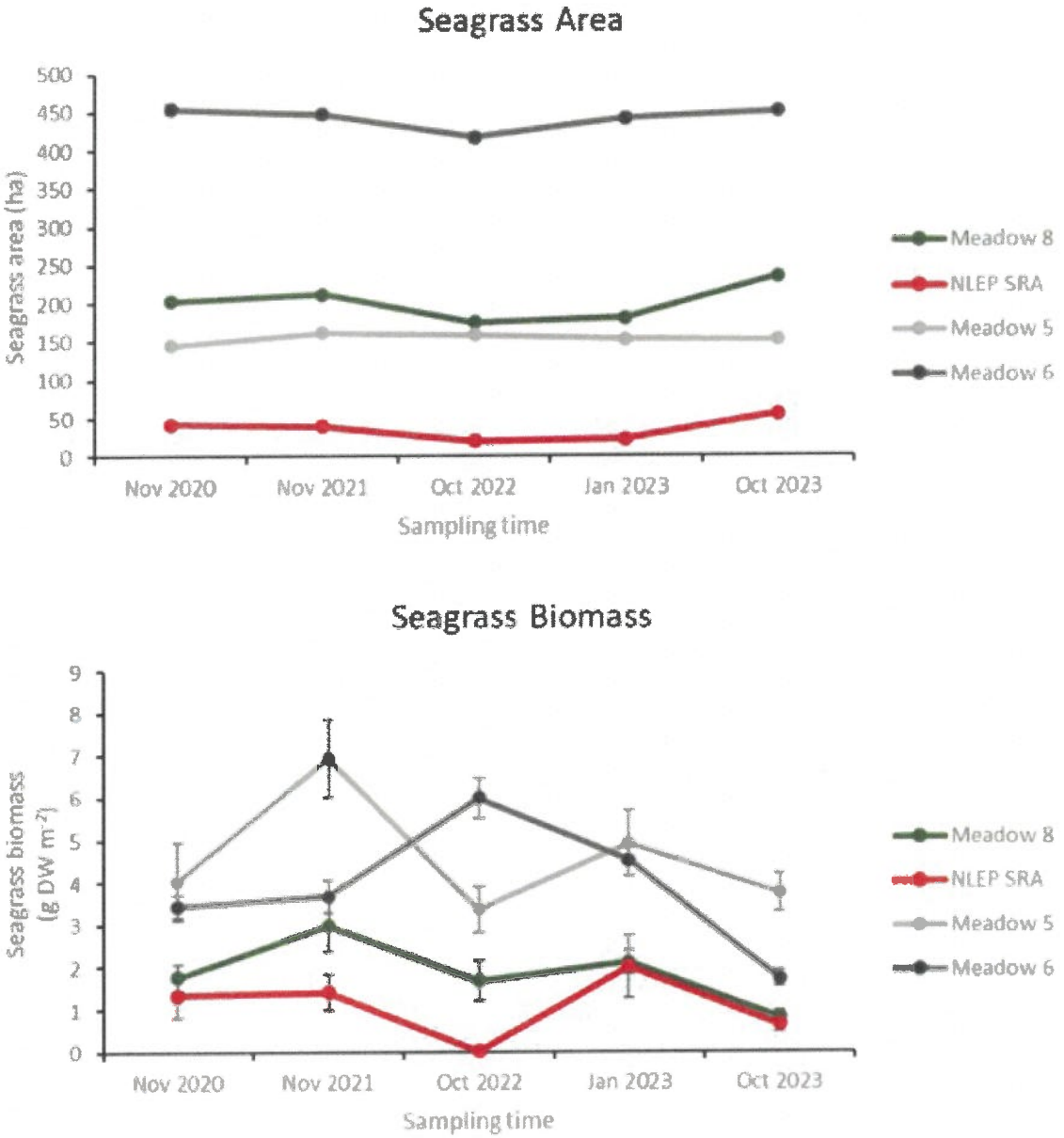


Figure 5 ***Variation in mean seagrass biomass (± SE) and area at Meadow 8, the NLEP SRA within Meadow 8 and reference Meadows 5 and 6 in November 2020, 2021, October 2022, January 2023 and October 2023.***

Like many tropical and sub-tropical areas, the meadows in the Port of Gladstone are a mix of enduring and transitory meadows, with opportunistic and colonising seagrass species dominating (Kilminster et al. 2015). Enduring meadows persist over time, even though they may fluctuate in biomass or area. Transitory meadows are not persistent and may have periods without seagrass. Enduring and transitory meadows can show temporal variations in species composition and abundance. Transitory meadows may endure for several years if the disturbances are infrequent or recovery is quick (Aiken et al. 2022). As the meadow can fluctuate between transitory to enduring, its form must be defined at an appropriate timescale, with an enduring meadow, or part thereof, being one that has been present for five years or more under

natural conditions (Kilminster et al. 2015), an important consideration and the reason the first review period for the offsets are proposed as five years. The long-term mapping of seagrass in the Port of Gladstone allows these definitions to be applied and used for management, including offsets described below in the context of the meadows in question. Surveys show that the seagrass meadow at the NLEP site (Meadow 8) has been present for more than five years and, therefore, can be defined as enduring (Table 1). Still, it has shown significant variability over the last 20 years (Figure 6).

In summary, the proposed target for direct offset, based on the quantity and quality of seagrass, would be to enhance 55.04 ha (55 ha) of intertidal *Z. muelleri* with mixed species at a biomass of >5 g DW.m^{-2} (which would represent a five-fold increase in biomass – net gain) (Table 1).

A key component to successful ecological restoration is understanding levels of connectivity between restoration locations and neighbouring seagrass populations that promote natural recovery (source and sink populations), identifying potential donor populations, and assessing the genetic diversity of restored meadows and material used for restoration. Jackson et al. (2021) undertook a genetic analysis of 352 individuals from 13 seagrass populations across the Port of Gladstone and Rodds Bay using 11 polymorphic microsatellite loci to inform seagrass restoration activities by i) understanding levels of genetic and genotypic diversity within meadows, and ii) understanding genetic structure and patterns of connectivity among these meadows to determine which source sites may be most appropriate to assist recovery of potential restoration sites. The study identified high genotypic diversity within the locations studied, indicating that sexual reproduction is vital in maintaining regional populations. It also detected significant genetic structuring among sites with a Bayesian structure analysis identifying genetic clusters largely conformed to a northern, central, and southern region. Limited gene flow between areas suggests that restoration material should be sourced locally where possible.

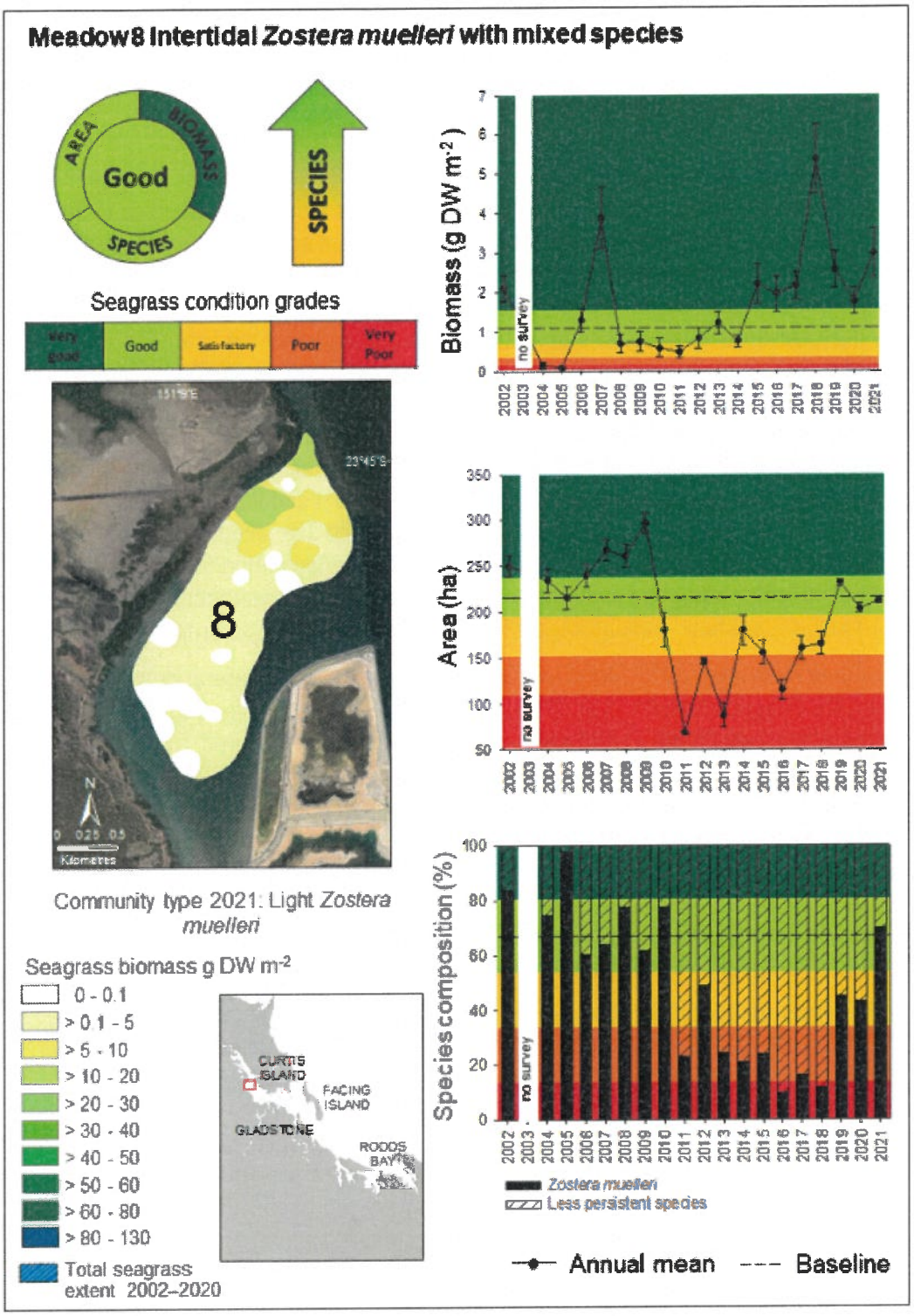


Figure 6 Changes in meadow area, biomass and species composition for Meadow 8, NLEP SRA, 2002–2021 (biomass error bars = SE; area error bars = "R" reliability estimate) [Source: Smith et al., 2022].

Dispersal modelling suggests that there is likely to be high seed retention at Meadow 8 and that although there is minimal immigration of seeds, the location does act as a potential source of

propagules (fragments and seeds) to other seagrass meadows in the harbour (Jackson et al. 2021). This suggests that efforts to incorporate seagrass (*H. ovalis* and *Z. muelleri*) into living seawall designs (see Research Proposal), whilst experimental and unlikely to result in large areas of meadow, could be advantageous in terms of connectivity.

2.1.2. Macroalgae

In addition to the seagrass, in March 2022, 0.64 ha of filamentous algae was observed in the NLEP SRA footprint (Figure 7). Similar filamentous algae (identified as *Ectocarpus* sp. by the Coastal Marine Ecosystems Research Centre CMERC) are observed ephemerally on most other seagrass meadows and mud banks in the harbour, including the target site at Pelican Banks, often resulting from elevated nutrients and occurring as a natural part of the seagrass ecosystem. Erect macroalgae (primarily *Sargassum* sp.) is found within the footprint but mostly attached to rocks associated with the existing bund wall and rock barriers placed to reduce erosion scars from water draining the bunded area. *Sargassum* sp. and *Asparagopsis taxiformis* are abundant across the Port, with significant patches around the marina, Fisherman's Landing, Tide Island (-23.8026°,151.2272°), Rat Island (-23.7636°, 151.315°) and Farmer's Reef (-23.772786°, 151.318953°). They can cope with low light levels and also occur on degraded coral reef at Seal Rocks and Manning Reef. Sargassum peaks in abundance during the summer months and dies back to hold fasts during the summer (Vuki and Price 1994). *Asparagopsis taxiformis* is found all year round in Gladstone and can cope with low light levels (Rula, in prep).

Surveys of the site in November 2022 found small areas of low-cover ephemeral brown macro-algae throughout the seagrass (Smith et al. 2022b) Meadow 8. They extended past the meadow boundary in some areas (see Figure 7). Ephemeral brown macro-algae covered 1.79 ha within the NLEP SRA, taking the combined area of seagrass and algae within the NLEP SRA to 21.15 ± 0.43 ha. CMERC has been examining *Sargassum* seasonality in the harbour (only one year of observations). Species vary, but they are similar to the patterns observed and reported on for Magnetic Island (Martin-Smith 1993), with biomass peaking in summer, followed by tissue breakdown and dying back to the holdfast after reproduction. Therefore, it is possible that surveys in March and November are not monitoring peak cover for this macroalgae.

The most recent surveys of the site in October 2023 recorded macroalgae throughout Meadow 8 and the NLEP SRA footprint (Smith et al. 2024). Filamentous algae was the most common algae recorded (41 sites) and found in the meadow's northern part and along the eastern edge (Figure 6). Filamentous algae in the meadow had low (<5%) cover. Macroalgae consisted of erect macrophytes and were recorded at 14 sites along the eastern side of the meadow and the bund wall. The macroalgal cover was less than 5% at all sites except three sites, ranging from 10-40% at the bund wall and northern tip of the meadow (Figure 7). Turfing algae was found at six sites with less than 5% cover. The number of sites where algae were recorded was much more significant in October 2023 than in January 2023 but was similar to surveys in 2020 and 2022 (Figure 7).

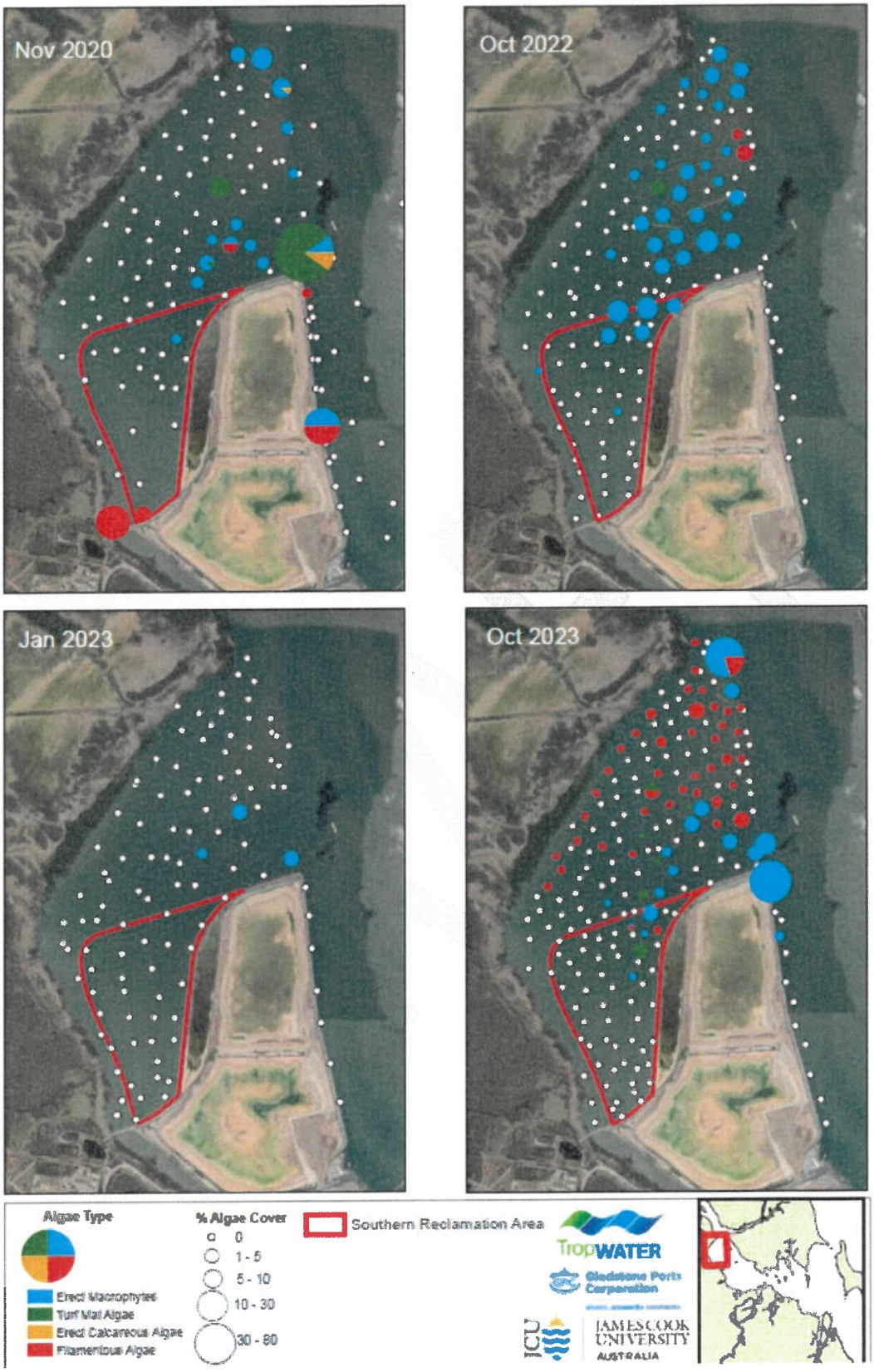


Figure 7 Percentage and type of macroalgae cover in the NLEP SRA in November 2020, October 2022 and January and October 2023. [Source: Smith et al. (2024)]

Within the tropics and subtropics, *Sargassum* is regarded as the most structurally dominant and, therefore, conspicuous macroalgae, where it plays critical ecological roles in primary production and nutrient absorption, stabilising water quality including temperature, pH, dissolved oxygen, water flow and seabed Photosynthetically active radiation (Yeh et al. 2020). *Sargassum* also provides valuable nursery and spawning areas and habitation for many marine species (Huisman 2019).

There are 359 species of *Sargassum* currently accepted, of which 39 occur in Queensland waters (Guiry and Guiry 2022). Literature on Central Queensland marine botany is scarce, and the species-rich genus *Sargassum* is under constant taxonomy revision. Based on morphology alone, the Port of Gladstone seems home to at least four to five species of *Sargassum* (Figure 8). DNA barcoding of *Sargassum* by (Costa et al. 2022) revealed the presence of *Sargassum illicifolim* and species in a group identifying as *Sargassum vachellianum*, but also as *Sargassum spinuligerum* from Tide Island. One species (sampled from Rat Island) that could not unequivocally be identified was most closely related to a specimen identified as Sargassum polycystum from China and a *Sargassum quinhonense* from Vietnam (Dai 2002) but was genetically separate from other samples labelled as *Sargassum polycystum*.

Asparagopsis taxiformis inhabits tropical, subtropical, and warm-temperate waters and is widely distributed in the Great Barrier Reef (GBR) lagoon. It has a unique triphasic, heteromorphic life cycle, alternating between haploid gametophyte and diploid carposporophyte and tetrasporophyte stages. The red algae Asparagopsis is commercially valuable due to its secondary metabolites, which are effective as livestock feed supplements to reduce methane emissions, which has led to extensive study of this species, including local research on its phenology and cultivation relevant to restoration.

The justification for focussing on *Sargassum* and *Asparagopsis* for the offset is that the *Ectocarpus* occurs primarily as an ephemeral filamentous alga and either as a drift algae on mudflats or even epiphytic on seagrasses, coral and other algae (including *Sargassum*). In some cases, filamentous brown algae can impact the health of these structural species through smothering and biological oxygen demand as it degrades. Benthic *Sargassum* species are structurally complex, creating a refuge for an array of marine organisms, creating an important fish habitat and having a good nutrient uptake capacity (Hoang Cong 2016). *Asparagopsis* is increasingly cultivated for bioremediation, given its high capacity to biofilter dissolved inorganic nitrogen, especially ammonia (Mata et al. 2010).

Figure 8. Morphologically distinct Sargassum species occurring in the Port of Gladstone: Sargassum illicifolim *(a),* S. sp. B *(b),* S. sp. C *(c) and* S. sp. D *(d).*

In summary, it is proposed that a suitable offset providing net gain in macroalgae will be to create 1.1 ha of macroalgal habitat adjacent to and on the newly constructed bund wall for the NLEP SRA. 90% of the area (1 ha) created will have at least 5 % cover, and 10% of the area (0.1 ha) will have 40% cover. The focus will be on erect macroalgae due to the ephemeral nature of filamentous algae and its association with poor water quality (see summary in Table 2).

2.1.3. Megafauna associations

Dugong

Dugong (*Dugong dugon* (Müller, 1776) Palmer, 1895) surveys are carried out in Gladstone Harbour, and data is available for Meadow 43 (Rasheed et al. 2017b, Cleguer et al. 2023). Surveys do not extend to the NLEP SRA site due to the low seagrass biomass and higher water turbidity, which prevents aerial surveys. Satellite tagging of dugongs was also conducted opportunistically as part of the Gladstone Ecosystem Research and Monitoring Plan (ERMP). Only two dugongs were tagged. One of the tagged animals spent its time moving between Pelican Banks (Meadow 43, South Trees and Wiggins Island) but did not move up into Meadow 8. The other dugong tagged in 2015 moved out of the Gladstone area, north to Shoalwater Bay (Cleguer et al. 2015). There is currently no record of dugong feeding trails at the impacted site. Therefore, one dugong feeding trail observed within the enhanced site would indicate greater usage relative to the impacted site.

