4. KEY ENVIRONMENTAL PRINCIPLES AND FACTORS

4.1 PRINCIPLES OF THE EP ACT

Part I, section 4A of the EP Act sets out five core principles by which protection of the environment is to be achieved in Western Australia. The principles are further elaborated on in the EPA's Statement of Environmental Principles, Factors and Objectives (EPA 2018c).

These principles and the manner in which Subsea 7 has sought to apply them in the design and planned implementation of the Proposal are described in Table 4-1.

Principle	Consideration of Principle in Proposal
The Precautionary Principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decision should be guided by: • Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and • An assessment of the risk-weighted consequences of various options.	Subsea 7 has undertaken comprehensive environmental studies on aspects of the Proposal that may impact the environment, including BCH, terrestrial flora and fauna, coastal processes and marine fauna. These studies are described under the relevant preliminary key environmental factor, within the 'receiving environment' section. The Proposal design has, as much as practicable, taken into account the outcomes of the environmental technical studies, in consultation with the relevant agencies. Project design was amended to minimise the risk of serious or irreversible impacts and appropriate management measures have been adopted to minimise residual impacts. Management and mitigation measures to minimise potential environmental impacts during construction and operations will be addressed through an overarching Construction Environmental Management Plan (CEMP) and Operational Environmental Management Plan (OEMP). Specific key management plans have been developed as components of this ERD (refer Attachment 3).
The Principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	Subsea 7 commits to manage environmental impacts within their control, such that the risks of adverse impacts are minimised and the quality of the environment is maintained or enhanced wherever possible.

Principle	Consideration of Principle in Proposal
The Principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Impacts to BCH will be minimal when assessed at the worst case and will not impact the biological diversity and ecological integrity of the Heron Point area or wider region. Impacts to marine fauna will be managed through the implementation of the MFMP (Attachment 3) to maintain the biological diversity and abundance of marine fauna in Exmouth Gulf. Impacts to terrestrial vegetation, flora and fauna are not expected to be significant, or pose a risk of loss of biological diversity and ecological integrity.
Principles relating to improved valuation, pricing and incentive mechanisms Environmental factors should be included in the valuation of assets and services The *polluter pays* principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. The user of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	Where possible, Subsea 7 will employ appropriately trained local personnel and source local goods and services. Subsea 7 will ensure leading best practice standards during construction and operations to minimise emissions and discharges as far as possible and ensure negative legacies are not created. Subsea 7 recognises the need to provide sufficient capital and operating funds to ensure environmental management measures are implemented throughout the project life. Provision has also been made for costs associated with closure and decommissioning and these costs form part of the cost of production. Where practicable Subsea 7 will source goods and services that have the least environmental impact.

Principle	Consideration of Principle in Proposal
The principle of waste minimisation All reasonable and practicable measures should be undertaken to minimise the generation of waste and its discharge into the environment.	All reasonable and practicable measures to minimise the generation of waste and its discharge to the environment will be taken. Waste generated from the Proposal will be minimised through the implementation of the hierarchy of waste controls; avoid, re-use, recycle, recover and dispose. Waste avoidance and minimisation objectives will be outlined in the CEMP and OEMP.

Table 4-1: Principles of the EP Act

4.2 PRELIMINARY KEY ENVIRONMENTAL FACTORS

The following preliminary key environmental factors require assessment, as identified within the ESD (Attachment 1):

- Benthic Communities and Habitats.
- Coastal Processes.
- Marine Environmental Quality.
- Marine Fauna.
- Flora and Vegetation.
- Subterranean Fauna.
- Terrestrial Fauna.
- Inland Waters.
- Social Surroundings.
- Other Environmental Factors or Matters: Terrestrial Environmental Quality (not considered a key environmental factor, but to be addressed).

5. PRELIMINARY KEY ENVIRONMENTAL FACTORS

5.1 KEY ENVIRONMENTAL FACTOR 1 – BENTHIC COMMUNITIES AND HABITAT

5.1.1 EPA Objective

To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.

In the context of this objective, 'Ecological integrity' is the composition, structure, function and processes of ecosystems, and the natural variation of these elements. The objective for this factor recognises that marine benthic communities are important components of almost all marine ecosystems, and are fundamental to the maintenance of ecological integrity and biological diversity of the marine environment as a whole.

5.1.2 Policy and Guidance

Subsea 7 has taken into consideration relevant policy and guidance in the design of the Proposal, the completion of the environmental impact assessment and through the development of this ERD.

A summary of the policy and guidance relevant to BCH, and how Subsea 7 has considered these, is presented in Table 5-1.

Policy/Guidance	Consideration for Proposal
Statement of Environmental Principles, Factors and Objectives (EPA 2016c, 2018c)	Referred to in the identification and assessment of Preliminary Key Environmental Factors.
Environmental Factor Guideline – Benthic Communities and Habitats (EPA 2016d)	This guidance was consulted in the consideration of potential direct and indirect impacts to Benthic Communities and Habitat (BCH) as a result of the Proposal, and in the development of options to avoid or mitigate impacts. The guidance states that '*When assessing potential impacts on benthic communities and habitats, the EPA is mainly concerned with changes that are likely to significantly impact on biological diversity and ecological integrity. The EPA is therefore mainly focused on the extent, severity and duration of the impact(s) and hence whether any consequent losses to benthic communities or their habitats are temporary or permanent*.'
Technical Guidance – Protection of Benthic Communities and Habitats (EPA 2016e)	This guidance was consulted in the development of local assessment units (LAUs) for the assessment of potential impacts to BCH, the characterisation of the BCH present within the LAUs, and in the calculation of cumulative impacts.
Technical Guidance Environmental Impact Assessment of Marine Dredging (EPA 2016v)	This guidance was referenced in the definition of the zones of impact associated with launchway construction and Bundle launch and tow.