However, dugong populations are closely related to seagrass biomass and composition. Sheppard et al. (2007) found that seagrass biomass was the most important factor determining dugong feeding patterns in tropical north Queensland. Dugong feeding behaviour is theorised to follow an optimal foraging strategy in that dugong-select sites based on the maximum energy gained with minimal energy expended, i.e. areas with higher biomass of more digestible and nutrient-rich species of seagrass (Preen 1992, Aragones et al. 2006, Sheppard et al. 2007, Tol et al. 2016). Intertidal seagrass meadows with species of high available nitrogen are likely to be the preferred feeding grounds (Preen, 1998; Sheppard et al., 2010)

The nutritional quality of seagrass also varies between species for Dugong. Based on digestibility and nutrient content, Sheppard et al. (2017) rank *Zostera muelleri* and *Halodule uninervis* more highly than the *Halophila* species, which currently dominate at Meadow 8. *Halophila spinulosa* has

long been identified as the most fibrous and least digestible seagrass (Lanyon 1991). According to Sheppard et al. (2017), whether dugongs are energy or nitrogen-limited, *Z. muelleri or H. ovalis* will be the most nutritional seagrass after *H. uninervis*.

The latest survey mapping shows that 22 ha of the 55 ha identified as seagrass in the NLEP SRA footprint is <0.1 g DW m^{-2} (Smith et al. 2024), with the rest (33 ha) between 0.1 and 5 g DW m^{-2}. Based on this, we estimate the total biomass of the seagrass within the impacted site to be less than 1672 kg DW. According to Preen (1992), a dugong's average daily seagrass dietary intake was estimated at 3.22 kg dry weight. It is assumed that the carrying capacity of a seagrass pasture to sustain a dugong population follows a linear relationship with its biomass (Sheppard et al. 2007), in which case the NLEP SRA impacted area of Meadow 8 has the potential to support one dugong per year (rounded down from 1.4), assuming the dugong consumes 3.22 kg of dry weight per day over a year, based on peak biomass and therefore not accounting for gain in seagrass biomass over the year (Table 1). Using the same calculation, enhancing an equivalent seagrass area at Pelican Banks (Meadow 43) to a higher biomass with *Zostera muelleri* is estimated to provide sufficient seagrass (total 2750 kg) to support two dugongs per year. The site is a well-used dugong feeding area.

Green Turtle

Green turtles (*Chelonia mydas* (Linnaeus, 1758) play a significant role as grazers within their foraging environments, primarily consuming seagrass and algae. Green turtles demonstrate a broad foraging behaviour, exploiting diverse tidal and subtidal benthic habitats such as sandflats, mudflats, coral reefs, rocky reefs, and mangroves. Within these habitats, their diet comprises not only seagrass and algae but also includes mangrove fruits and leaves, along with certain soft-bodied invertebrates (Read 1991, Forbes 1996, FitzSimmons and Coffee 2020).

In 2015, a four-year study was initiated to increase the understanding of the green turtle population in Port Curtis (Queensland Department of Environment and Heritage Protection (EHP) and Gladstone Ports Corporation). The study focused on Pelican Banks, the entrance to the Boyne River estuary, the Western Basin and The Narrows. However, after the first year (2016), sampling was discontinued in The Narrows and Western Basin due to water clarity not being sufficient to capture turtles by the turtle rodeo method consistently, and the habitat was not conducive to effective capture using blocking nests (FitzSimmons and Coffee 2020). Despite conducting several days of boat-based searches around the perimeter of the Western Basin during the 2016 field trips, no areas with a significant concentration of turtles were found west of Wiggins Island (FitzSimmons and Coffee 2020) in the vicinity of the NLEP SRA. In contrast, turtles are regularly observed in the Pelican Banks region, demonstrating the value of the proposed offset site for turtle foraging (Figure 9).

Across the study sites sampled from 2016 to 2019, most turtles were captured on the Pelican Banks, accounting for 42.8% of the total captures (n = 674) (FitzSimmons and Coffee 2020). During the study, recaptured turtles showed a 96.9% fidelity to a particular foraging site across study years.

a) b)

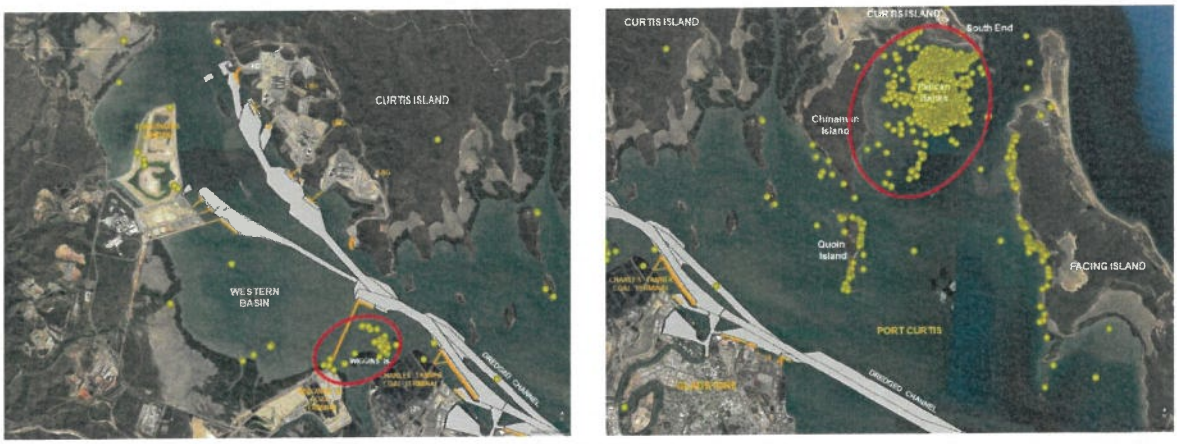


Figure 9 Distribution of captures of Green turtles, Chelonia mydas, within Port Curtis during 2010-2019. a) Western Basin and Wiggins Island; b) Pelican Banks, western Facing Island and Quoin Island [Source: FitzSimmons and Coffee (2020)]

Green turtle diets have been studied in Port Curtis; for example, Prior et al. (2016) used an analysis of "last-bite" food items in 47 turtles at Pelican Banks and 12 turtles at Wiggins Island to show a substantial difference between turtles at the two sites, with their diets dominated by seagrass and red algae respectively, based on the relative mass. FitzSimmons and Coffee (2020) sampled the diets of Green turtles at nine sites in the Port Curtis area from 2015 – 2019 (Pelican Banks, Chinaman Island (western bank), Facing Island, Quoin Island, The Narrows, Wiggins Island, the mouth of the Boyne River, South Trees, and Wild Cattle Island). Stomach contents were sampled, and an index of relative importance (IRI) was calculated, which combined the frequency of occurrence and the relative food volume. Based on an IRI of >30%, important food items at the sites of interest for this strategy were *Z. muelleri* at Pelican Banks, the red algae *Catenella nipae* at The Narrows.

The proposed offset strategy aims to increase macroalgal cover in the Western Basin Region (seawalls of the NLEP) and seagrass cover in the Pelican Banks area, supporting this differentiation in turtle population diets. It is noted that turtles were observed to switch their diets.

FitzSimmons and Coffee (2020) noted that different species of seagrass varied in their provision of gross energy to turtles (9.6 KJ/g) in comparison to *Z. muelleri*, (22.1 KJ/g) *Halodule uninervis* (20.6 KJ/g) and *Halophila ovalis* (18.4 KJ/g). Studies have shown that Green Turtles ingest small amounts daily (0.24–0.33% of body mass, dry weight to wet weight) (Hadjichristophorou and Grove 1983); therefore, a 20 kg green turtle would consume between 44 and 66 g DW seagrass day^{-1}. If it is again assumed that the carrying capacity of a seagrass pasture to sustain a turtle population follows a linear relationship with its biomass, the NLEP SRA impacted area of Meadow 8 has the potential to support 69 turtles per year, assuming the average turtle weight of 20kg, consuming 66 g of dry weight per day over a year, and not accounting for gain in seagrass biomass over the year (Table 1). The proposed seagrass offset would support an estimated 114 turtles (Table 1).

Dolphin

The Australian humpback (*Sousa sahulensis*) and snubfin dolphins (*Orcaella heinsohni*) were recently identified as new species native to the coastal waters of northern Australia and southern

New Guinea. Both species are currently classified as "Vulnerable" on the International Union for Conservation of Nature (IUCN) Red List. They are listed as "cetacean" and "migratory species" under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) in Australia. Their designation as "migratory species" also categorizes them as "Matters of National Environmental Significance". Furthermore, both species are listed as "Vulnerable" under Queensland's Nature Conservation Act 1992. In the Great Barrier Reef Marine Park, humpback and snubfin dolphins are considered priority species for conservation under the Reef 2050 Long-Term Sustainability Plan.

Research has indicated that snubfin dolphins in northern Queensland exhibit a preference for slightly shallower waters (1–2 m) compared to humpback dolphins (2–5 m) and show a greater inclination towards seagrass meadows (Parra et al. 2006) and are therefore addressed in this strategy.

The Western Basin Dredging and Disposal Project approval of the Port Curtis Ecosystem Research and Monitoring Program (ERMP) was developed to acquire a detailed ecological understanding of the marine environment of Port Curtis and Port Alma and included surveys on marine megafauna, including dolphins, in the ERMP survey area (Cagnazzi 2017). Throughout these surveys, the Australian humpback dolphin (*Sousa sahulensis* Jefferson & Rosenbaum, 2014) was the most encountered species, with sightings (n = 249) distributed across the ERMP survey area. Conversely, Australian snubfin dolphins (*Orcaella heinsohni* Beasley, Robertson & Arnold, 2005) (n = 122) were only observed in Port Alma (Cagnazzi 2017). The distribution of humpback dolphin groups sighted in the ERMP survey area during boat-based transect surveys between 2014 and 2016 is shown in Figure 10.

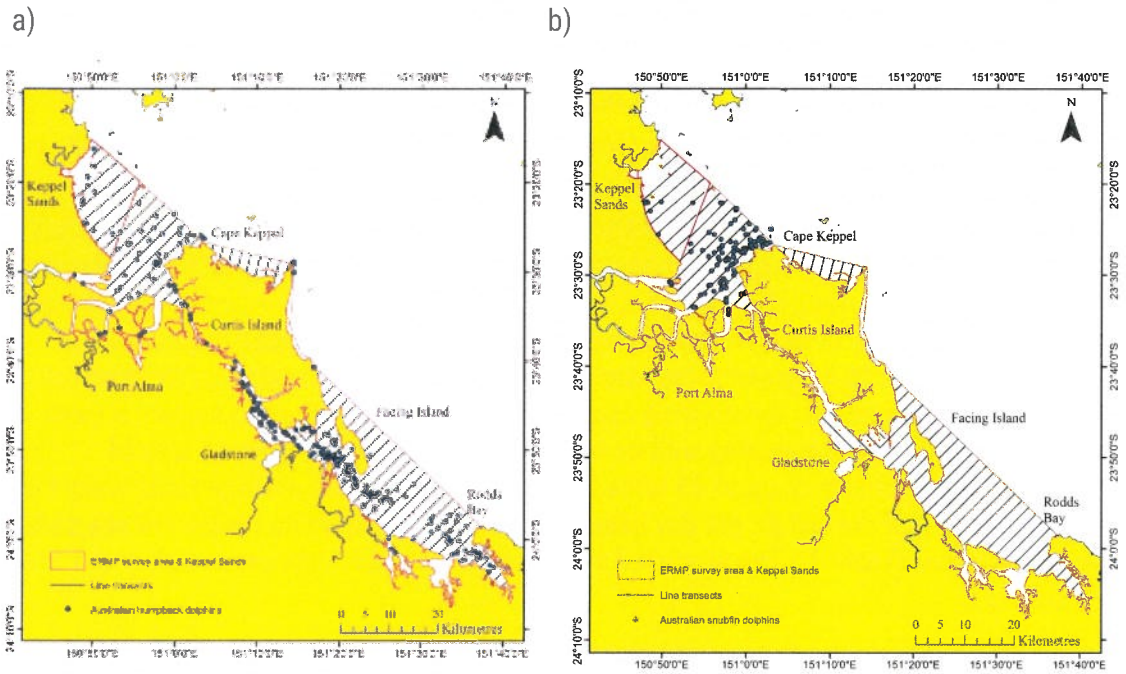


Figure 10 Distribution of a) humpback dolphin and b) snubfin dolphin groups sighted in the ERMP survey area and Keppel Sands during boat-based transect surveys between 2014 and 2016. [Source: Cagnazzi (2017)]

The ERMP data was combined with previous surveys to create a mark-recapture dataset spanning a decade (2007–2016). Cagnazzi et al. (2020) explored the potential impacts of flooding and port development on the population dynamics of Australian humpback dolphins in the Fitzroy River and Port Curtis regions and covered both Meadow 8 and Meadow 43 regions. Across the 10-year survey, no dolphins were not observed in the areas of Meadow 8 and Meadow 43, potentially due to the shallow depth of these banks (Cagnazzi 2017, Cagnazzi et al. 2020). However, it may be that dolphins were utilising the sites at different times of the year or tides.

Although no dolphin sightings have been made in the area, seagrass may support dolphin populations by providing a nursery and foraging habitat for fish in the region, which dolphins feed on. Seagrass beds are known to have a fundamental role in maintaining populations of commercially exploited fish and invertebrate species by providing one or more of the following: (1) a permanent habitat, allowing completion of the entire life cycle, (2) a temporary nursery area for the successful development of the juvenile stages, (3) a feeding area for various life-history stages and (4) a refuge from predation. In addition to these primary roles, seagrass beds are thought to indirectly maintain fisheries by providing organic matter incorporated into coastal nutrient cycles and supporting secondary production, including fisheries species.

Parra and Jedensjö (2014) analysed stomach contents of snubfin and humpback dolphins stranded or incidentally caught in shark nets along the Queensland coast between 1970 and 2008. The majority and most important prey items in the stomachs of the humpback dolphins were teleost fish, with cephalopods and bivalves only found in one stomach and very low numbers. Grunter (*Pomadasys sp.*) were the most numerically important prey (52.9%), followed by the cardinal fish (*Apogon* sp., 10.4%) and smelt-whiting (*Sillago* sp., 9.7%)(Parra and Jedensjö 2014).

Connolly et al. (2006) undertook demersal fish surveys from 105 intertidal and shallow subtidal sampling stations across Port Curtis, including the regions of Meadow 8 and Meadow 43. *Apogon sp, Pomadasys kaakan,* and *Silago analis* were abundant across the harbour. Species found at the two locations showed some overlap. However larger abundances of *Apogon sp.* and *Sillago sp.* at Pelican Banks drove differences in species composition between this site and others. Between 2018 and 2021, fish health surveys undertaken by CMERC for GHHP also found significant numbers of grunter (Flint et al. 2019, Flint et al. 2020) across the sites sampled.

Whilst there is insufficient data on local nursery habitat use by fish, multiple studies have demonstrated the value of seagrass meadows as nursery and foraging of fish, and have demonstrated positive relationships with biomass and cover, and that densities of benthic invertebrates and epifauna for carnivorous fish are significantly higher in seagrass meadows compared to unstructured sand- or mud-flats (Coles et al. 1992, Jenkins and Hammond 1993, Connolly 1997, Arrivillaga and Baltz 1999, Jackson et al. 2001, Connolly and Hindell 2006, Murphy et al. 2010). However, it is essential to note that some species of fish show greater abundance in the unvegetated seabed (Bell and Westoby 1986).

A study examining the changes in the abundance of fish with seagrass biomass in Cockle Bay, Townsville, found a strong correlation ($r^2 = 0.94$) between seagrass biomass and fish abundance across two sites and seasons. Still, all sites in the analysis had seagrass biomasses above 25 g DW m^{-2}.

In summary, the proposed sites (impact and offset) show no firm evidence of being foraging areas for dolphins. Snubfin dolphins, which have been shown to feed on shallow seagrass banks,

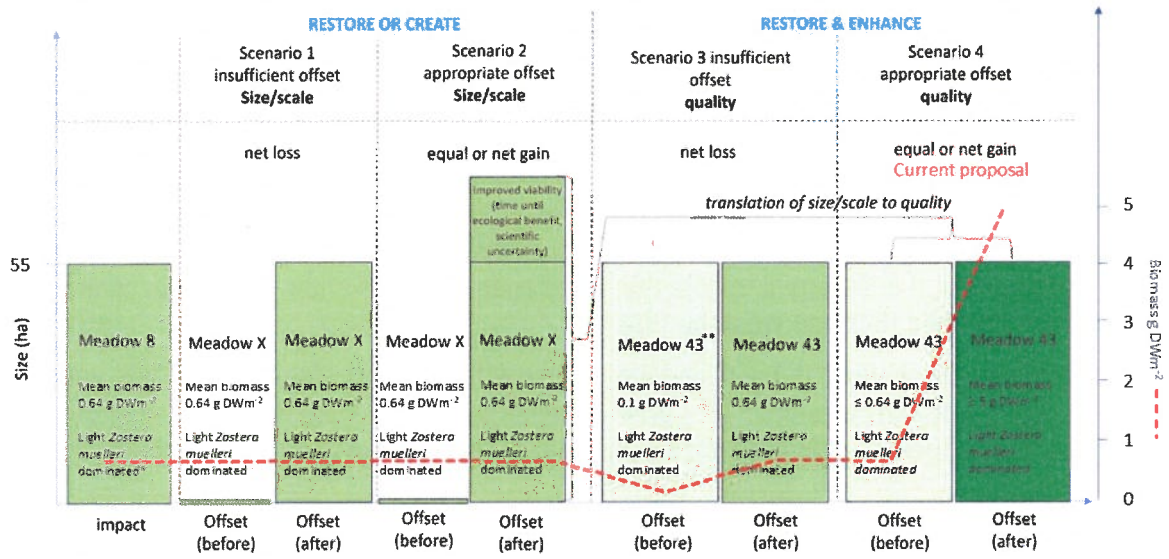
were not observed in the region across a 10-year survey, and humpback dolphins were observed to prefer deeper water areas in the Port. The gain in seagrass biomass from the proposed offset is expected to show increases in benthic infauna and epifauna (for carnivorous foraging fish) and create additional nursery habitat to support juvenile fish. These factors may relate to increases in fish abundance in regions where dolphins do forage; however, given the highly mobile nature of the dolphin, demonstrating a direct relationship would be difficult. Examining changes in macro-invertebrate fauna as a proxy for fish habitat use of different seagrass densities (see Section 5) would be helpful information for future assessments.

3. DIRECT OFFSET: ENHANCING RESILIENCE OF DEGRADED SEAGRASS AT PELICAN BANKS

3.1. Description

The seagrass ecosystems in the Port of Gladstone are constantly changing, so their restoration and management must be adaptable and ongoing. While scientific knowledge about seagrass restoration is essential, it is still developing and evolving. Adaptive management is a valuable approach that can be implemented from the beginning of any management intervention, especially when uncertainties surround the ecosystem and the restoration process. This allows for adjustments and improvements based on new scientific information and programmatic insights.

In assessing the proposed project as a direct offset and against the principles of the offsets policy, DCCEEW interprets local restoration as requiring a net gain offset compared to an averted loss offset. Therefore, the proposal is for the quality of the direct offset to be improved compared to the impact site. In terms of a similar area but significantly greater biomass. Figure 11 is a schematic showing the comparison between the current State of the impact site (Meadow 8) and Pelican Banks (Meadow 43), demonstrating proposed net gain through rehabilitation measures at Meadow 43 (Figure 11).



Note: appropriate offset can also be achieved through a combination of size/scale and quality mechanisms

Figure 11 Schematic showing the comparison between the current State of the impact site (FL8) Pelican Banks (Meadow 43), demonstrating net gain through rehabilitation measures at Meadow 43

The proposed offset will take an adaptive management for ecosystem restoration approach by incorporating new scientific and programmatic information into the implementation of the project. Analysis of ongoing monitoring data will allow continuous evaluation of the approach, which will be adapted as needed during the offset programme, specifically at a suggested five-year review of the proposed seagrass offset programme.

This project proposes to enhance seedbanks to restore cover at the degraded Pelican Banks meadow (elsewhere in Gladstone Harbour – see Figure 1), which will serve as this project's main proposed offset site. Monitoring data indicates this meadow has not recovered from flooding events in 2014 (see section 3.2.1 for further details). The intervention will promote recovery, focusing on areas where biomass and seedbanks are low. It will also build the capability to respond to future disturbance events (i.e. flood events and storms) in the meadow, enabling its recovery and enhancing its resilience. This project will demonstrate, at scale, the ability to restore degraded intertidal *Z. muelleri* meadows and develop infrastructure, protocols, and capacity to support regular seed enhancement of sites that show poor recovery following flood and storm events. These interventions will build metapopulation resilience and offset losses of seagrass caused by port development, preserving key ecosystem services that these meadows provide.

There is general agreement that successful seagrass restoration is linked to scaling up restoration efforts, for which seagrass seeds are practical and cost-effective. There is also the benefit that seeds can be used to enhance large areas and increase biomass and resilience in areas with low density but continuous seagrass cover. Research for seed-based restoration for the genus *Zostera* is beyond the initial proof of concept, and there are established protocols and international case study examples of successful large-scale seed-based seagrass restoration (e.g. Orth et al. 2009, Unsworth et al. 2019, Govers et al. 2022, Xu et al. 2023). For *Z. muelleri,* there is sufficient knowledge on the collection, storage and dispersal of seeds to undertake enhancement and restoration trials, improving chances of success by utilising large numbers of seeds. This project builds on existing infrastructure and seagrass restoration research at CMERC and their links to ongoing international research on seagrass re-sowing processes. Over the past five years, CQUniversity researchers have been building the science base for restoring seagrass in Central Queensland amidst a backdrop of rapid industrialisation, catchment inputs, and climate variability (Benham et al. 2016, Weatherall et al. 2016, Dalby et al. 2022, Aiken et al. 2023, Lekammudiyanse et al. 2023, Tan et al. 2023). Research has included site selection for restoration trials, seed and plant collection methods, seagrass ranching (grow outs of donor plants before transplanting), and germination trials (Connolly et al. 2016, Jackson et al. 2018a, Jackson et al. 2018b, Jackson and Irving 2018, Jackson et al. 2018c). The project has built local community volunteers and citizen scientists while engaging key partners such as the Gidarjil Development Corporation, Green Army, Conservation Volunteers Australia, and youth groups to sustain ongoing seagrass restoration efforts.

3.2. Project objective

The objective of the offset will be to demonstrate increased resilience of the enhanced seagrass meadow through decreased recovery time post-disturbance and/or greater success of the recovery (e.g., increased seagrass density) compared to un-seeded reference sites (degraded

and healthy) and maintaining persistence of seagrass cover over time, with co-benefits of enhancing fish habitat, green turtle and dugong foraging.

3.2.1. Baseline data on offset target location, Pelican Banks

Pelican Banks (referred to as Meadow 43 in monitoring) is the largest (> 600 ha) meadow in the Port of Gladstone. It is intertidal and dominated by the seagrass *Z. muelleri*. Monitoring has shown that this meadow has yet to recover from flood events in 2014 (following multiple La Niña years) and has received a report card score of poor (D) or less for the last seven consecutive reported years in the Gladstone Harbour Report Card (Gladstone Healthy Harbour Partnership 2022). These scores were due to a significant drop in biomass and a shift from the opportunistic species *Z. muelleri* to colonizing species *H. ovalis*.

Meadow 43 at Pelican Banks (Figure 12) showed a significant drop in biomass while maintaining extent, which indicates that, despite being populated by colonising and opportunistic species, the environment at this site supports an enduring meadow. Enduring meadows often exhibit greater resilience to perturbations (Connolly et al. 2018). However, recovery at Pelican Banks has been slow and minimal (Table 3). A gradual reduction in the dominance of *Z. muelleri*, along with poor retention of propagules (see dispersal modelling and genetics section above), may indicate that this meadow requires interventions to support resilience, for example through large scale sowing, before the next La Niña event, which could be a tipping point for this meadow. The past three consecutive years were La Niña years with unusually high rainfall, but are now entering what is predicted to become a hot and dry El Niño year. Pelican banks is described as a seagrass community similar to the proposed impacted Meadow 8 – Light *Zostera muelleri (average biomass of 2.97* g DW m^{-2}*)*.

Zostera muelleri and *H. ovalis* have transient seed banks. Seeds of species with transient seed banks live for one year, which means that whilst the seed banks offer some resilience and recovery potential, the loss of seagrass in an area for more than two years will make it unlikely to see natural recovery from seed banks. If *Z. muelleri* seeds are not present long enough or in large enough numbers to be classed and function as an actual seed bank, the probability of the meadow recovering from the seed bank is less likely. However, recovery can also result from the immigration of fragments and seeds from other meadows. In 2013, a large-scale assessment of the spatial variability in seed bank density was undertaken across the Pelican Banks meadow (450 cores taken across the entire meadow) following La Niña conditions and significant rain events. The results of this study at Pelican Banks, Gladstone, showed a significant difference in seed density between locations, with a greater abundance of *Z. muelleri* relating to greater seed density (Dillon 2018). The limited quantity of seed found during the study suggested that seed may be either fast germinating, lost through other means like herbivory, or dispersed to other meadows (Dillon 2018).

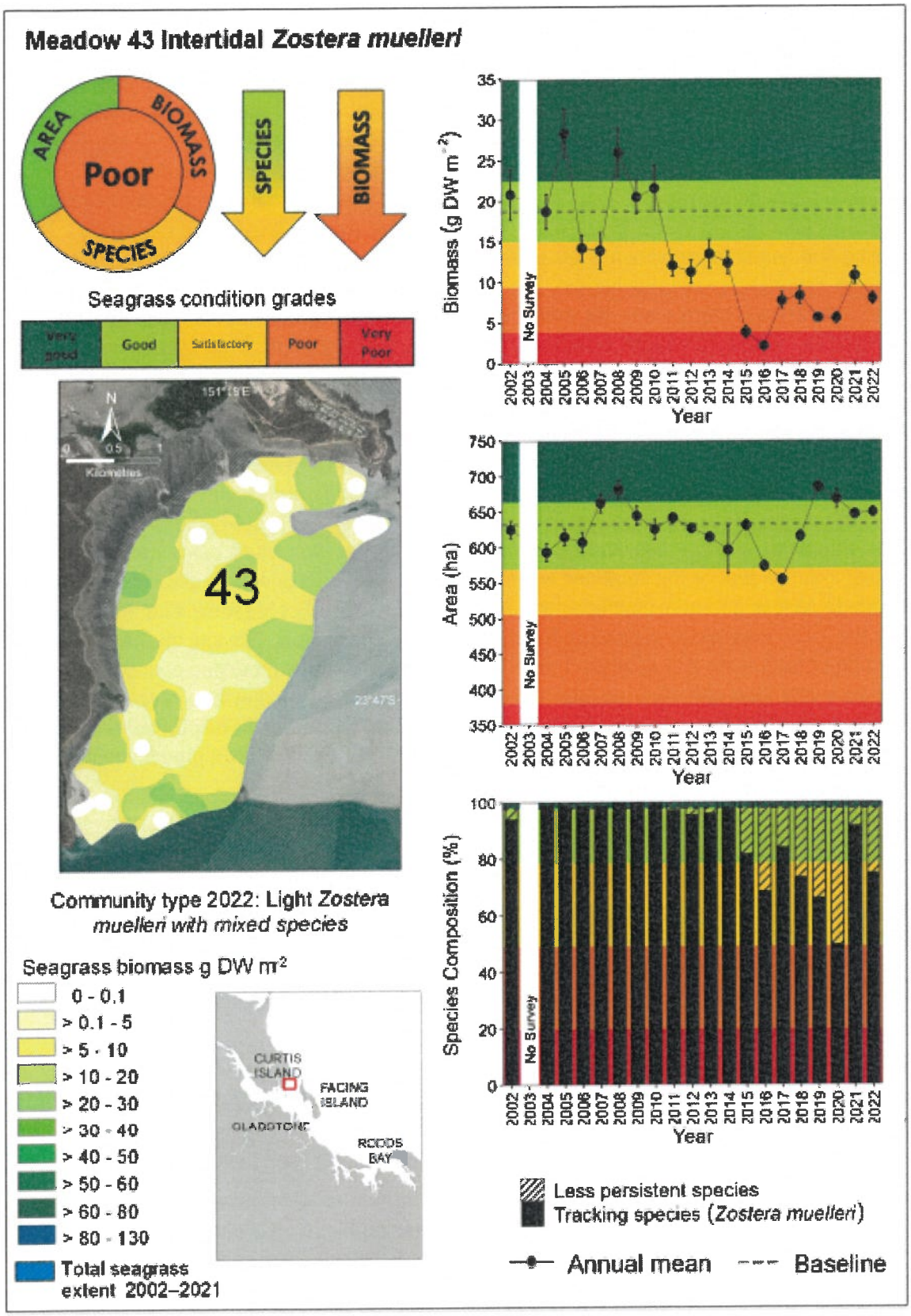


Figure 12 Changes in the meadow area, biomass and species composition for Meadow 8, NLEP SRA, 2002–2022 (biomass error bars = SE; area error bars = "R" reliability estimate) [Source: Smith et al., 2023].

In 2016, Weatherall et al. examined the dispersal potential of seagrass vegetative fragments, comparing different subtropical species found in the Port of Gladstone (Weatherall et al. 2016). It was found that *H. spinulosa* settled significantly faster than the remaining species, whilst *Z. muelleri* settled the slowest. Variables influencing settling velocity included rhizome length, weight and surface area. CMERC and BMT WBM hydrodynamic modellers utilised this information in connectivity modelling. The study modelled the dispersal potential of three sub-tropical species of seagrass (*Z. muelleri*, *H. uninervis* and *H. ovalis*). It used hydrodynamic modelling and habitat suitability models to identify critical sources (sites with high propagule emigration ending up in suitable habitat) and sinks (sites with high immigration) of seagrass across 25 meadows. Importantly, the modelling looked not only at the dispersal but also the settlement, i.e., where conditions were likely to result in the fragments or seeds settling and staying at a location (Jackson et al. 2021). Inputs into the model included wind, wave and tide data. The numerical modelling was performed using the flexible mesh finite volume solver TUFLOW-FV (www.tuflow.com). Modelling indicated seagrass propagule supply and retention by creating probability density maps indicative of relative retention and immigration of seeds and propagules and particle tracking matrices indicative of retention of propagules and critical sources and sinks. Matrices of connectivity based on the simulated hydrodynamic dispersal of *Z. muelleri* fragments and spathes, and seeds represent the proportion which came from a particular location (out of the locations examined) assuming equal coverage and biomass at all locations to assess potential connectivity) (Jackson et al. 2021). For Meadow 43 at Pelican Banks, the local retention of vegetative fragments and spathes is low. The site showed little to no deposition of fragments and spathes from other locations within the modelled period. Such low immigration and local retention indicate recruitment limitation, which may be a reason for slow recovery at the site. More recently (Aiken et al. 2022) modelled the conditions for seagrass persistence based on meadows' connectivity and identified Meadow 43 as a predominantly self-recruiting population that would benefit from enhancement.

Dugong surveys are carried out for Meadow 43 (Rasheed et al. 2017b, Cleguer et al. 2023) but do not cover the whole meadow. The latest survey in 2022 had one aerial transect that only intersected the southern part of Meadow 43 and observed up to c. 15 dugong. In 2015/2016, Rasheed et al., 2017b successfully developed a new method to quantify feeding trails using low-level aerial photography and next-generation photogrammetry, including Meadow 43 (but not Meadow 8). All meadows sampled showed dugong feeding activity throughout the year. Sites in the mid harbour (Wiggins Island, South Trees and Pelican Banks) had higher feeding levels than the two Rodds Bay meadows.

Again, assuming that the carrying capacity of a seagrass pasture to sustain a dugong population follows a linear relationship with its biomass (Sheppard et al. 2007), Meadow 43 in its entirety has the potential to support 102 dugong (rounded down from 1.4), assuming the dugong consumes 3.22 kg DW. ha^{-1} d^{-1} over a year, and not accounting for the growth of the seagrass.

Given that dugongs select sites with high biomass and given the other observations, dugongs are feeding in significant numbers at Meadow 43 and increasing the biomass at 55ha of degraded parts of the meadow with biomass < 0.64 g DW. m^{-2} is currently estimated to support no dugongs to a biomass > 5 g DW. $m^{-2,}$ through the proposed offset is estimated to support at least two dugongs (twice as many as the area lost at Meadow 8).

3.2.2. Site selection and habitat quality

In addition to annual mapping and monitoring by Gladstone Ports Corporation, seagrass is also monitored via permanent transect monitoring under the Marine Monitoring Program for inshore seagrass, which allows the condition of meadows within the Port to be observed in relation to larger regional and state-wide changes in seagrass health and abundance and includes a traits-based indicator of resilience. The resilience metric was devised in 2020 (Collier et al., 2021) and transects at Pelican Banks and Rodds Bay have been monitored since 2005 and 2007, respectively. In 2020-21, the resilience score in the wider Fitzroy region had the most significant annual decrease (18 points) since 2007, primarily driven by declining abundances and resilience at the Pelican Banks site (McKenzie et al. 2022). The 2021-22 Inshore Seagrass monitoring report noted that the entire meadow seascape has deteriorated with increased erosion along drainage channels and increased scarring (McKenzie et al. 2023).

Pelican Banks has, therefore been selected as a site for a direct offset in this plan. The offset aims to improve resilience by promoting recovery post-natural disturbance and enhancing and restoring degraded patches. In the latest seagrass monitoring (2021), Pelican Banks is described as light *Z. muelleri* (average biomass of 2.97 g DW. m^{-2}), which is a similar seagrass community to the proposed impacted Meadow 8 (0.64 g DW. m^{-2}) (Figure 14). Fragmentation of Pelican Banks is visible from aerial imagery (see example in Figure 13), and continued disturbance may reach a critical threshold where the seagrass will be structurally incapable of withstanding the scouring effects of storm disturbances.

One of the most significant current drivers of seagrass loss in the Port of Gladstone is storms and flood events, which are becoming more frequent and intense with climate change. Some meadows are entirely lost during an event but recover quickly, whilst others are slow to recover biomass or continuity of seagrass patches. With projected scenarios of more frequent La Niña climate conditions and severe storms, losses will likely increase, particularly when combined with cumulative anthropogenic pressures facing seagrasses. Proactive intervention is a necessity. Table 3 illustrates grades for 14 regularly monitored meadows based on GPC and TropWater monitoring data (Carter et al. 2019). Many of the meadows showed significant loss and degradation during the repeated La Niña events in 2010, 2011 and 2013, which resulted in above-average rainfall and peak river flow events, increasing turbidity and limiting seagrass photosynthesis (Bryant et al. 2014).

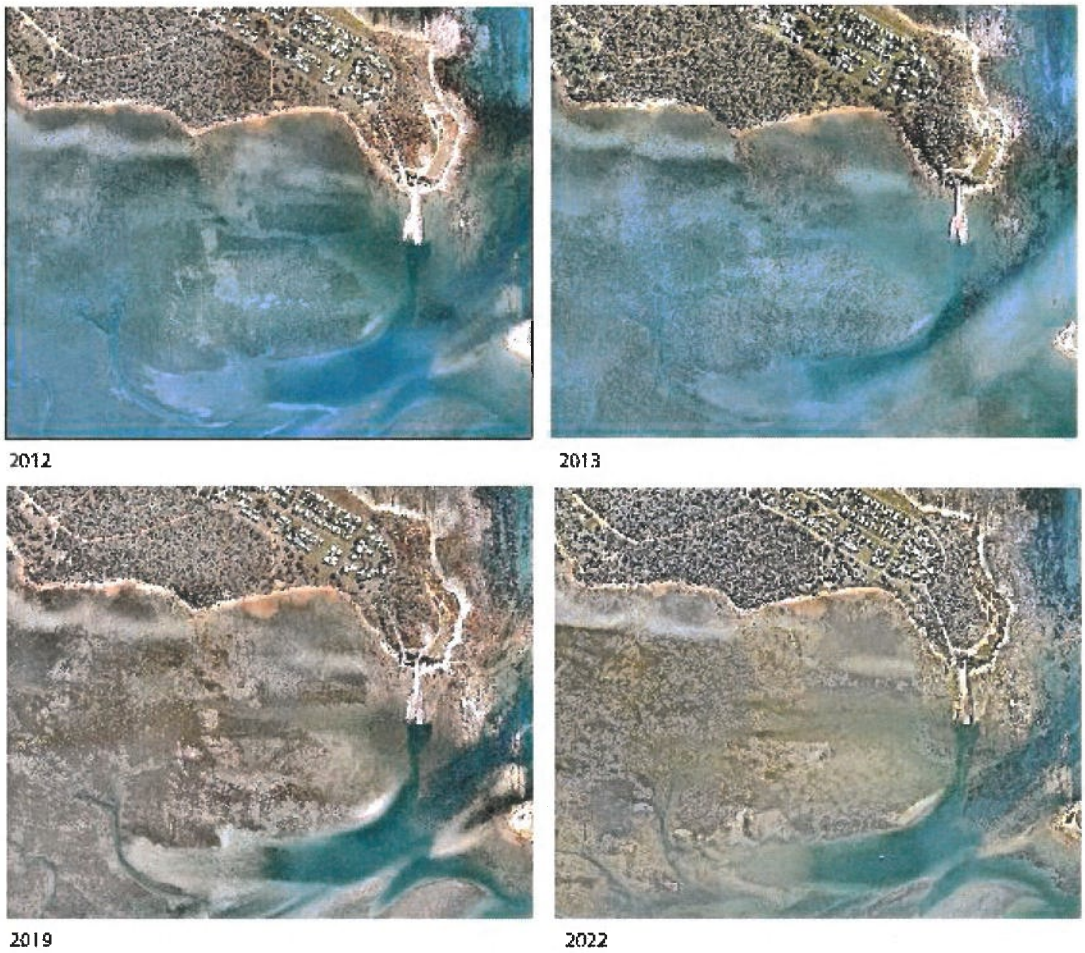


Figure 13 Example of change in seagrass cover at South End, Pelican Banks. Images were taken in July each year. In 2013 large continuous dense seagrass patches are visible as dark patches on the mud banks, which are already fragmenting following the 2013 flood events. There will be some recovery by 2019, but meadows are still severely fragmented in 2022. Image Source: NearMap

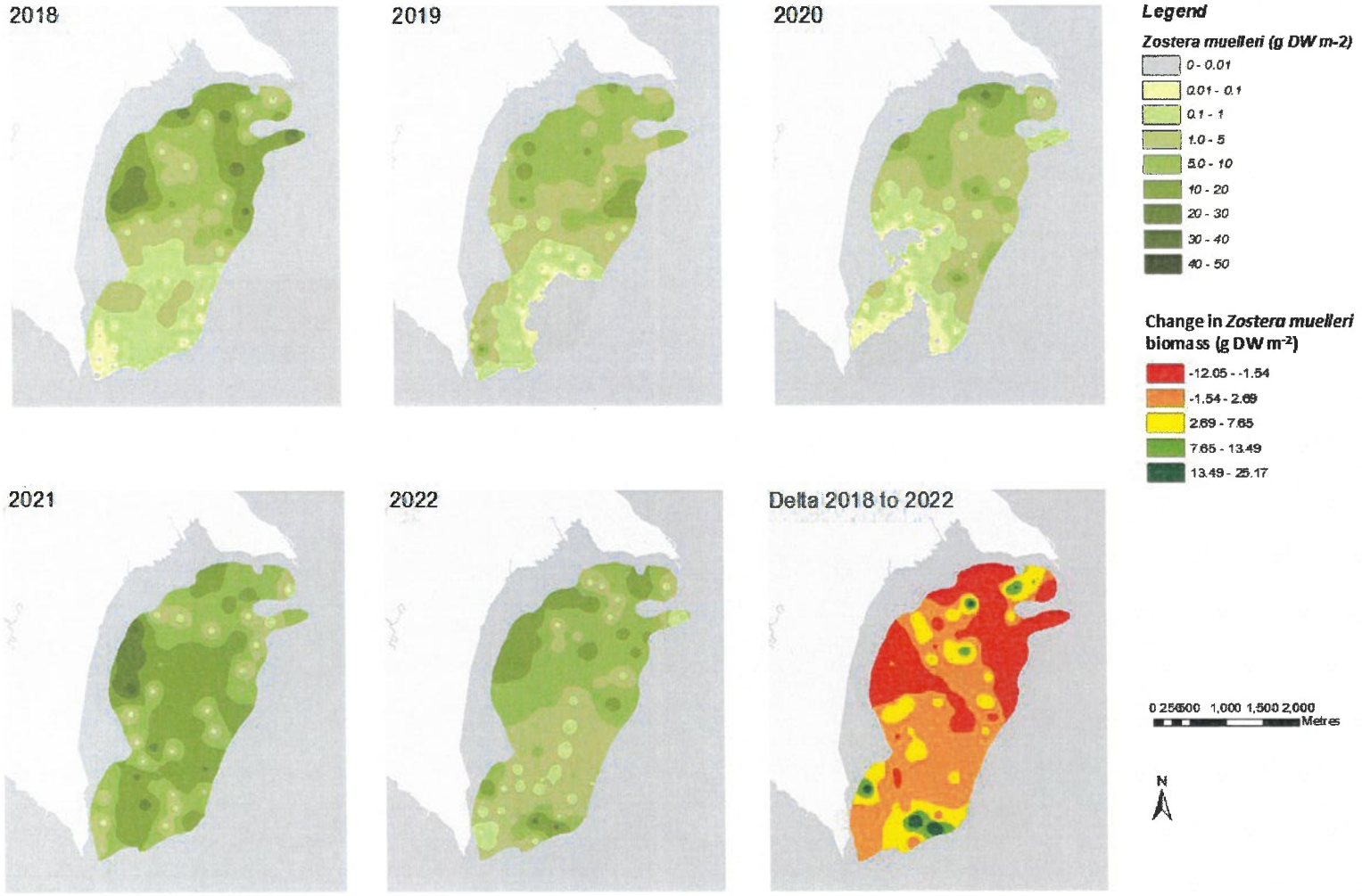


Figure 14 Changes in biomass and outer extent of seagrass at Meadow 43. Detailed change maps will target areas of <0.64 biomass in the red zones to rehabilitate 55 ha of the meadow.

Table 3 Grades for individual seagrass monitoring meadows from annual (November) surveys, 2002–2021 (Source: Smith et al., 2021). Meadow 8 corresponds with the NLEP site.

Zone	Meadow	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1. The Narrows	21								A	B	B	C	E	D	D	C	D	B	A	A	B
3. Western Basin	4	B		C	D	B	A	B	A	E	D	B	D	D	C	B	D	C	A	A	A
	5	C		D	C	B	B	A	C	D	D	C	E	D	D	C	C	C	A	A	B
	6	B		D	C	B	A	B	A	E	D	D	D	B	B	B	D	C	A	A	B
	7	B		B	E	A	D	B	D	E	E	E	D	B	B	D	E	A	B	B	C
	8	A		D	E	B	B	B	B	C	E	D	E	D	D	E	D	D	B	B	C
	52-57*								C	E	E	B	B	C	D	B	B	A	B	B	B
5. Inner Harbour	58	B		D	B	D	B	B	B	E	D	C	E	D	D	D	E	E	B	B	C
8. Mid Harbour	43	B		B	B	C	C	A	B	B	C	C	C	C	D	E	D	D	D	D	D
	48	B		C	B	B	A	B	E	D	D	D	C	D	D	C	C	C	C	C	C
9. South Trees	60	A		E	E	B	A	A	C	E	E	C	E	C	D	B	A	A	A	A	A
13. Rodds Bay	94	A		D	A	B	A	A	E	E	E	E	E	D	E	E	E	C	A	A	B
	96	B		D	C	B	A	A	B	D	E	D	E	D	D	D	E	B	A	A	B
	104	B		D	B	B	B	A	C	E	E	E	E	C	D	E	E	D	A	A	C

Key

Seagrass condition grades

Very good	Good	Satisfactory	Poor	Very Poor

Seagrass species composition, density and morphology are related to site environmental conditions. Andrews et al. (2022) recently investigated whether morphometric variations of four known subpopulations of *Z. muelleri* in the Port of Gladstone correlated with their meadow-specific environmental conditions and whether this varied between seasons. They found that *Z. muelleri* subpopulations exhibited distinct morphologies throughout their seasonal growth cycle that correlate with meadow-specific differences in sediment composition, hydrodynamic stress, and light availability. Aquaria-based experiments within the same research program have shown adaptation to changed environmental conditions, indicating phenotypic plasticity. Such results support the theory that transplanted populations are likely to adapt to the new conditions at a site. However, restoring or creating a seagrass meadow that is identical in coverage and form to the impacted meadow is unlikely as environmental conditions are never identical. Existing habitat suitability modelling is utilised below to identify conditions similar to those of the SRA seagrass meadow since the restoration or creation of seagrass habitats in the same region and with similar environmental conditions has a higher potential to support similar seagrass communities and functions.

Decisions for restoration are usually made based on the past occurrence of a seagrass species at a specific location, which relies on robust historical data. In tropical systems where many seagrass meadows are transitory and the distribution is highly dynamic, identifying an area where seagrass has been permanently lost is difficult without long-term data. In areas where the natural environment has been significantly modified, some seagrass meadows may be lost permanently (e.g. through land claim) or have become unsuitable for growth. Equally, sites may exist where seagrass has yet to be recorded, but the habitat may be suitable.

Suitable intertidal seagrass habitat within the Port of Gladstone was predicted for *H. ovalis* and *Z. muelleri* by CMERC using Maximum Entropy (MaxEnt) modelling (Phillips and Dudík 2008), which is a presence-only modelling technique (Elith et al. 2011). The habitat suitability model was run using the "samples-with-data" approach, which controls for sample bias and improves predictive performance. The model was cross-validated using 75/25% training test data splits. Composite spatial data on the distribution of *Z. muelleri* and *H. ovalis* was compiled from the Port of Gladstone seagrass monitoring carried out annually (Chartrand et al. 2018). Environmental data were selected based on their reported relevance to seagrass distribution using habitat suitability modelling studies from other locations (Bekkby et al. 2008). Habitat suitability modelling has been shown to provide reliable predictions of seagrass distribution relative to field validation of suitability predictions (e.g. Erftemeijer et al. 2023). The model used three key environmental variables that operate at a larger scale and work together to influence light and energy regimes and the growth of the different species: depth, bed shear stress and sea bed slope. Final suitability maps used a probability of 0.5 as a threshold for suitable and unsuitable habitats (Jackson and Millar 2020), with only suitable habitats above 0.7 selected as potential offset sites. The maps were also queried to identify how similar depth, bed shear stress, representative wave energy and slope at target restoration sites were to the impacted site (Figure 15). Meadow 43 at Pelican Banks (Figure 15) was similar in terms of these environmental variables to the site at NLEP, except for the slope, which varied more at the NLEP site.

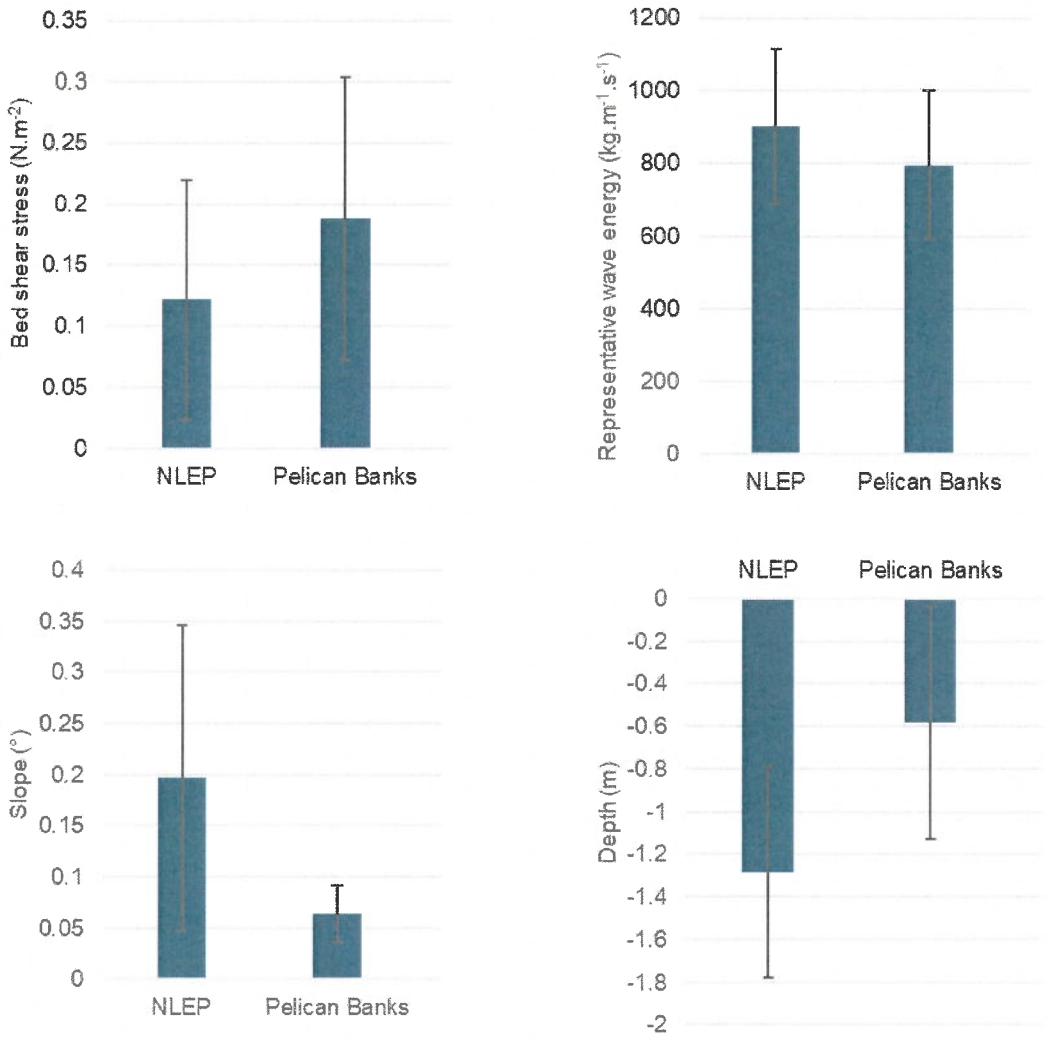


Figure 15 Compares environmental conditions between impacted sites and potential offset locations. Error bars represent one standard deviation.

Overlaying actual and potential locations of seagrass habitat with maps of seagrass seed and vegetative fragment dispersal for seagrass transplanting can identify areas of suitable habitats where seagrass persistence may be limited due to low immigration from other meadows (ideal for restoration and enhancement); areas where restoration may increase the resilience of the metapopulation; and regions where natural recovery potential was high.

After selecting meadows with suitable habitats, poor recovery potential, and value in terms of connectivity to the broader metapopulation, the next step was to identify which meadows were degraded, in decline, and where natural recovery was limited.

Regular monitoring of 14 meadows by GPC and JCU TropWater (Carter et al., 2019 and Smith et al., 2021) allows the assessment of not only which meadows in the area are lost or degraded but also their resilience, i.e. which meadows were able to resist disturbances and recovery quickly to either a previous or new state. Some meadows showed complete loss – for example, Meadow 4 at Wiggins Island, at the mouth of the Calliope River – but then showed recovery, indicating a

transitory meadow with opportunistic and colonising species, with good connectivity to other meadows and a seed bank to aid recovery. Hands-on restoration of meadows with good connectivity or a viable seed bank would likely be a waste of effort due to the high potential for natural recovery. On the other hand, meadows that are lost and do not recover naturally are potential targets for restoration interventions, such as transplants or facilitated dispersal of seeds.

Pelican Banks has been selected in this plan as a site for a direct offset due to the similarities in environmental conditions, similar expected seagrass biomass and species composition, and because it is a site that is showing degradation and slow recovery (Gladstone Healthy Harbour Partnership 2022, McKenzie et al. 2023). Pelican Banks is over 600 ha, and the proposal aims to enhance the seagrass across three different sites to spread the risk across regions with various depths, wave exposure and grazing pressure (Figure 16).

As our understanding of the importance of seagrass systems has grown, the aim of re-establishing and restoring seagrass meadows has become increasingly attractive and recent advances in methodology and approach have brought the realisation of these aims closer (e.g. Erftemeijer 2020, Gamble et al. 2021). Identifying whether the goal is to restore (plant seagrass where it was historically present), create (plant seagrass where it was historically not present) or enhance (plant seagrass where it is currently present but degraded) will inform not only the location for the restoration activity (and the prioritisation for intervention) but also the methodologies and timings of interventions. For example, enhancing meadows with poor resilience due to poor connectivity with others may require subsequent interventions (e.g. regular re-seeding) to maintain.

With general agreement that successful seagrass restoration is linked to scaling up restoration efforts, seagrass seed is practical and cost-effective. There is also the benefit that seeds can enhance large areas, help maintain genetic diversity, and increase biomass and resilience in areas with low-density but continuous seagrass cover, especially areas with depauperate seed banks. Sowing is a low-impact intervention; collection of spathes is estimated to be less than 0.0001% of the spathes in the population during a single season. Spathes are removed from the plant, leaving the rest of the plant and rhizomes intact.

However, as terrestrial studies have shown (Pedrini et al. 2020), the successful use of seeds in restoration requires research about collection, storage technique after collection, sterilisation technique, viability of seeds, genetic diversity and adaptation to various environmental conditions. Local research is available for the species *Z. muelleri* on the influence of seed age and colour, sterilisation techniques and ecological factors influencing germination and early seedling survival (Jackson et al. 2018a). Nationally for *Z. muelleri,* there is also research on the influence of light, temperature, salinity, scarification and anoxia on germination (Conacher et al. 1994, Stafford-Bell et al. 2016).

Halophila ovalis seeds are very small (though numerous) and challenging to handle, but given that this species is colonizing and can establish rapidly from vegetative fragments, scaling up using seeds may not be necessary for this species, and research on this species is proposed as a lower priority than the species *Halodule* (Inglis 2000).

For *Z. muelleri,* there is a sufficient knowledge base on the collection, storage and dispersal of seeds to undertake enhancement and rehabilitation, improving chances of success by utilising large numbers of seeds (Jackson et al. 2018a). This knowledge has been developed for local

populations in Gladstone by CMERC. Ongoing research will improve methodologies to increase seed production, storage and sowing protocols, increasing survival and reducing the number of seeds required. This research is continuing at CMERC in partnership with Deakin University.

It is not expected that this will be a one-off event, and the plan is to undertake repeat sowing annually to promote faster recovery. The aim is to build on existing infrastructure, protocols, and capacity to support regular seed enhancement of sites showing poor recovery following events. This would build metapopulation resilience and offset seagrass losses.

Figure 16 Example of resowing areas (yellow polygons, 20 ha each) based on current cover, biomass, and latest seed bank densities. Two 1 ha trial plots (green squares) will be set up within each resowing area to test specific resowing methodologies. Note that the final resowing locations will be based on drone mapping during peak growth in November 2024.

3.2.3. Management actions: Key project stages and methodology

The following section has been drafted based on an approach where CMERC completes the offset implementation services. However, suppliers to be used for the Implementation Services scope (in accordance with this offset plan) are yet to be confirmed and subject to future GPC procurement processes and project approvals.

Year 1

Activity 1.1 Permit approvals

The project will start as soon as possible after the State and Commonwealth approve the offset. The project will require permits for the collection and dispersal of marine plant material:

- Accepted Development requirements under the *Fisheries Act 1994* for the Operational work that is the removal, destruction or damage of a marine plant (Schedule 10, part 6, division 3, subdivision 1)
- Operational work for tidal works or work completely or partly in a coastal management district (Schedule 10, part 17, division 1).

Regarding the permit requirements, we will liaise with the Queensland Department of Environment and Science (DES) staff. The collection and dispersal of seagrass seeds will be included in a restoration project plan for endorsement by the Department of Agriculture and Fisheries (DAF) as an accepted development operational work that is the removal, destruction or damage of marine plants.

The project location is outside of MSES declared high ecological value waters and outside the GBRMP and State Marine Parks and, therefore, will not trigger requirements for a State Marine Park Permit Application under the *Marine Parks Act 2004*, where habitat restoration is considered minor works under the definitions in the act.

The proposed activity complies with all the requirements for accepted development (new work for a public purpose) under 2.12 Fish habitat rehabilitation or restoration work (including not-for-profit marine plant nursery establishment) that provides a net benefit to marine plant communities. Collection of plant material (see below) will be less than 20 L/day and bagged and labelled with location and collection date (spathe collections) and < 10 m^2 removal of adult plants for the nursery stock plants. A notification form for accepted development will be submitted with a complete project plan under preparation for DAF endorsement.

There are no legal or unresolved Indigenous disputes related to elements of this proposed offset. The Port Curtis Coral Coast Traditional Use of Marine Resources Agreements Port Curtis Coral Coast Traditional Use of Marine Resources Agreement (PCCC TUMRA) is supportive of seagrass restoration at this site (based on previous requests to the TUMRA for consent, although this would be re-sought for this particular project). Local Indigenous Sea Rangers are already involved in seagrass restoration in Gladstone through a partnership with CMERC and the Gidarjil Development Corporation.

Activity 1.2 Establish programme governance

Project progress meetings will be held with representatives from the Department of Environment and Science (DES), DCCEEW, GPC and CMERC every six months to advise on progress against milestones and review the Offset Strategy and the performance of offsets.

CMERC will lead the project management, monitoring, and evaluation of project requirements. GPC will be responsible for submitting reports in line with agreed project milestones and outcomes. GPC will facilitate any compliance or site visits to ensure that DCCEEW can obtain or conduct any confirmation of reports, including ad hoc report requests for record-keeping and audits. This monitoring and reporting will follow the Activity Work Plan (section 3.8) and Budget submitted as a part of the proposed strategy. As the approval holder, GPC will be responsible for the project funding's expenditure and relevant reporting (biennial) through an agreement between GPC and a third party (e.g. CMERC). Any responsibility outlined in this plan relating to approval conditions is with the approval holder, GPC.

Activity 1.3 Seagrass spathe (flower) collection

CMERC has established Citizen Science seagrass spathe collection events in Gladstone for restoration and research (Figure 17). Due to the small volumes, spathes are collected under Accepted Development requirements under the Fisheries Act 1994 for the Operational work, that is, the removal, destruction or damage of a marine plant (Schedule 10, part 6, division 3, subdivision 1). Targeted seagrass spathe collections (five events per year) will supplement the Citizen Science collections to reduce the risk of poor harvest numbers. These additional events will be supported through offset funding. Trained personnel are available from CMERC, the Gidarjil Development Corporation Sea Rangers, GPC, Fitzroy Basin Association and Burnett Mary Regional Groups across the target seagrass meadow extent and from meadows with evident connectivity with Pelican Banks (South Trees, -23.865909°, 151.322017° and South Trees -23.865539°, 151.322179°. Events will occur during low spring tides from October and November 2023 to 2033. The aim will be to collect > 500,000 spathes (on average each season) from the target meadow and other connected meadows in the same population. *Z. muelleri* spathes from August to December in the Port of Gladstone, with peak flowering in October and November offering the most cost-effective collections regarding spathe densities and seed maturation potential.

Whilst no standard approaches for wild seed collection exist for ecological restoration of seagrass (van Katwijk et al. 2021), they are well established for terrestrial systems. They will be followed (Pedrini et al. 2020), including sustainable collections to avoid effects on the reproductive capability of the source population and avoiding active selection for specific traits to limit unintended selection and maintain genetic variability of the seed lot. Spathes will be collected using CMERC's strict protocols to minimise impact, e.g., restrictions on the number of spathes collected per m^2 to ensure natural seedbanks are maintained (calculated at < 0.001% of spathes present at the site are removed, so impact on the donor sites is minimal), spacing out of collectors to minimise trampling of seagrass meadow on soft mud, and standard collection technique (snapping off spathes rather than pulling to avoid up-rooting plants).

Taking a conservative approach that there may be spatial variation in the success of germinates and early seedlings, the estimated requirement of seeds per ha is 2,000,000 in areas completely devoid of seagrass (density of 200 seeds per m^2). This represents a minimum density; more will be added if available from collections and the nursery. The proposed density is based on previous studies for the species *Zostera marina*, which has had success at densities of as little as 30 seeds per m^2 (Marion and Orth 2010). Still, also these densities are similar to natural seed bank densities at viable seed depths at the Pelican Banks site (Bryant et al. 2016).

The proposed offset aims to seed 55 ha of degraded patchy seagrass to a more continuous and persistent patch, starting with 10 ha but building up to the entire area (55 ha) over the twenty years. Seagrass seeds will be stored in unrefrigerated seawater; sterilisation and aeration are required to manage pests and disease and prevent premature germination.

Figure 17 Citizen science spathe collection events are undertaken under strict protocols to protect existing meadows.

Pedrini et al. (2020) advise that the proliferation of native seeds under cultivated production (e.g. nurseries) is preferable and should replace or supplement collection from natural populations whenever feasible, as it reduces the impact on natural populations and allows for higher productivity, improved quality, reliability, and reduced seed cost. If cultivated production is not feasible, natural populations can be managed to optimise seed production by understanding areas of high spathe production and phenology of seagrass flowering, both of which exist for Gladstone.

Activity 1.4 Extension of the existing SeaGrow (purpose-built seagrass nursery for restoration purposes).

Terrestrial Australian native plant nurseries are well established, supplying seeds and propagating plants from specific provenances for revegetation associated with terrestrial offset projects and playing a vital role in furthering research on the propagation of land grasses. Marine developers also recognise their responsibility but are limited in their mitigation and revegetation capacity by a lack of supporting industries that can provide seeds or transplants for revegetation projects.

Enhancing the resilience of seagrass at Pelican Banks through seeding is supported by a large-scale dedicated seagrass nursery, "SeaGrow", currently in development at CMERC, which the GBR Foundation and Coles have funded through the GBRF Blue Carbon Programme. The nursery is at 100% design, and tanks and paddle wheels have been delivered. The nursery is on track to be finalised in October 2024. Research conducted at this facility will establish protocols and best practices to extend seagrass cultivation techniques. GPC is a partner providing in-kind support

for the nursery, supporting restoration activities, training, and capacity building for local First Nations people[5].

To support this proposed offset, GPC will fund an extension to the planned SeaGrow nursery infrastructure of two additional raceway tanks and ten additional seagrass spathe storage and seed collection devices and tanks to store sterilised seeds (Figure 18). Costs include parts, construction, running and maintenance for the life of the offset (20 years).

CMERC is a founding member of the Global Seagrass Nursery Network and facilitated an international workshop on nursery design and operation at the recent International Seagrass Biology Workshop in Annapolis, USA, which involved a site visit to the world's largest seagrass restoration site and seed production nursery in Virginia, USA.

Proposed seed production for the offset will be through a combination of seeds collected from nursery stock (initially 5 %, but set to increase each year as techniques improve, Hopkins et al. (1998)) and spathes collected from the wild (95%), which are held at the nursery until seeds can be harvested, sterilised and stored. The continued inclusion of wild seeds has been shown to maintain natural genetic diversity, which is essential for seagrass population resilience (van Katwijk et al. 2021).

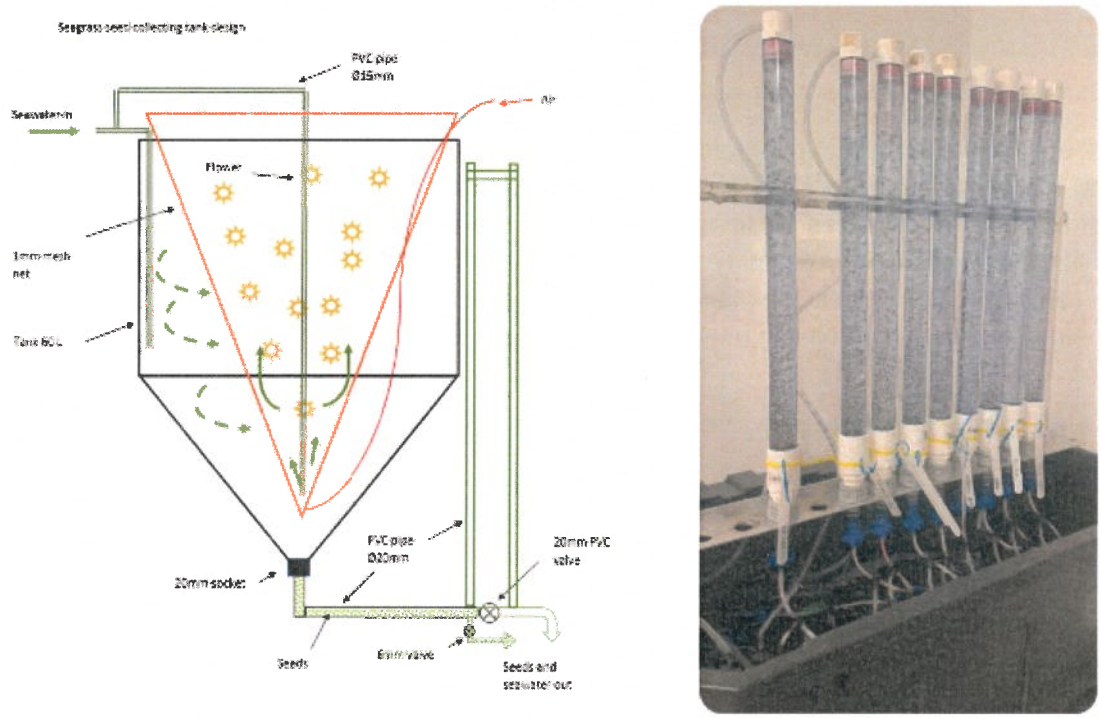


Figure 18 Schematic of the spathe (flower) storage and seed collection device (Left) and seed storage tanks (Right).

Separation of seeds from other plant material by hand is necessary for storage but is time-consuming. However, sorting can be partially automated using a flume system (Marion and Orth 2010). Flumes can also be utilised to sort seeds of variable quality (Marion and Orth 2010). To

[5] https://www.colesgroup.com.au/media-releases/?page=coles-commits-10-million-to-help-protect-the-great-barrier-reef

improve the efficiency in collecting seeds from the spathe storage tanks, offset funding will be used to construct a 4 m x 0.3 m x 0.3 m flume for sorting seeds from other plant material and grading seeds. These two additions to the seagrass nursery system will increase capacity to provide additional seed material (c. 5 million seeds per season) for the restoration offset. All protocols will be made available through the project to promote capacity for other seagrass nurseries for restoration in Australia.

Seed production and viability will be assessed monthly. A target of a 40% germination rate will be aimed for, which is mid-range based on previous assessments of germination rates for this species in Gladstone (Jackson et al. 2018a).

Activity 1.5 Baseline mapping of seagrass cover at target locations

Figure 16 identifies areas of Pelican Banks where the sowing would occur (three 20 ha regions, within which a minimum of 42 ha will be enhanced) based on current cover and biomass and the latest seed bank densities. Large sections of the meadow at Pelican Banks are showing fragmentation. The final sowing locations will be based on drone mapping during peak growth in November 2024.

Target restoration locations will be mapped using multi-spectral (IR/NIR and RGB) and LiDAR imaging to inform targeted seed dispersal. Smaller-scale plots (1 ha plots) will be established as monitoring and reference sites. Drones will be used to take random quadrats for biomass and measures of seagrass morphometrics. We will ground truth drone imagery to assess the accuracy of microtopography (Leica RTK) and seagrass cover. Cores will be collected to measure seed bank densities before sowing.

As part of the offset approach, analyses of aerial imagery from the last six years and drone imagery from 2022 and 2024 (Continuous Change Detection and Classification (CCDC) method) will be used to identify the patch configurations (fragmentation) within each of three target resowing locations, to inform seed dispersal:

- To avoid sowing edaphic patches – areas where seagrass has never grown, likely due to underlying geomorphology.
- To avoid sowing patches where seagrass is high in density and persistent.
- Identify areas requiring sowing within the area of interest (previously covered but devoid of seagrass before sowing).

Six 1 ha monitoring reference sites will be established (three healthy patches without intervention – i.e. no seeding and three degraded patches without intervention), and baseline mapping will be carried out.

Year 1 Milestones: Inception meeting, annual progress meeting, and two six monthly progress reports will be provided to provide an update on each activity. Biannual reporting to be published on the approver holder's website.

Year 2

Activity 2.1 Baseline data collection: fish and bird foraging habitat and megaherbivore usage

Dugong feeding ecology and habitat use have previously been assessed at Pelican Banks by examining the persistence of feeding trails (Rasheed et al. 2016). This method will estimate dugong grazing density with reference and seeded 1 ha monitoring plots on Pelican Banks every

two years. The technique will be complemented by traditional aerial imagery surveys where water clarity allows (Cleguer 2022). Images will be reviewed by trained image reviewers using the Dugong Detector software (DD) using methods detailed by Cleguer (2022). All potential dugong sightings will be labelled manually using the Wildlife Imagery Survey – Detection and Mapping (WISDAM) software. Aerial imagery will also be used to count the number of turtles resting on the seagrass banks at low tide as a proxy for turtles' habitat use. These methods may be updated to ensure alignment with monitoring protocols being finalised by DCCEEW.

To assess changes in fish foraging capacity, we will use macrofaunal (infauna and mobile epifauna) functional diversity as a proxy for prey abundance and an adaptation of the squid-pop method (Duffy et al. 2015) as a proxy of predation variability deployed at canopy height (using degradable twine and locally collected prey) to assess variation in shorebird foraging (low tide) and fish predation (high tide). Squid-pops consist of a piece of dried squid attached to a pole (at different heights), put out on the seagrass meadow. After 24 hours, the amount of squid eaten is quantified. Baseline benthic surveys and squid pops will be undertaken in the monitoring plots and at reference sites in year two and biennially in the wet and dry seasons until the end of the offset programme.

Activity 2.2 Seed dispersal

UAV (Unmanned Aerial vehicles or drones) technology offers a unique opportunity to disperse seeds smartly by mapping seagrass cover, detailed topography and environmental conditions (e.g. sediment type and topography) and machine learning techniques to vary densities of sowing to the conditions, improving efficiency. CMERC are currently working in partnership with OzTech Drones[6] through funding from Australian Ethical), The Great Barrier Reef Foundation, The Land Restoration Fund and the Fitzroy Basin Association are developing techniques for dispersing seeds, which will be employed in this project (drone and seed ball dispersal).

In Year 2, one 5 ha area will be seeded and intensively monitored (in situ transects and quadrats) to inform future seeding of the remaining 37 ha. Maps from Year 1 will be used to design seed dispersal flight plans for pre-germinated and ungerminated seeds (50:50 ratio), targeting low-cover areas that are not channels, mounds, or pools to aid retention. Seed dispersal densities will average 200 seeds per m^2, depending on the existing cover. Before the seed dispersal, seed traps will be deployed, and seed bank cores of random replicate sites within each location will be collected. Seed dispersal will be undertaken between March and May in Year 2.

Activity 2.3 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated in Year 2, following the approach outlined in Activity 1.3 (above).

Year 2 Milestones: Annual progress meetings and two six monthly progress reports will be provided to provide an update on each activity. Biannual reporting to be published on the approver holder's website.

Year 3

Activity 3.1 Annual seed dispersal at enhancement locations

[6] https://www.oztechdrones.com/aerial-sowing

In Year 3, the same 5ha (Activity 2.2) + additional 5ha =total 10ha area will be repeat seeded,

Activity 3.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated in Year 3, following the approach outlined in Activity 1.3 (above).

Activity 3.3 Biannual monitoring (see section 3.3 for details).

Year 3 Milestones: Annual progress meeting and two six monthly progress reports will be provided to provide an update on each activity.

Year 4

Activity 4.1 Monitoring: fish and bird foraging habitat and megaherbivore usage

See the approach in Activity 2.1.

Activity 4.2 Annual seed dispersal at enhancement locations

In Year 4, the same 10 ha and an additional 10 ha (Activity 2.2) area will be repeat seeded

Activity 4.3 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated in Year 4, following the approach outlined in Activity 1.3 (above).

Year 4 Milestones: Annual progress meeting and two six monthly progress reports will be provided to provide an update on each activity.

Year 5

Activity 5.1 Annual seed dispersal at enhancement locations

In Year 5, the same 20 ha and an additional 10 ha (Activity 2.2) area will be repeat seeded

Activity 5.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated in Year 5, following the approach outlined in Activity 1.3 (above).

Activity 5.3 Biannual monitoring (see section 3.3 for details).

Activity 5.4 Five yearly review (Interim Milestone)

The approach and progress against the completion criteria will be reviewed, and the project plan will be updated to implement learnings.

Year 5 Milestones: Annual progress meeting, Five yearly review reports, and two six monthly progress reports will be provided that will provide an update on each of the activities. Biannual reporting to be published on the approver holder's website.

Year 6

Activity 6.1 Annual seed dispersal at enhancement locations

In Year 6, the same 30 ha (Activity 5.1) area and an additional 12 ha will be seeded, incorporating learnings from the five-year review.

Activity 6.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated following the approach outlined in Activity 1.3 (above), incorporating learnings from the five-year review.

Activity 6.3 Monitoring: fish and bird foraging habitat and megaherbivore usage

See the approach in Activity 2.1, incorporating learnings from the five-year review.

Year 6 Milestones: Annual progress meeting and two six monthly progress reports will be provided that will provide an update on each of the activities

Year 7

Activity 7.1 Annual seed dispersal at enhancement locations

In Year 7, the same 42 ha will be seeded, and an additional 13 ha will be seeded, incorporating learnings from the five-year review.

Activity 7.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated, following the approach outlined in Activity 1.3 (above), incorporating learnings from the five-year review.

Activity 7.3 Biannual monitoring (see section 3.3 for details), incorporating learnings from the five-year review.

Year 7 Milestones: Annual progress meeting and two six monthly progress reports will be provided that will provide an update on each of the activities

Year 8

Activity 8.1 Annual seed dispersal at enhancement locations

In Year 8, the same 55 ha will be seeded where needed to maintain persistence, incorporating learnings from the most recent five-year review.

Activity 8.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated in Year 8, following the approach outlined in Activity 1.3 (above).

Activity 8.3 Monitoring: fish and bird foraging habitat and megaherbivore usage

See the approach in Activity 2.1 and below in Section 3.3.

Year 8 Milestones: Annual progress meeting and two six monthly progress reports will be provided that will provide an update on each of the activities

Year 9

Activity 9.1 Annual seed dispersal at enhancement locations

Understanding the optimal substrate for maximizing settlement, survival, and growth of local macroalgal species is crucial when offsetting the loss of removed seaweed because it directly impacts the effectiveness of restoration efforts. Substrate suitability influences how well macroalgae can establish and thrive, which is essential for restoring lost biomass and ecological functions. By identifying substrates that promote successful attachment and growth, restoration practitioners can enhance macroalgal recruitment, leading to healthier and more resilient ecosystems.

Additionally, macroalgae play key roles in coastal ecosystems by providing habitats, food sources, and contributing to nutrient cycling. Effective restoration can help to quickly restore these functions and combat the impacts of seaweed loss due to human activities or environmental changes. Selecting the right substrate can also improve the survival rates of transplants, making restoration efforts more efficient and sustainable over time.

6.3. Approach

It is proposed that GPC fund a PhD student project to research the optimum substrates for seeding structural macroalgal species local to the Gladstone and the wider GBR region, in terms of maximising settlement, survival and RGR of germlings.

The study will be conducted in the Port of Gladstone, where CMERC has been researching the ecology and phenology of *Sargassum* and *Asparagopsis* species, and recently completed a review of key coastal Queensland species of macroalgae (Theobald et al. 2024). The student will design the specific research approach but will include:

- Comprehensive field surveys to assess occurrence of macroalgal species on different substrates around the port (natural and artificial).
- Aquaria experiments to investigate the effects of substrate type on the settlement, survival, and relative growth rate (RGR) of a local macroalgal species.
- Grow-out trials on different substrates across a range of environments in the Gladstone coastal waters.

6.4. Expected Outcomes

This study would provide insights into the optimal substrate types for supporting the settlement, survival, and growth of local macroalgal species, which could significantly enhance restoration success rates and maximise the biomass of macroalgae provided through the direct offset beyond the proposed target. By understanding how different substrates influence early developmental stages, researchers can design more effective restoration strategies, helping to mitigate the impacts of seaweed loss.

In addition to supporting practical restoration efforts, the study would contribute to broader ecological knowledge by revealing how abiotic factors, such as substrate characteristics, impact macroalgal germling development. These findings could inform conservation practices beyond the specific species and region studied (including interactions with inshore corals, fish friendly marina development), advancing marine habitat restoration and biodiversity support on a larger scale.

There are numerous opportunities to present the findings from this project, particularly regarding recommended methods for seaweed restoration and biodiversity offset outcomes, at key national and international conferences. Events such as the International Seaweed Symposium, Australian

CMERC researchers have also published highly cited papers in the assessment of ecosystem services of seagrass ecosystems:

Boström, C., **Jackson, E.L.** and Simenstad, C.A., 2006. Seagrass landscapes and their effects on associated fauna: a review. *Estuarine, Coastal and shelf science*, *68*(3-4), pp.383-403.

Jackson, E.L., Rowden, A.A., Attrill, M.J., Bossey, S.J. and Jones, M.B., 2001. The importance of seagrass beds as a habitat for fishery species. *Oceanography and marine biology*, *39*, pp.269-304.

Luisetti, T., Jackson, E. L., & Turner, R. K. (2013). Valuing the European 'coastal blue carbon'storage benefit. Marine Pollution Bulletin, 71(1-2), 101-106. Nordlund, L.M., Jackson, E.L., Nakaoka, M., Samper-Villarreal, J., Beca-Carretero, P. and Creed, J.C., 2018. Seagrass ecosystem services–What's next?. *Marine pollution bulletin*, *134*, pp.145-151.

Potts, Tavis, Daryl Burdon, Emma Jackson, Jonathan Atkins, Justine Saunders, Emily Hastings, and Olivia Langmead. "Do marine protected areas deliver flows of ecosystem services to support human welfare?." Marine Policy 44 (2014): 139-148.

Jackson, E.L., Rees, S.E., Wilding, C. and Attrill, M.J., 2015. Use of a seagrass residency index to apportion commercial fishery landing values and recreation fisheries expenditure to seagrass habitat service. Conservation Biology, 29(3), pp.899-909.

Understanding the benefits of restoration on seagrass ecosystem services is essential for informing conservation and management decisions to preserve these critical coastal habitats. This study will contribute to the broader understanding of seagrass restoration's ecological and socio-economic value by conducting comprehensive assessments of restored seagrass ecosystems. The project's research and findings can inform future offset requirements and encourage advanced planning of restoration efforts under the EPBC Act

5.5. Estimated budget

REDACTED

6. INDIRECT OFFSET PROPOSAL: SEAWEED SUBSTRATE OPTIMISATION (RESEARCH COMPONENT)

6.1. Objectives

Investigate the optimal substrate for maximising settlement, survival and growth of local macroalgal species.

6.2. Description

An emerging opportunity for the creation of structural habitat to increase biodiversity is to promote the establishment and growth of macroalgae on artificial marine infrastructure including rip rap seawalls, wharves and breakwaters, where the growth does not interfere with marine operations.

resilience, demonstrate the socio-economic importance of seagrass restoration efforts, and provide evidence-based recommendations for investment in conservation and restoration initiatives.

There are opportunities to present findings from the project, including recommended methods and restoration and biodiversity offset outcomes, at national and international conferences. For example, the Australian Marine Sciences Association conference, Australian Coastal Restoration Network Symposium, Australian Society for Phycology and Aquatic Botany conference, World Seagrass Conference, and Society for Ecological Restoration international conference provide a platform to disseminate project information to the broader scientific community, government agencies, Traditional Owner groups, and industry. Additionally, project findings will be published in peer reviewed journals. CMERC researchers have a strong track record of publications demonstrating expertise in coastal ecology, and developing methods for restoration, detailed below.

Past five years:

Jongen, R., Marzinelli, E.M., Bugnot, A.B., Ferguson, A., Fraser, M.W., Glasby, T.M., **Jackson, E.L.**, Martin, B.C., Sherman, C.D., Sinclair, E.A. and Trevathan-Tackett, S.M., 2024. Integrating Belowground Interactions into Seagrass Restoration Strategies. In *Oceanography and Marine Biology* (pp. 192-214). CRC Press.

Sievers, M., Connolly, R.M., Finlayson, K.A., Kitchingman, M.E., **Ostrowski, A.**, Pearson, R.M., Turschwell, M.P., Adame, M.F., Bugnot, A.B., Ditria, E. and Hale, R., 2024. Enhanced but highly variable biodiversity outcomes from coastal restoration: A global synthesis. *One Earth*, *7*(4), pp.623-634.

Dalby, O., Coleman, R.A., Tan, Y.M., Jennings, G., Cook, P.L., **Jackson, E.L.**, Macreadie, P.I. and Sherman, C.D., 2023. Understanding the seagrass-sediment-light feedback to guide restoration planning: a case study using Zostera muelleri. *Restoration Ecology*, *31*(8), p.e14044.

Tan, Y.M., Coleman, R.A., Biro, P.A., Dalby, O., **Jackson, E.L.**, Govers, L.L., Heusinkveld, J.H., Macreadie, P.I., Flindt, M.R., Dewhurst, J. and Sherman, C.D., 2023. Developing seed-and shoot-based restoration approaches for the seagrass, Zostera muelleri. *Restoration Ecology*, *31*(5), p.e13902.

Aiken, C.M., Navarrete, S.A. and **Jackson, E.L.**, 2023. Reactive persistence, spatial management, and conservation of metapopulations: An application to seagrass restoration. *Ecological Applications*, *33*(2), p.e2774.

Dalby, O., Pucino, N., Tan, Y.M., **Jackson, E.L.**, Macreadie, P.I., Coleman, R.A., Young, M.A., Ierodiaconou, D. and Sherman, C.D., 2023. Identifying spatio-temporal trends in seagrass meadows to inform future restoration. *Restoration Ecology*, *31*(3), p.e13787.

Sievers, M., Brown, C.J., Buelow, C.A., Hale, R., **Ostrowski, A.**, Saunders, M.I., Silliman, B.R., Swearer, S.E., Turschwell, M.P., Valdez, S.R. and Connolly, R.M., 2022. Greater consideration of animals will enhance coastal restoration outcomes. *BioScience*, *72*(11), pp.1088-1098.

Jackson, E.L., Smith, T.M., York, P.H., Nielsen, J., Irving, A.D. and Sherman, C.D., 2021. An assessment of the seascape genetic structure and hydrodynamic connectivity for subtropical seagrass restoration. *Restoration Ecology*, *29*(1), p.e13269.

and organic matter, and a resulting increase in carbon capture. The research project will examine the benefits of restoration intervention for blue carbon sequestration and habitat provision.

In areas with uneven and changing meadows, the carbon stored from past vegetation can make it tricky to assess newly planted seagrass using core samples. We aim to compare carbon levels in different parts of the meadow to predict how a more substantial seagrass presence affects these stocks. The primary objective of this study is to assess the impact of restoration activities on providing ecosystem services by seagrass habitats. Specific objectives include:

- Evaluating changes in seagrass coverage, density, and species composition following restoration efforts.
- Assessing the effectiveness of restoration in enhancing carbon sequestration and nutrient cycling within seagrass ecosystems.
- Investigating the role of restored seagrass habitats in providing habitat and food resources for associated fauna, including commercially important fish species.
- Examining the potential of restored seagrass ecosystems to provide coastal protection and mitigate the impacts of erosion and storm events.
- Apply environmental economics approaches to value restored ecosystem services.

The study will be conducted in the Port of Gladstone, where restoration activities have been implemented to restore degraded seagrass habitats. The student will design the specific research approach but will include:

- Comprehensive field surveys to assess the condition of both restored and degraded seagrass habitats. This will measure seagrass coverage, density, species composition, and associated faunal diversity.
- Carbon Sequestration and Nutrient Cycling: Collect sediment samples from restored and degraded sites to analyze organic carbon content and nutrient concentrations. Utilize established models to estimate carbon sequestration rates and nutrient cycling processes.
- Faunal Surveys: Conduct surveys to assess the abundance and diversity of fish and invertebrate species within restored and degraded seagrass habitats using standardised sampling techniques and assess megaherbivore foraging by identifying dugong feeding trails within restored and degraded seagrass habitats.
- Coastal Protection: Assess the effectiveness of restored seagrass meadows in reducing wave energy and mitigating shoreline erosion through field measurements and modelling approaches.
- Economic Valuation: Utilize established economic valuation techniques, such as the market-based approach, the cost-based approach, and the benefit transfer method, to estimate the economic value of seagrass ecosystem services provided by restored habitats.

5.4. Expected Outcomes

The study is expected to provide valuable insights into the benefits of restoration on seagrass ecosystem services. Specifically, it will demonstrate the role of restored seagrass habitats in providing essential ecosystem services, including carbon sequestration, nutrient cycling, habitat provision, and coastal protection.

The project will also provide empirical evidence to support the implementation of seagrass restoration as a viable conservation strategy to maintain and enhance coastal ecosystem

4.6. Estimated budget

REDACTED

5. INDIRECT OFFSET PROPOSAL: CO-BENEFITS OF RESTORATION (RESEARCH COMPONENT)

5.1. Objectives

The objective is to examine blue carbon sequestration and other co-benefits of the seagrass restoration intervention.

5.2. Description

Currently, large-scale seagrass restoration is reliant on funding from biodiversity offsets. Understanding and having data on the co-benefits of restoring seagrass is critical to securing alternative funding - blue carbon, nature crediting, potential reef credits and sustainable seafood initiatives. A lack of GBR-specific data on these co-benefits is a bottleneck for seagrass restoration. Further research would lead to benefits for the impacted seagrass by promoting an increase in seagrass restoration projects in the region, beyond those proposed by the current offset strategy.

The persistence of seagrass at the sites is expected to result in a more stable and diverse in-faunal biodiversity (a proxy for fish or bird foraging value), enhanced trapping of fine sediments and organic matter, and a resulting increase in carbon stocks. There is also strong evidence that dugong and turtle populations are closely related to seagrass biomass and composition (Sheppard et al. 2007, Meylan et al. 2022).

To assess changes in fish and shorebird foraging capacity, we propose the use of macrofaunal (infauna and mobile epifauna) functional diversity as a proxy for prey abundance and an adaptation of the squid-pop method (Duffy et al., 2015) as a proxy of predation variability deployed on the seabed (using degradable twine and locally collected prey) to assess variation in shorebird foraging (low tide) and fish predation (high tide). To evaluate the potential changes in fish habitat use in these areas, we propose trialling CHIRP (Compressed High-Intensity Radiated Pulse) to identify fish size abundance and potential fish species in these highly turbid environments.

Legacy of carbon stocks in deposits from previous vegetation would likely confound assessments of this through coring methods in the sowed areas that were previously vegetated. Therefore, it is proposed that carbon stocks in different types of patches found across the meadow be compared to predict the influence of a more persistent seagrass coverage.

5.3. Approach

It is proposed that GPC fund a PhD student project to research changes in co-benefits in intervention areas during the second to fifth year of the programme.

The persistence of seagrass at the sites is expected to result in a more stable and diverse in-faunal biodiversity (a proxy for fish or bird foraging value), enhanced trapping of fine sediments

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Monitoring shows no enhancement effect of seeding seawall and no change in macroalgae cover.	Project delivery	Offset success criteria not met	Regular monitoring will feed into a 5-year review, and new scientific research will be used to adapt and improve methods.	Major	Possible	High	18	Moderate	Rare	Medium	6
Introduce pathogens into the marine environment.	Operations Environment Organisational integrity and public image	Loss and decline of natural populations	A biosecurity plan will be developed specifically for the project and based on the Commonwealth of Australia Aquaculture Biosecurity Plan Guidelines. Existing protocols (for sterilizing and provenance data management) will be applied and developed further in the project. Close collaboration with the new seaweed National Hatchery Network will ensure best practices.	Moderate	Unlikely	Medium	9	Moderate	Rare	Low	6

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Seeding seawalls reduces genetic diversity in natural sargassum populations.	Operations Environment Organisational integrity and public image	Loss and decline of the resilience of natural populations	Careful management of propagule source, including information on environmental and morphology. Follow well-established terrestrial guidelines on the genetic composition of any materials released into the environment. The target area for habitat creation is small, and we expect natural recruitment of concrete material.	Moderate	Unlikely	Medium	14	Moderate	Rare	Low	6

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Insufficient propagules collected or germlings established.	Operations Project delivery	Smaller area sowed.	Reproductive material will be tracked, and additional collection events will be instigated if volumes are low. We will target a large number of germling attachments to account for germling establishment probabilities. Probabilities will be based on local research in 2023/24 at CMERC.	Moderate	Unlikely	Medium	13	Moderate	Rare	Low	6

Table 7 Risk analysis and a risk management and mitigation strategy against offset completion criteria. The risk rating calculation method is provided at the end of the table.

Risk rating calculation					
	Rare	Unlikely	Possible	Likely	Almost Certain
Insignificant	Low (1)	Low (2)	Low (3)	Low (7)	**Medium (11)**
Minor	Low (3)	Low (5)	**Medium (8)**	**Medium (12)**	High (16)
Moderate	Low (6)	**Medium (9)**	**Medium (13)**	High (17)	High (20)
Major	**Medium (10)**	High (14)	High (18)	Extreme (21)	Extreme (23)
Catastrophic	High (15)	High (19)	Extreme (22)	Extreme (24)	Extreme (25)

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Delays with permits for macroalgal material collection	Operations Project delivery	Delays in the delivery of the project	Early liaison with relevant authorities for permits. Material will be collected using previously accepted methods under permit to minimise damage to natural populations.	Moderate	Unlikely	Medium	9	Moderate	Rare	Low	6
Staff changes – staff leave or become unavailable during the project.	Administration Project delivery	Delays in project delivery or additional costs to the university for replacing staff resources.	Additional staff will be resourced from within CQUniversity or externally advertised through an expedited process to ensure delivery against timelines. Recruitment and selection processes will follow CQUniversity recruit for success policy.	Moderate	Possible	Medium	13	Minor	Unlikely	Low	5

These targets represent a net gain in area and cover (see Table 2).

4.5. Risk Analysis

A risk analysis and a risk management and mitigation strategy for all risks to the successful implementation of the environmental offset and timely achievement of the offset completion criteria is provided in Table 7. This includes a rating of all initial and post-mitigation residual risks.

Activity 3.4 Placement of seeded substrate

In year three, an additional 100 x 0.25 m^2 cement plates (32 inoculated (if required)with local *Sargassum* germlings paired with 32 bare plates) will be placed in the bunded area.

Year 4

Activity 4.1 Monitoring

Ongoing monitoring as per Activity 2.1.

Activity 4.2 Reproductive macroalgal collection

Reproductive macroalgae collections will be repeated from June to September in year four unless monitoring has shown significant natural recruitment to the tiles.

Activity 3.4 Placement of seeded substrate

In year four, an additional 100 x 0.25 m^2 cement plates (32 inoculated (if required)with local *Sargassum* germlings paired with 32 bare plates) will be placed onto the new NLEP SRA seawall.

Year 5

Activity 5.1 Monitoring

Ongoing monitoring as per Activity 2.1.

Activity 5.2 Reproductive macroalgal collection

Reproductive macroalgae collections will be repeated from June to September in year five unless monitoring has shown significant natural recruitment to the tiles.

Activity 3.4 Placement of seeded substrate

In year five, an additional 120 x 0.25 m^2 cement blocks (32 inoculated (if required)with local *Sargassum* germlings paired with 32 bare plates) will be placed onto the new NLEP SRA seawall. This will bring the total placement to 1.2 ha.

Year 6-10

In year 6, seaweed cover will be reviewed, and if required, an alternative (more labour-intensive) transplanting method will be employed to ensure the offset target is met by Year 10.

4.4. Offset completion criteria

The success of the offset will be reported on and confirmed at year 10 of the project, or at least one year before the expiry of the approval (whichever comes first). Offset completion will be derived when the following criteria are met:

- By Year five, 0.1 ha of macroalgal habitat had been incorporated into living seawall habitat.
- By year ten, 1 ha of macroalgal habitat has been incorporated into living seawall habitat; 80% of the area will have at least 5 % cover and 20% of the area will have 40% cover.

selected at random per site along the designated transect lines. Specimens will be cut at the base of the holdfast using a knife, and the samples will be stored in a mesh bag until they surface. At the surface, samples will be transferred to containers filled with natural seawater collected at the site. Mature specimens will be housed within 200 L mesocosms under natural lighting until the receptacles mature. Upon significant egg release, fertilised eggs will be collected and rinsed in filtered seawater. Fertilisation of the eggs will be confirmed under a dissecting microscope to assess for cell divisions. Within two days of egg release, the settlement substrate will be added to the mesocosms to promote germ settlement.

Activity 1.3 Placement of seeded substrate

Substrates with and without established germlings (to promote natural recruitment) will be placed along the bunded seawall (Figure 20). Placement will occur at the start of the growing period during October/November. In the first year, we will incorporate 64 x 0.25 m^2 cement tiles (32 inoculated with local sargassum germlings and 32 bare tiles).

Year 2

Activity 2.1 Monitoring

Monitoring will be conducted quarterly for five years, commencing in May 2025. Monitoring will be conducted by snorkelling and underwater ROV. Permanent quadrats will be assigned at ten sites where the paired tiles have been placed. Within the permanent quadrats, the number of adult thalli/ juvenile thalli will be recorded to calculate density, recruitment, and the percentage of cover of *Sargassum* spp. (as a proportion of the area occupied when viewed from above) will be recorded. Transects along the seawall will record the presence, absence, and percent cover of *Sargassum* and other species of macroalgae.

Activity 2.2 Reproductive macroalgal collection

Reproductive macroalgae collections will be repeated from June to September in year 2.

Activity 2.3 Placement of seeded substrate

In year two, an additional 100 x 0.25 m^2 cement plates (32 inoculated with local sargassum germlings and 32 bare plates) will be placed in the bunded area.

Year 3

Activity 3.1 Monitoring

Ongoing monitoring as per Activity 2.1. In particular, monitoring in year three will assess the increased recruitment to tiles without germling injection in the lab to feed into a third-year review of the need to continue lab inoculation versus natural recruitment.

Activity 3.2 Third-year review

The approach and progress against the completion criteria will be reviewed, and the project plan will be updated to implement learnings.

Activity 3.3 Reproductive macroalgal collection

Reproductive macroalgae collections will be repeated from June to September in year 3.

The project will start as soon as possible after the State and Commonwealth approve the offset. The project will require permits for the collection and dispersal of marine plant material:

- Accepted Development requirements under the *Fisheries Act 1994* for the Operational work that is the removal, destruction or damage of a marine plant (Schedule 10, part 6, division 3, subdivision 1)
- Operational work for tidal works or work completely or partly in a coastal management district (Schedule 10, part 17, division 1).

We will liaise with the Queensland Department of Environment and Science (DES) staff regarding the permit requirements. The collection of reproductive *Sargassum* will be included in a habitat creation project plan for endorsement by the Department of Agriculture and Fisheries (DAF) as an accepted development operational work that is the removal, destruction or damage of marine plants.

The project location is outside of MSES declared high ecological value waters and outside the GBRMP and State Marine Parks and, therefore, will not trigger requirements for a State Marine Park Permit Application under the *Marine Parks Act 2004*, where habitat restoration is considered minor works under the definitions in the act.

The proposed activity complies with all the requirements for accepted development (new work for a public purpose) under 2.12 Fish habitat rehabilitation or restoration work (including not-for-profit marine plant nursery establishment) that provides a net benefit to marine plant communities. Collection of plant material (see below) will be less than 20 L/day and bagged and labelled with location and collection date (spathe collections) and < 10 m^2 removal of adult plants for hatchery stock plants. A notification form for accepted development will be submitted with a complete project plan under preparation for DAF endorsement.

There are no legal or unresolved Indigenous disputes related to elements of this proposed offset. The Port Curtis Coral Coast Traditional Use of Marine Resources Agreements Port Curtis Coral Coast Traditional Use of Marine Resources Agreement (PCCC TUMRA) is supportive of seagrass restoration at this site (based on previous requests to the TUMRA for consent, although this would be sought for this particular project).

Activity 1.2 Establish programme governance

As per section 3.2.3.

Activity 1.3 Baseline mapping of sargassum cover at target locations

Transects along the bunded seawall will be carried out in January, year 1, to assess the baseline cover of *Sargassum* at the site.

Activity 1.4 Reproductive macroalgal collection

Sample collection (*Sargassum*)will be carried out from June to September in year 1 when the reproductive branches are present, following the completion of bi-monthly monitoring of transects currently undertaken by CMERC. Collections will be conducted from significant patches around the marina, Fisherman's Landing, Tide Island (-23.8026°,151.2272°), Rat Island (-23.7636°, 151.315°) and Farmer's Reef (-23.772786°, 151.318953°). Whole, intact, reproductive benthic specimens of *Sargassum* will be collected by snorkel, with 30 *Sargassum* specimens

secured in crevices or depressions. Transplants will be maintained by removing any species competing with the macroalgae.

Figure 20 Locations for seagrass and macroalgal habitat creation for indirect offset trial and direct offset respectively.

4.3. Management actions: Key project stages and methodology

Year 1

Activity 1.1 Permit approvals

Laboratory trials are currently being carried out at CMERC to ascertain settling capability, attachment rate and relative growth rate of algal species of commercially important brown macroalga (*Sargassum*) and red macroalga (*Asparagopsis*) upon green/grey hybrid concrete tiles (approx. 3 cm width x 3 cm height and 2 cm thick, provided in partnership with JPower), in comparison to other substrate types (limestone and blue stone, the latter being the material of the rip rap seawall), under a range of temperature and irradiance conditions. Initial results show that materials can be seeded, and this is an established approach in other regions beyond proof of concept (Yu et al. 2012).

Stage 2 Grow out of "seeded" tiles in bunded area and to harden plants and select strains for the NLEP environment

Currently, GPC is funding a PhD project examining the modification of seawall designs to create a habitat for mangroves and oysters to improve the biodiversity, fish habitat and carbon sequestration potential of traditional rip rap seawalls, including those around the NLEP (Figure 20). A site in the bunded area where these living seawall trials are taking place (blue square in Figure 20) offers an opportunity to place larger "seeded" substrate on the rock of the seawall and created groynes to harden the germlings in a similar but controlled location to the final placement. In June 2024 a PhD student was approved through co-funding from GPC and CQU (Elevate Scholarship program), which will examine the ecosystem services delivered from seawall created habitats and their interactions. This project is funded separately but will provide valuable additional information to assess the ecosystem value of this direct offset. A further PhD scholarship is proposed to optimise the settlement of a range of seaweed species on different natural and artificial substrata is proposed as part of the Indirect offset (section 6), which will further optimise

Green/grey hybrid (low carbon) concrete tiles (25 cm width x 25 cm height x 3 cm thickness) will be seeded with *Sargassum* and *Asparagopsis* germlings and placed on groynes and seawall at the existing bunded area in Year 2. Tiles will be paired with unseeded tiles to determine the natural recruitment of macroalgae. Tiles will be monitored periodically to identify settled species and monitor their growth. They will also determine successional changes in species settlement and compare this to other substrates.

Stage 3 Placement of algal-seeded substrate along the new NLEP SRA seawall

Following the construction and settling in of the new NLEP SRA seawall, macroalgae -friendly blocks (of the appropriate material and with protrusions that increase hydraulic roughness and provide attachment points for macroalgae) will be added adjacent to and on the newly constructed bund wall for the NLEP SRA. Progress towards the offset target of 90% of the area (1 ha) created with at least 5 % cover, and 10% of the area (0.1 ha) at 40% cover, with be monitored seasonally twice a year. This approach has previously been demonstrated, albeit at smaller scales, and is therefore classed as an innovative but proven technology; see (Terawaki et al. 2003, Yu et al. 2012, Jung et al. 2020).

In year 6, macroalgal cover will be assessed, and if required, an alternative (more labour-intensive) transplanting method will be employed to ensure the offset target is met (De La Fuente et al. 2019). Macroalgal fragments or seedlings will be introduced onto the seawall surface and

3.10. Estimated Budget

Table 6 Estimated budget for Direct Offset, including monitoring. Detailed costs for the first five years, calculated based on cost plus a margin of 20%.

REDACTED

4. DIRECT OFFSET PROPOSAL: INCORPORATING MACROALGAL HABITAT CREATION INTO SEAWALL DESIGN

4.1. Objectives

Place substrate for maximising settlement on NLEP seawalls of the brown algae *Sargassum* and red seaweed *Asparagopsis taxiformis* to 1.1 ha of macroalgal habitat adjacent to and on the newly constructed bund wall for the NLEP SRA. 90% of the area (1 ha) created will have at least 5 % cover, and 10% of the area (0.1 ha) will have 40% cover.

4.2. Description

In addition to seagrass, 1.06 ha of algae was observed in the NLEP SRA footprint (Figure 7). Similar filamentous algae (identified as *Ectocarpus* sp. by CMERC) are observed ephemerally on most other seagrass meadows and mud banks in the harbour, including the target site at Pelican Banks, often resulting from elevated nutrients and occurring as a natural part of the seagrass ecosystem. Erect macroalgae (primarily *Sargassum* sp.) is found within the NLEP footprint but mostly attached to rocks associated with the existing bund wall and rock and barriers placed to reduce erosion scars from water draining the bunded area.

Observations from the existing seawall structures and trial living seawall sites demonstrate that introducing a hard structure and increasing flow (through the constriction of the channel) create suitable habitat for several macroalgal species; the bottleneck is the recruitment of the algae, which is limited by appropriate substrate and supply.

CMERC is developing hatchery techniques for typical habitat-forming algae species found in the Gladstone harbour, *Sargassum sp*. and *Asparagopsis taxiformis*. Appropriate substrate will be incorporated into seawall designs and "pre-seeded" with macroalgae.

The macroalgal offset is proposed in three stages:

Stage 1 Lab base selection of optimal substrate to maximise macroalgal cover.

Macroalgae grow on a range of substrates, with some providing high initial recruitment and sustained growth. CMERC is currently developing hatchery techniques for typical habitat-forming algae species found in the Gladstone harbour and have demonstrated inoculation of substrates for both *Sargassum sp*. and *Asparagopsis taxiformis* germling establishment on green/grey hybrid concrete tiles (approx. 3 cm width x 3 cm height and 2 cm thick, provided in partnership with JPower) (Theobald et al., in prep).

- Year 20 Target: Offset completion criteria have been met in 55 ha of seagrass.

Actions and Milestones	Associated outputs and KPIs	Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	>2,000,000 *Zostera* seeds. A target of a 40% germination rate will be achieved.																				
Action 5.3: Biannual survey of monitoring plots	Field report on cover, landscape metrics, seagrass morphology, seed bank, and ephemeral brown algal cover.																				
Activity 5.4 Five yearly review	Five-year interim review and adaptive management recommendations. Report to the management group and State and Federal Government.																				
Milestone 5.2: Five-year Review Meeting	Meeting minutes, including recommendations and actions for adapting the project. New five-year plan.																				
Milestone 5.3: Comprehensive review report	A comprehensive independent review report reviews the progress and recommends any adaptations to the program plan. Reports will be published on the approver holder's website.																				

Milestones and KPI activities in years 6-20 will be adapted based on the 5-yearly review but involve maintaining the rehabilitated areas through the activities detailed in section 3.2.3. and the following KPIs:

- Continued biannual reporting to be published on the approver holder's website.
- Year 10 Target: Offset completion criteria have been met in 20 ha of seagrass.
- Year 15 Target: Offset completion criteria have been met in 40 ha of seagrass.

Actions and Milestones	Associated outputs and KPIs	Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Action 4.3: Annual seagrass flower collecting and nursery harvesting.	Evidence of five intensive spathe collection events plus four Citizen science-funded events per year. >2,000,000 *Zostera* seeds. A target of a 40% germination rate will be achieved.																				
Milestone 4.2: Annual progress meeting.	Progress report and meeting minutes, including recommendations and actions for the 5-year review.																				
Milestone 4.3: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each activity. Reports will be published on the approver holder's website and will take place over the 20 years of the project.																				
Activity 5.1 Seed Dispersal	Field report on seed dispersal of 20 ha and monitoring plot assessments 1, 3 and 6 months after.																				
Milestone 5.1: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each activity. Reports will be published on the approver holder's website and will take place over the 20 years of the project.																				
Action 5.2: Annual seagrass flower collecting and nursery harvesting.	Evidence of five intensive spathe collection events plus four Citizen science-funded events per year.																				

Actions and Milestones	Associated outputs and KPIs	Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Activity 3.2 Annual seagrass spathe (flower) collection and nursery harvesting.	Evidence of five intensive spathe collection events plus four Citizen science-funded events per year. >2,000,000 *Zostera* seeds. A target of a 40% germination rate will be achieved.																				
Action 3.3: Biannual survey of monitoring plots	Field report on pre-sowing cover, landscape metrics, seagrass morphology, seed bank, and ephemeral brown algal cover.																				
Milestone 3.2: Annual progress meeting.	Progress report and meeting minutes, including recommendations and actions.																				
Milestone 3.3: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each of the activities. Reports will be published on the approver holder's website and will take place over the 20 years of the project.																				
Activity 4.1 Monitoring: habitat usage	Field report on seagrass habitat use by fish and megaherbivores.																				
Activity 4.2 Seed dispersal	Field report on seed dispersal of 20 ha and monitoring plot assessments one, three and six months after.																				
Milestone 4.1: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each activity. Reports will be published on the approver holder's website and will take place over the 20 years of the project.																				

Actions and Milestones	Associated outputs and KPIs	Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	will take place over the 20 years of the project.																				
Activity 2.3 Annual seagrass spathe (flower) collection and nursery harvesting.	Evidence of five intensive spathe collection events plus four Citizen science-funded events per year. >1,000,000 *Zostera* seeds in year 2 for sowing project (10 ha). A target of a 40% germination rate will be achieved.																				
Milestone 2.2: Annual progress meeting.	Progress report and meeting minutes, including recommendations and actions.																				
Milestone 2.3: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each of the activities. Reports will be published on the approver holder's website and will take place over the 20 years of the project.																				
Activity 3.1 Seed dispersal	Field report on seed dispersal and monitoring plot assessments 1, 3 and 6 months after.																				
Milestone 3.1: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each activity. Reports will be published on the approver holder's website and will take place over the 20 years of the project.																				

Actions and Milestones	Associated outputs and KPIs	Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Activity 1.5 Baseline mapping	Baseline mapping report. LiDAR (DEM) and multispectral (RGB, NIR/IR) GIS layers of 60 ha seagrass area during peak seagrass growth before sowing. Thematic layers and landscape metrics. Field report of the in-situ data on seagrass cover, seed banks, and ephemeral brown algal cover.																				
Milestone 1.3: Annual progress meeting.	Progress report and meeting minutes, including recommendations and actions.																				
Milestone 1.4: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each activity. Reports will be published on the approver holder's website and will take place over the 20 years of the project.																				
Activity 2.1 Baseline data collection habitat usage	Field report of the baseline data on seagrass habitat use by fish and megaherbivores.																				
Activity 2.2 Seed dispersal	Field report on seed dispersal and monitoring plot assessments 1, 3 and 6 months after. Publication on seagrass seed retention following large-scale dispersal.																				
Milestone 2.1: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each activity. Reports will be published on the approver holder's website and																				

Table 5 Milestones, timelines and associated outputs and KPIs, up to 5-year review.

Actions and Milestones	Associated outputs and KPIs	Year 1				Year 2				Year 3				Year 4				Year 5			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Milestone 1.1: Inception meeting	Inception meeting minutes with a detailed updated work plan.																				
Activity 1.1 Permit approvals	All necessary permits and approvals are in place for seed collection and enhancement.																				
Milestone 1.2: Biannual progress report	Six monthly progress reports will be provided, which will give an update on each of the activities. Reports will be published on the approver holder's website and will take place over the 20 years of the project.																				
Activity 1.2 Establish program governance	Signed project agreement between all parties.																				
Activity 1.3 Seagrass spathe (flower) collection	Evidence of five intensive spathe collection events plus four Citizen science-funded events per year. >1,000,000 *Zostera* seeds in year 1 for sowing project (10 ha). A target of a 40% germination rate will be achieved.																				
Activity 1.4 Extension of SeaGrow	Digital management plan of tanks, showing each tank's planned, current and future usage. Report on Flume design and SOPs. Stock plant catalogue (source, date, environmental conditions, plant traits).																				

3.9. Milestones and timeline

Key milestones, KPIs and timelines for the successful delivery of the project are presented in Table 5.

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Introduce pathogens into the marine environment.	Operations Environment Organisational integrity and public image	Loss and decline of natural populations	A biosecurity plan based on the Commonwealth of Australia Aquaculture Biosecurity Plan Guidelines will be developed specifically for the project. Existing protocols (for sterilizing and provenance data management) will be applied and developed further in the project.	Moderate	Unlikely	Medium	9	Moderate	Rare	Low	6
Seagrass nursery system failure	Operations	Seagrass nursery stock dies due to pump failure or electricity outage	Plant material was moved temporarily to research the aquaria system. Backup power generator included in installation design. A system set up to send alerts to the manager in case of pump failure or water quality drops.	Moderate	Possible	Medium	13	Moderate	Rare	Low	6

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Monitoring shows no enhancement effect of seeding and no change in the persistence of seagrass at plots.	Project delivery	Offset success criteria not met	Regular monitoring will feed into a five-year review, and new scientific research will be used to adapt and improve methods. Such learnings will be shared through publications with other seagrass restoration practitioners and researchers for a broader impact. Should the offset fail, the Minister will propose a new offset for approval in writing.	Major	Possible	High	18	Moderate	Rare	Medium	6
Bad weather delays seed dispersal beyond holding times	Operations Project delivery	Unable to sow seeds	Seeds will be sowed to the nursery for stock for the following year. Research to address the optimum time of year to sow seeds based on climatic conditions.	Moderate	Possible	Medium	13	Minor	Possible	Medium	8

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Seeding reduces genetic diversity in natural seagrass populations.	Operations Environment Organisational integrity and public image	Loss and decline of the resilience of natural populations	Seed-based restoration provides greater genetic diversity than other transplant-based methods– careful management of seed source, including information on environmental and morphology. Follow well-established terrestrial guidelines on the genetic composition of any seeds released into the environment. CMERC has researched local genetic diversity in the Port of Gladstone, and others have looked at genetic relationships among Eastern Australian populations in *Zostera*. CMERC has a PhD student examining the importance of seed provenance and adaptation for restoration.	Moderate	Unlikely	Medium	14	Moderate	Rare	Low	6

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Insufficient seeds produced in any one year	Operations Project delivery	Smaller area sowed.	Over the last six years, previous collections of spathes estimate how many seeds can be harvested from a set volume of spathes. Spathe collections will be tracked, and additional collection events will be instigated if volumes are low. Reconnaissance of connected meadows will be used to find high-density flowering spots. A smaller area will be sowed, and additional seeds will be collected for a larger area the following year.	Moderate	Unlikely	Medium	13	Moderate	Rare	Low	6

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Cyclone damages natural local meadows for spathe/seed collection.	Operations Project delivery	Loss of local supply of seagrass stock plants and flowering	CMERC has been involved with seagrass projects along the east coast of Australia. CMERC/CSIRO PhD student has data on flowering locations. Plants and spathe collections will be relocated to other environmentally relevant locations and increased to meet the demand for propagules to aid local populations in recovering. Area reseeded that year will be reduced and increased in subsequent years to meet the overall target	Moderate	Unlikely	Medium	9	Moderate	Rare	Low	6

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
The degraded reference site shows natural recovery.	Rigour of monitoring	Compromise the ability to detect the enhancement management interventions have had versus natural drivers.	Replicating reference sites of degraded and healthy plots will mitigate the risk (not all reference sites are likely to recover naturally). Post-seeding monitoring at 1, 3 and 6 months after each enhancement will provide temporal resolution to detect changes due to seeding. Comparison of long-term pre-restoration(baseline versus post-restoration conditions) may also be used if the control sites show natural recovery.	Moderate	Possible	Medium	13	Moderate	Rare	Low	6

Table 4 Risk analysis and a risk management and mitigation strategy against offset completion criteria. The risk rating calculation method is provided at the start of the table.

Risk rating calculation					
	Rare	Unlikely	Possible	Likely	Almost Certain
Insignificant	Low (1)	Low (2)	Low (3)	Low (7)	**Medium (11)**
Minor	Low (3)	Low (5)	**Medium (8)**	**Medium (12)**	High (16)
Moderate	Low (6)	**Medium (9)**	**Medium (13)**	High (17)	High (20)
Major	**Medium (10)**	High (14)	High (18)	Extreme (21)	Extreme (23)
Catastrophic	High (15)	High (19)	Extreme (22)	Extreme (24)	Extreme (25)

Risk Analysis Mitigation Strategy

Risk Description	Risk Impact Area	Potential Consequences	Risk Controls	Current Risk Level			Current Risk Rating	Residual Risk Level			Residual Risk Rating
				Consequences	Likelihood	Risk Rating		Consequences	Likelihood	Risk Rating	
Delays with permits for seagrass material collection	Operations Project delivery	Delays in the delivery of the project	Early liaison with relevant authorities for permits. The material will be collected using previously accepted methods under permit to minimise damage to natural populations.	Moderate	Unlikely	Medium	9	Moderate	Rare	Low	6
Staff changes – staff leave or become unavailable during the project.	Administration Project delivery	Delays in project delivery or additional costs to the university for replacing staff resources.	Additional staff will be resourced from within CQUniversity or externally advertised through an expedited process to ensure delivery against timelines. Recruitment and selection processes will follow CQUniversity recruit for success policy.	Moderate	Possible	Medium	13	Minor	Unlikely	Low	5

- The connectivity between meadows, which is linked to recovery potential and identifying important sinks and sources in the population;
- Reproductive effort of different populations and local phenology;
- Data on the risk of disturbance of different meadows (including the potential for bi-stability);
- Ecosystem function of different meadows and the services provided, and
- Restoration methodologies developed for the local conditions and ecosystems.

Advice for the Restoration of Fish Habitats is presented under the Fish Habitat Guidelines (FHG 002) (Hopkins et al., 1998). The guidelines describe developing propagation and stock management techniques, incorporating collection, care and storage of plant materials. The guidelines require updating, and the nursery protocols, sowing program, and review supported through this offset strategy can contribute to an update regarding seagrass.

3.8. Risk Analysis

A risk analysis and a risk management and mitigation strategy for all risks to the successful implementation of the environmental offset and timely achievement of the offset completion criteria are provided in Table 4. This includes a rating of all initial and post-mitigation residual risks.

Marine plants are protected under Section 123 of the Queensland Fisheries Act 1994 as a fish habitat, irrespective of whether they are within a Declared Fish Habitat. Advice on the Restoration of Fish Habitats is presented under the Fish Habitat Guidelines (FHG 002) by the Department of Primary Industries, produced in October 1998 (Hopkins et al. 1998). Under these guidelines, note is made of successional development, whereby certain species (pioneering species) are more likely to colonise a new site. It may then either dominate, preventing other species from colonising or create an environment more suitable for different species, e.g. opportunistic species (see Box 1).

Box 1: *Why the focus on Zostera?:* Seagrass species of the genus *Halophila* are classed as colonising species, and *Z. muelleri* is classed as an opportunistic species. Seagrass species with persistent traits are not naturally found in the estuarine ecosystem of the Port of Gladstone. Successional development has two important considerations for the offset process in this case. Firstly, given that the proposed site shows variability in cover over time due to natural disturbance events, at any one point in time the species richness and diversity of the community may vary as the species shift from colonising to opportunistic. In the 2022 surveys *Z. muelleri* dominates after previous years of the dominant species being the colonising *Halophila* species. Secondly when planning restoration activities as an offset, the target species should be the desired endpoint of successional development of the community, in this case *Z. muelleri*.

Other challenges to overcome for seagrass restoration under offset policy are poor restoration success rates, the considerable effort and cost often associated with seagrass restoration, and the uncertainty in achieving goals, such as in the extent and functional equivalency. Globally, past success rates for seagrass restoration are relatively low, primarily due to poor choices of transplant method, suboptimal transplant sites and a failure to understand the donor population's environmental conditions (Van Katwijk et al. 2009). Understanding the physiology and thresholds of local species and local environmental conditions is required. It can be used to identify suitable habitats or the species' fundamental niche (where a species could grow). Identification of this fundamental niche is a valuable tool in identifying transplant locations.

Whilst there is always some uncertainty, success rates for seagrass restoration can and have been improved significantly by basing restoration approaches on sound research, which considers both the most up-to-date research globally on restoration approaches, combined with a comprehensive knowledge of the local conditions and seagrass population dynamics, to select the most appropriate intervention. A recent review of seagrass restoration in Australia and New Zealand identified that despite some setbacks, seagrass restoration is possible (Tan et al. 2020).

Often, this lack of prior restoration ecology research at a location undermines confidence in undertaking seagrass restoration under an offset policy. A considerable body of research on the ecology and distribution of local seagrasses within the Port of Gladstone exists, together with assessments of sites that would benefit from restoration and methodologies that would support restoration interventions:

- Long-term monitoring data on other meadows in the region to identify meadows in decline, lost, or those unable to naturally recover;
- Comprehensive data on the area of seagrass to be lost and a measure of its quality, e.g. density, biomass;

- An additional 10 ha of seagrass was reseeded and monitored at 1, 3 and 12 months parallel to reference sites to assess successful establishment.
- Biannual reporting will take place and be published on the approver holder's website.
- A 5-year review of monitoring data, progress and new research to inform adaptive management.
- Implementation of corrective actions
- Target: Offset completion criteria have been met in 10 ha of seagrass.

Year 6 – 20

- Additional KPIs are based on the review's output.
- Continue biannual reporting to be published on the approver holder's website.
- Year 10 Target: Offset completion criteria have been met in 20 ha of seagrass.
- Year 15 Target: Offset completion criteria have been met in 40 ha of seagrass.
- Year 20 Target: Offset completion criteria have been met in 55 ha of seagrass.

3.6. Traditional Owner consent and partnership

As part of the PCCC People (Bailai, Gurang, Gooreng Gooreng and Taribelang Bunda), all options for seagrass offsets would be presented to local elders to seek free, and prior informed consent for the restoration works to take place on Traditional Owner Sea Country. It is recommended that GPC have these discussions with PCCC TRUST and TUMRA before the strategy is finalised. Consent has been received for the seagrass nursery and demonstration site funded under the GBR Foundation, but additional consent is needed for the extension. Elders' sitting fees have been incorporated into the budget for annual meetings and discussions with PCCC Elders.

All activities will include Indigenous Sea Ranger partnerships to deliver the offset.

3.7. EPBC Act Documents and other conservation advice, relevant recovery plans and threat abatement plans

There is no approved conservation advice or threat abatement plans for seagrass meadows. However, certain species associated with seagrass do have recovery plans; for example, seagrass die-off is identified in the Turtle Recovery Plan (Commonwealth of Australia, 2017) as impacting green turtle foraging, with the loss of seagrass continuing to impact turtle health for several years. The plan notes the influence of climatic factors, including the pulsed release of nutrients and fine sediments that quantify and predict the frequency of pulse flood events and their impacts on seagrass meadows. It also implements relevant mitigation measures, which the proposed offset addresses.

- By year 20 Target: Offset completion criteria (see above for year 5) have been met in 55 ha of seagrass.

3.5. Interim milestones

The progress and completion of the offsets will be assessed annually against the following KPIs.

Year 1

- All permits were approved for collecting propagation plant material and sowing seagrass at Pelican Banks.
- Seagrass nursery capacity extension (additional seed storage tanks and flume separator) is completed to cultivate seagrass seed and store wild seed (>5 million seeds).
- Baseline mapping of seagrass at offset locations and reference sites completed.
- Baseline assessments of fish habitat use of offset locations and reference sites.
- Baseline assessments of megaherbivore foraging activity.
- Over 5 million seeds were collected and stored for sowing offset locations in Year 2.

Year 2

- 5 ha of seagrass seeded and monitored at 1, 3 and 12 months parallel to reference sites to assess successful establishment.
- Biannual reporting will take place and be published on the approver holder's website over the 20 years of the project.
- Over 5 million seeds were collected and stored in the nursery for sowing offset locations in Year 3.

Year 3

- The same 5 ha and an additional 5 ha of seagrass were reseeded and monitored quarterly with reference sites.
- Biannual reporting will take place and be published on the approver holder's website.
- Over 6 million seeds were collected and stored in the nursery for sowing offset locations in Year 4.

Year 4

- The same 10 ha (as years 1 and 2) of seagrass were reseeded and monitored quarterly with reference sites.
- An additional 10 ha of seagrass was reseeded and monitored at 1, 3 and 12 months parallel to reference sites to assess successful establishment.
- Biannual reporting will take place and be published on the approver holder's website.
- Over 6 million seeds were collected and stored in the nursery for reseeding offset locations in Year 4.

Year 5

- The same 20 ha (as year 4) of seagrass was reseeded and monitored quarterly with reference sites.

separated to the lowest taxonomic group possible. Density, abundance, and species composition of all infauna and epifauna will be recorded, and comparisons will be made between rehabilitated and reference sites across the meadow.

3.4. Offset completion criteria

The success of the offset will be reported on and confirmed at year 20 of the project, or at least one year before the expiry of the approval (whichever comes first). Any large-scale disturbances (e.g., cyclones) that occur during the project that influence the success of the offset will be presented to DCCEEW for consideration, where relevant. Offset completion will be derived when the following criteria are met (See Table 1):

- By year 20, at least 55.04 ha of intertidal *Z. muelleri* with mixed species has been rehabilitated from a biomass ≤ 0.64 g DWm^{-2} to ≥ 5 g DWm^{-2} at the offset site (Meadow 43, Pelican Banks) compared to areas of no intervention (reference sites) through repeated sowing;
- Rehabilitated areas are shown, over more than five years of biannual monitoring, to have greater persistence (from transitory to enduring, i.e. persist for > five years) compared to areas of no intervention (reference sites).
- Rehabilitated areas are shown, over more than five years of biannual monitoring, to have greater cohesion (less fragmentation or patchiness) compared to areas of no intervention (reference sites).
- Over more than five years of biannual monitoring, rehabilitated areas are shown to have increased in biomass from <0.64 to 5 g $DW.m^{-2}$ across the 55.04 ha of rehabilitated area (sufficient to support an estimated two dugongs over one year, and 114 turtles).
- More than one dugong feeding trail is observed in rehabilitated areas.
- Aerial surveys of turtles identify similar number using the rehabilitated areas compared to the reference areas.
- Densities, species diversity and community composition of benthic invertebrates (epifauna and infauna) of rehabilitated areas are comparable to sites with no intervention (reference sites of similar biomass) and greater than the impacted site, to demonstrate increased food availability for foraging fish (available as food for dolphins).

The following interim completion targets will be used to assess the requirement for early intervention and adaptive management at 5 yearly review:

- By year 5, at least 10 ha of intertidal *Z. muelleri* with mixed species has been rehabilitated from a biomass ≤ 0.64 g DWm^{-2} to ≥ 5 g DWm^{-2} at the offset site (Meadow 43, Pelican Banks) compared to areas of no intervention (reference sites) through repeated sowing;
- By year 5 at least one dugong feeding trail is observed in rehabilitated areas.
- By year 5 densities, species diversity and community composition of benthic invertebrates (epifauna and infauna) of rehabilitated areas are greater than sites with no seagrass (unvegetated reference sites), to demonstrate increased food availability for foraging fish (available as food for dolphins).
- By year 10: Offset completion criteria (see above for year 5) have been met in 20 ha of seagrass.
- By year 15 Target: Offset completion criteria (see above for year 5) have been met in 40 ha of seagrass.

dugong are feeding in the rehabilitated areas and undertake comparisons with reference locations. Surveys of the six 1 ha reference and rehabilitation areas (1 ha plot per 10 ha of rehabilitation sites), will be undertaken bi-annually following the methods outlined in Rasheed et al. (2016). The number of feeding trails will be determined across enhanced and reference sites, and the enhanced sites must demonstrate equivalent or greater usage relative to the impacted site.

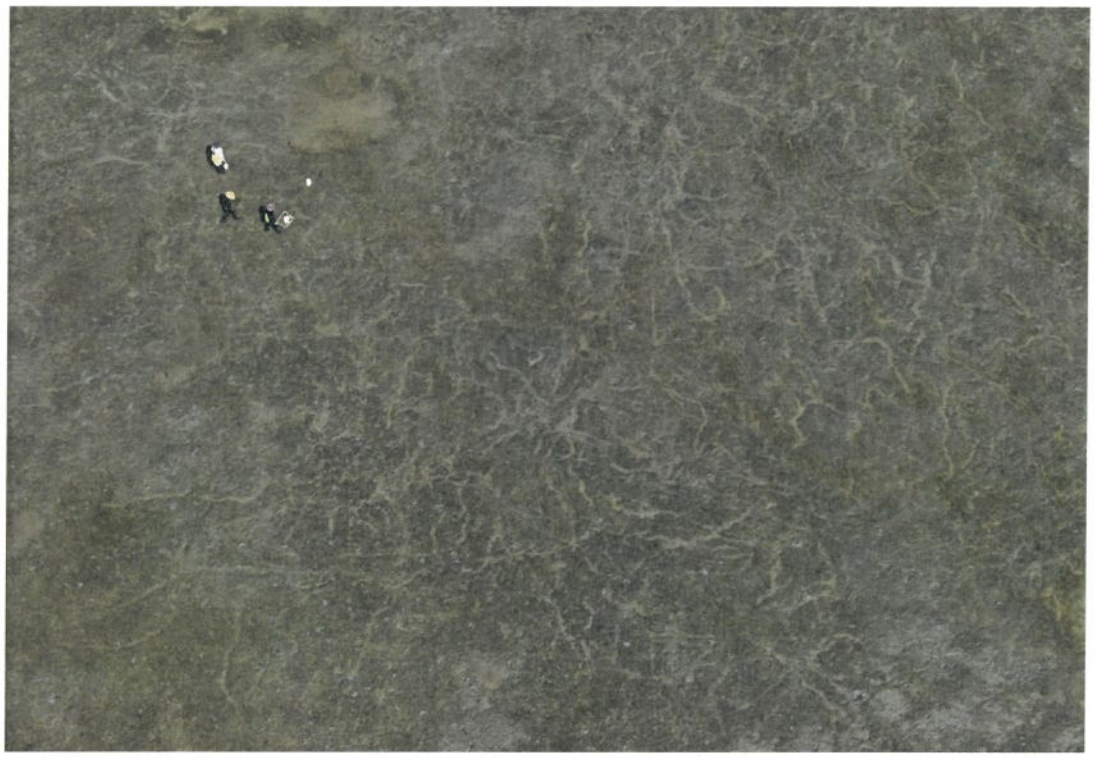


Figure 19 An example of dugong feeding trails visible on an intertidal Zostera muelleri *meadow in Queensland.*

Green turtle foraging does not leave obvious feeding trails. The occurrence of green turtles feeding in the rehabilitated area versus the reference sites will be assessed using the shallow water drone imagery, DFT imagery and observations during field work. All occurrences of turtles will be georeferenced and stored, and distributions compared between reference and rehabilitated sites every five years.

Benthic invertebrates can indicate food availability for fishes that utilise seagrass meadows for foraging and demonstrate ecosystem productivity. In turn, higher food availability to support a greater abundance of fishes can provide food for the local dolphin populations foraging in the harbour. Therefore, monitoring benthic invertebrate abundance can be used as an indirect indicator of ecosystem benefits to dolphins in the rehabilitated sites. Annual monitoring of benthic invertebrate communities will be conducted to compare rehabilitated areas to unseeded reference areas (with seagrass present and absent). Infauna and epifauna will be sampled at a minimum of 20 replicates per area. Infauna will be collected using handheld cores (0.025 m^2, 200-250 mm deep). Sediment samples will be sieved (1 mm) and retained material will be placed into a sample container with 4% buffered formaldehyde solution. In the laboratory, invertebrates will be sorted, identified (to the lowest practical level) and counted. Mobile and sessile epifauna will be collected prior to coring from a 0.25 x 0.25 cm quadrat. Again, individuals will be

Meadow 43 at Pelican Banks for direct comparisons without confounding influences from other locations, but at a distance of more than 500 m from rehabilitated (seeded) sites to avoid potential influences from the seeding. Comparisons between rehabilitated and reference sites will also be reported on within the context of wider changes to seagrass in the region, using data an annual ongoing monitoring of seagrass meadows across the Port of Gladstone, which is carried out as part of the Gladstone Ports Corporation's sustainable dredge management plan.

Monitoring will be on two spatial scales. Fixed 1 ha plots in the sowed areas (1 ha for every 10 ha of seeded area) will be compared to six 1 ha reference areas (three unvegetated un-sowed and three vegetated un-sowed) to assess if the change in seagrass cover is due to external drivers. The spatial configuration of the patches is an important indicator; therefore, monitoring at this level should provide full coverage mapping, for example, via repeat high-resolution multispectral and LiDAR or another valid method. The method selected will monitor changes in cover and elevation in each of the monitoring plots repeated biannually for ten years, with an expectation that change will be evident and can be reviewed after five years. Data from ongoing annual seagrass monitoring (TropWater commissioned by GPC) and the Marine Monitoring Program will also reference changes in the sowed plot due to interventions or significant environmental drivers.

The characteristics of the spatial landscape contiguity of each sowed and referenced permanent monitoring site will be quantified at the seagrass class level within each landscape using the Contagion (Cohesion) index (as an indication of the degree to which a seagrass landscape may be subdivided into separate seagrass patches). This correlates with the existing monitoring data's definitions of aggregated and small isolated patches but provides a more quantifiable approach.

Low density seagrass is not always visible from aerial drones, therefore to allow a measure of cohesion in this situation, for the first five years on the ground assessments of fragmentation will be undertaken, to guarantee sufficient data for the 5-year review and adaptive management strategies. Permanent transects will be set out (four per monitoring plot). In-situ surveys will be carried out before and after sowing (within three months and during peak growth, November). In addition to following standard Marine Monitoring Programme protocols, transects will be used as an on-the-ground assessment of change in configuration (fragmentation or cohesion) of the Sowed and un-sowed areas will be calculated as a fractal dimension (Burrough 1986, Manzanera and Romero 2000). The position of each seagrass/ bare sediment transition will be recorded along each transect. For each section, the length of the seagrass section (L) was measured at increasing levels of resolution [(R): 1 m, 2 m, 4 m and 8 m]. The slope of the line obtained by regressing log(L) on record (R) gives a value of the fractal dimension (Burrough, 1986), with a size of zero denoting strict spatial dependence (homogeneity) and values moving towards one reflecting an increase in heterogeneity.

Monitoring plots will be surveyed biannually and reported on. Severe weather events resulting in habitat degradation (identified in biannual monitoring) will trigger additional corrective action regarding a repeat sowing event in existing and other plots where needed.

The use of remote sensing as a sampling tool to provide a census of dugong feeding trails has been trialled locally across a large study area and over multiple years (Rasheed et al. 2016). This method works well in intertidal meadows to identify the occurrence of trails (see Figure 19, but does not provide data to make meaningful inferences regarding the size of local dugong populations. For the purposes of the offset completion criteria the aim will be to identify that

Years 12, 14, 16, 18

Activity #.1 Annual seed dispersal at enhancement locations

The same 55 ha will be seeded where needed to maintain persistence, incorporating learnings from the five-year review.

Activity #.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated, following the approach outlined in Activity 1.3 (above), incorporating learnings from the five-year review.

Activity #.3 Biannual monitoring (see section 3.3 for details), incorporating learnings from the five-year review.

Milestones: Annual progress meeting and two six monthly progress reports will be provided that will provide an update on each of the activities. Biannual reporting to be published on the approver holder's website.

Year 20

Activity 20.1 Annual seed dispersal at enhancement locations

The same 55 ha will be seeded where needed to maintain persistence, incorporating learnings from the five-year review.

Milestones: Annual progress meeting and two six monthly progress reports will be provided that will provide an update on each of the activities. Biannual reporting to be published on the approver holder's website. Final offset report produced and published on the approver holder's website.

3.3. Monitoring Program

The project expects that facilitated recovery through seed enhancement within the demonstration site would result in a press response with a more sustained period of cover at the site after the intervention, stabilising longer-term fluctuations. Therefore, the first objective of monitoring is to assess the change in the area (ha), landscape contiguity (Aggregated patches versus isolated patches) and persistence (enduring versus transitory, Kilminster et al. 2015) of seagrass at sowed versus un-sowed sites in the area. Persistence and contiguity of seagrass at the sites are expected to result in a more stable and diverse in-fauna (a proxy for fish and bird foraging value), enhanced trapping of fine sediments and organic matter, and an increase in carbon capture (including recalcitrant allochthonous sediment organic carbon).

Given that this project will be undertaken at a location where there is significant variation in space and time for seagrass cover if an impact of the restoration is to be detected, the demonstration site requires a sampling design and adequate replication of control areas in space and time. Monitoring will be carried out both before and after the intervention (sowing) and in both a control and at the impacted (intervention) area (BACI, Before After, Control, Impact or in this case, Intervention). Reference sites (vegetated and unvegetated) will be established within

In Year 9, the same 55 ha will be seeded where needed to maintain persistence, incorporating learnings from the five-year review.

Activity 9.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated in Year 9, following the approach outlined in Activity 1.3 (above), incorporating learnings from the five-year review.

Activity 9.3 Biannual monitoring (see section 3.3 for details), incorporating learnings from the five-year review. Biannual reporting to be published on the approver holder's website.

Year 9 Milestones: Annual progress meeting and two six monthly progress reports will be provided that will provide an update on each of the activities

Year 10

Activity 10.1 Annual seed dispersal at enhancement locations

In Year 10, the same 55 ha will be seeded where needed to maintain persistence, incorporating learnings from the five-year review.

Activity 10.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated in Year 10, following the approach outlined in Activity 1.3 (above).

Activity 10.3 Monitoring: fish and bird foraging habitat and megaherbivore usage

See the approach in Activity 2.1.

Activity 10.4 Five yearly review (Interim Milestone)

Year 10 Milestones: Annual progress meeting and two six monthly progress reports will be provided that will provide an update on each of the activities. Biannual reporting to be published on the approver holder's website.

Years 11, 13, 15, 17, 19

Activity #.1 Annual seed dispersal at enhancement locations

The same 55 ha will be seeded where needed to maintain persistence, incorporating learnings from the five-year review.

Activity #.2 Annual seagrass spathe (flower) collection

Spathe collection events will be repeated, following the approach outlined in Activity 1.3 (above).

Activity #.3 Monitoring: fish and bird foraging habitat and megaherbivore usage

See the approach in Activity 2.1.

Activity #.4 Five yearly review (Interim Milestone) Year 15 only.

Milestones: Annual progress meeting and two six monthly progress reports will be provided that will provide an update on each of the activities. Biannual reporting to be published on the approver holder's website.

Marine Sciences Association (AMSA) conference, the Australian Society for Phycology and Aquatic Botany conference, and the Australian Coastal Restoration Network Symposium offer platforms to share project outcomes with the broader scientific community, government agencies, Traditional Owner groups, and industry professionals. Additionally, the Society for Ecological Restoration (SER) international conference provides an ideal stage to engage with global experts in marine restoration.

CMERC has extensive macroalgal facilities and CMERC researchers have a track record of publications demonstrating expertise in macroalgal ecology and physiology, detailed below.

Past five years:

Theobald, E. J., Irving, A. D., Capper, A., Costa, J. F., Diaz-Pulido, G., Andrews, E. L., ... & Jackson, E. L. (2024). Selection of marine macroalgae for nutrient biofilter and bioproduct trials in the coastal waters of Queensland, Australia. *Aquaculture International*, 1-39.

Theobald, E. J., Rule, M. B., Jackson, T. L., Rula, N. A., Diaz-Pulido, G., & Jackson, E. L. (2024). Abiotic triggers for maximising germling numbers in Asparagopsis taxiformis (Rhodophyta, Bonnemaisoniales) via tetrasporogenesis. Journal of Applied Phycology, 1-19.

Aiken CM, Jackson EL and Kelly J (2023). *Seaweed biofilters: marine spatial planning and modelling workflow.* Coastal Marine Ecosystems Research Centre, CQUniversity Australia, Queensland.

Capper, A., Alahakoon, S., Aiken, C., Nunes, R., Chandra, S., Moore, S. (2023). Microalgal removal from aquaculture discharge using electro-flocculation. by the Coastal Marine Ecosystems Research Centre, CQUniversity for the Department of Agriculture and Fisheries Regional Economic Development fund.

Irving, A.D., Capper, A.C., Theobald, E.J., Costa, J.F., Jackson, E.L. Theobald, E., 2023. Selection of marine algae for nutrient biofilter and bioproduct trials in the GBR coastal region. Poster at International Seaweed Symposium, 19-24 February 2023, Hobart, Australia.

Rule, N., Smith, A., Kinley, R., Jackson, E. L (2023). Predicting habitat suitability for the red sea plume (Asparagopsis taxiformis) in the Great Barrier Reef. Poster at International Seaweed Symposium 19-24 February 2023, Hobart, Australia.

Contreras-Porcia, L., Meynard, A., Piña, F., Kumar, M., Lovazzano, C., Núñez, A., & Flores-Molina, M. R. (2022). Desiccation stress tolerance in Porphyra and Pyropia species: a latitudinal analysis along the Chilean coast. *Plants*, *12*(1), 12.

6.5. Estimated budget

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7. ALIGNMENT WITH BROADER STRATEGIES AND PROGRAMS FOR THE GREAT BARRIER REEF

The proposed offsets are the first to target direct seagrass rehabilitation and seaweed habitat creation. They use established methodology and are backed by significant existing investments in research, partnerships (including First Nations People, industry, community, practitioners, managers, and researchers), and infrastructure. The offset's target is a net gain in quality of habitats (Tables 1 and 2), with knock-on benefits for fish and migrating shorebirds and vulnerable species such as the dugong and green turtle.

The proposed offsets align with the broader strategies and programs for the Great Barrier Reef, including but not limited to the Reef 2050 Plan and will provide a net benefit to the GBRWHA, as detailed below.

7.1. Reef 2050 Plan objective: Resilient seagrass meadows that maintain condition.

- Pilot and implement interventions that support the resilience of coral reefs, seagrass, other marine habitats and islands
- Local traditional owners and land and sea management organisations are equipped to operate at the appropriate scale.

The most significant current drivers of seagrass loss in the GBR are storms and flood events, which are becoming more frequent and intense with climate change. Some meadows are entirely lost during an event but recover quickly, whilst others persist but are slow to recover in terms of biomass or continuity of seagrass patches. The loss will likely increase with projected scenarios of more frequent La Niña climate conditions and severe storms. Proactive intervention is a necessity, as is setting up facilities and capability ahead of a significant event to be ready to respond.

The team at CMERC have developed procedures for seed-based seagrass restoration to enhance resilience in seagrass meadows, which are now ready to scale up, supply large-scale demonstration sites and extend to other sites across the GBR in partnership with Traditional Owners, industry, local Natural Resource Managers (NRMs)and partner research organisations.

The establishment of the state-of-the-art seagrass nursery facilities at CMERC (November 2024) will not only provide seeds for the enhancement project but also support First Nations Ranger (Gidarjil Development Corporation) time working and training with CMERC on the nursery, to transfer management to local First Nations organisation and establish First Nation's led training and capacity for other GBR locations. Establishing seed enhancement areas and funding would need to support the growth of the nursery and broader capacity building. The facility will support research and training to develop the protocols and best practices to extend seagrass culture (propagation, seed storage, pest management). A focus is on building Traditional Owners' capabilities in Sea Country habitat restoration and nursery management for coastal restoration; supporting ongoing seagrass cultivation research and development; informing and supporting resource and port managers in restoration and mitigation strategies; and fast-tracking the development of a restoration mariculture industry that will stimulate job creation in this field in the region and support Blue Carbon capture, Biodiversity Offsets and fine sediment control, and protection of listed threatened and migratory species such as dugongs and marine turtles.

As a critical demonstrated fish habitat, the enhancement of these meadows also addresses the Reef 2050 Plan objective: Populations of fish and invertebrate species that are important for

recreational, commercial and culturally based fisheries are healthy. Fish, crustacea and cephalopods utilise these meadows for different stages of their lifecycles, including species that nursery in coastal habitats before moving out onto the reef (Olds et al. 2012).

Seagrass is recognised as providing a significant contribution to the OUV of the GBRWHA. Seagrass in the Port of Gladstone is an essential grazing area for dugongs and turtles (Scott et al. 2021), fish habitat (Connolly et al., 2006), foraging shorebird (Wildlife Unlimited 2020), and traps fine sediments and sequesters carbon at higher rates than terrestrial systems, but still with high variability depending on the state of the meadows and their location (Ricart et al. 2020).

Dugong (*Dugong dugon*) are protected under the EPBC Act as a migratory species and are considered an MNES. The meadow at Pelican Banks was previously identified as a key foraging area for local dugong populations by analysing temporal changes in dugong foraging trails (Rasheed et al. 2017a). Rasheed et al., 2017) found that the density of dugong feeding trails was positively correlated with increased seagrass presence and above-ground biomass. The meadow is also an important site for the Vulnerable (EPBC Act 1999) Green turtle *Chelonia mydas* (Limpus et al. 2017). Large-scale seagrass losses in Queensland have been linked to starvation and death of both dugong and green turtles (Meager and Limpus 2012, Marsh et al. 2022). With Offset targets that create a net gain in seagrass in terms of higher biomass and cover in an area where more turtles and dugongs currently graze, the project is expected to positively impact all grazing herbivores, including dugongs and green turtles.

Globally, nationally and at other sites in Queensland, the value of seagrass habitat (including intertidal *Zostera muelleri* habitat) to recreationally and commercially valuable species has been shown (Coles et al. 1993, Jackson et al. 2001). Fish habitat use data for Gladstone is limited; however, Connolly et al. (2006) undertook standardised trawl surveys across habitats and depths and found spatial variations in demersal fish species diversity and abundance that indicate differences in fish usage of meadows in the impacted site versus Pelican Banks, with Pelican Banks showing a more distinct seagrass fish fauna composition that was more similar to other mid harbour seagrass sites.

Shorebird monitoring carried out under the Ecosystem Research and Monitoring Program[7] (ERMP) ranked Pelican Banks highly in benthic prey availability for shorebirds (Choi et al. 2017). However, the site's quality differed across the seven shorebird species assessed. Based on the quotient of predicted prey intake rate divided by energy expenditure, Pelican Banks were identified as a profitable foraging area across all tidal zones for Bar-tailed godwits, Great knot, Grey-tailed tattlers, Red knot, Terek sandpipers and Whimbrel due to the high densities of polychaete, but not for the Eastern Curlew due to a less proportion of small crab available (Choi et al. 2017). Seagrass meadows are commonly shown to harbour greater species diversity and abundance of benthic fauna than unvegetated habitats, and recent studies on *Z. muelleri* colonisation found an increase in both biodiversity and abundance of macrofauna (Lundquist et al. 2018). Even short seagrass canopies baffle currents, promoting sedimentation and reducing the resuspension of organic particles, and roots trap sediments. This often maintains intertidal seagrass-covered mudbanks at elevations greater than adjacent unvegetated areas and protects

[7] The Ecosystem Research and Monitoring Program (ERMP) was a compliance requirement under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) approval for the Western Basin Dredging and Disposal project. The ERMP studies were completed in 2022 after a decade of research.

upper tidal flats from erosion (Bos et al. 2007, Christianen et al. 2013), which can indirectly positively influence available feeding time. Upper tidal flats are important to many shorebirds as they provide more than 70% of a bird's cumulative foraging time (Mu and Wilcove 2020). Conservation significant species recorded within the area of interest and its one-kilometre buffer include the Beach stone-curlew (NCA Vulnerable); Western Alaskan bar-tailed godwit (NCA and EPBC Vulnerable), Eastern curlew (NCA Endangered and EPBC Critically endangered) and whimbrel.

The sediment trapping process also aids the sequestration of organic material from within the seagrass meadow (autochthonous) and outside the meadow (allochthonous). As a result, carbon burial rates in seagrass meadows can be up to three times higher in seagrass compared to adjacent bare sediment (Gacia and Duarte 2001). Ricart et al. (2015) evaluated the influence of local scale landscape configuration on carbon storage in seagrass sediments at a site on Pelican Banks. They found that carbon stocks were significantly higher within seagrass patches than edges and bare sediment.

7.2. Reef 2050 Plan Objective: Expand Indigenous land and sea ranger programs to additional areas to deliver on-ground activities, including compliance, marine monitoring, and species protection and management.

CQUniversity and CMERC authentically engage with First Nations People across our research areas. These partnerships embody the actions outlined in our recently launched Innovate Reconciliation Action Plan and support First Nations people's empowerment.

CMERC is currently working with Traditional Owners in the PCCC TUMRA through a partnership with Gidarjil Development Corporation Sea Rangers in the Gladstone and Bundaberg Region, Whitsundays (Ngaro), Isaac Region (Koinmerburra People) and Konomie Island (Woppaburra People) to build capacity and training for seagrass restoration. A focus is on building Traditional Owners' capabilities in Sea Country habitat restoration and nursery management for coastal restoration; supporting ongoing seagrass cultivation research and development; informing and supporting resource and port managers in restoration and mitigation strategies; and fast-tracking the development of a restoration mariculture industry that will stimulate job creation in this field for First Nations People in the region and support Blue Carbon capture, Biodiversity Offsets and fine sediment control, and protection of listed threatened and migratory species such as Dugongs and marine turtles. The inclusion of seagrass restoration in this offset strategy provides the strong "end user" impetus for the operation of the GBRF Coles Large scale nursery (SeaGrow). It will help develop capacity and support First Nations Sea Rangers (Gidarjil Development Corporation and other PCCC Traditional Owner Groups) to ultimately manage the facility and seagrass restoration activities in the region and beyond. The facility will support research and training to establish the protocols and best practices to extend seagrass culture and restoration by First Nations People to other parts of the GBRMP and Australia.

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