Policy / Guidance	Consideration for Proposal
WA Environmental Offsets Policy (Government of Western Australia 2011)	These policies were considered as part of the determination of the need for offsets.
WA Environmental Offsets Guidelines (Government of Western Australia 2014)	
Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (DSEWPAC 2012a)	
Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005 – 2015 (MPRA and CALM 2005)	This management plan was reviewed during the assessment of BCH within the Ningaloo Marine Park and Muiron Islands Marine Management Area.

Table 5-1: Key Policy and Guidance Relevant to BCH

5.1.3 Receiving Environment

5.1.3.1 Regional Benthic Communities and Habitats

Benthic communities and habitats (BCH) play important roles in maintaining the integrity of marine ecosystems and the ecological services they supply. There is strong evidence that the presence of benthic communities can be important for the maintenance of biodiversity through provision of structurally complex and diverse habitat, provision of refuge, and increased food supply. Some of these complex habitats are important recruitment and nursery areas for many marine fauna species and may also provide essential food resources for large marine mammals, such as dugongs and turtles. Benthic primary producer habitats form the foundation of many marine food webs that, in turn, support productive and economically important fisheries (EPA 2016d).

A number of marine studies have previously been undertaken within the region (Exmouth Gulf and adjacent areas around the Muiron Islands) in the period 1994 to 2015, as outlined in Table 5-2. Subsea 7 has augmented the information available as a result of these previous studies by commissioning additional, Proposal-specific studies, to ensure a comprehensive level of information is available to support completion of the environmental impact assessment.

The Proposal-specific studies, as listed in Table 5-2, were undertaken by various technical specialists, and are included in full within Attachment 2. They are also referred to, as appropriate, in the assessment of potential impacts and proposed management measures.

Survey Date	Researcher / Consultant	Study Description / Title
Regional Studies		
1994	McCook *et al*.	Seagrass communities in Exmouth Gulf, Western Australia: a preliminary survey
1996	Hutchins *et al*.	Marine Biological Survey of the Muiron Islands and the Eastern Shore of Exmouth Gulf
1999	Loneragan *et al*.	Developing techniques for enhancing prawn fisheries, with a focus on Brown tiger prawns (*Penaeus esculentus*) in Exmouth Gulf

Survey Date	Researcher/Consultant	Study Description/Title
2003	Bancroft	Broad-scale regional marine habitats of selected areas in Western Australia
2006	CSIRO	Ecosystem characterisation of Australia's North West Shelf
2006-2007	Kobryn *et al*.	Ningaloo Reef: Shallow Marine Habitats Mapped Using a Hyperspectral Sensor
2013-2015	Vanderklift *et al*.	Natural dynamics: understanding natural dynamics of seagrasses in north-western Australia
2018	Oceanwise	Exmouth Gulf, north western Australia: A review of environmental and economic values and baseline scientific survey of the south western region
Project-specific Studies		
2016	360 Environmental	Survey of benthic habitats off Heron Point
2017	360 Environmental	Survey of benthic habitats within the Heron Point Local Assessment Unit (LAU)
2017	360 Environmental	Survey of benthic habitats within the 'Bundle Laydown Area'
2018	MBS Environmental	Exmouth Gulf Benthic Communities and Habitat survey report (Attachment 2C)

Table 5-2: Overview of Local and Regional BCH Studies

Various attempts have been made to map benthic habitats across the wider Exmouth Gulf, and particularly within the Ningaloo Marine Park (Bancroft 2003, Oceanica 2008, Kobryn *et al*. 2013); however, the naturally elevated turbidity has made reliable classification of benthic habitats from remote imagery difficult (Kobryn, H. pers comm. 2018). Numerous surveys have targeted subtidal benthic habitats in the Exmouth Gulf, including McCook *et al*. (1995), Hutchins *et al*. (1996) and Loneragan *et al*. (2003). McCook *et al*. (1995) published the first survey of seagrass communities of the east coast of the Gulf.

Seagrasses

It is widely recognised that a number of seagrass species (including *Cymodocea angustata, Cymodocea serrulata, Halodule uninervis, Halophila ovalis, Halophila spinulosa, Syringodium isoetifolium* and *Thalassodendron ciliatum*) occur within Exmouth Gulf, predominantly along the eastern and southern margins (McCook *et al*. (1995), Hutchins *et al*. (1996) and Loneragan *et al*. (2003)). A key driver of seagrass distribution is the amount of sunlight within the wavelengths necessary for photosynthesis (photosynthetically active radiation (or PAR)) reaching the seabed, which is affected by seabed depth and water clarity. Seagrasses were rare or absent below 5 m depth (McCook *et al*. 1995).

From August 2013 to March 2015 (18 months), surveys of seagrass abundance were undertaken in the Exmouth Gulf region under the Western Australian Marine Science Institution (WAMSI) Dredging Science Node Project 5.3 (Vanderklift *et al*. 2016). The locations surveyed (South Muiron Island, Bundegi and Exmouth Gulf) encompassed a range of water clarity from clear to turbid. The Bundegi site was located approximately 40 km north of the Development Envelope and the Exmouth Gulf sites (G1 and G2) were located approximately 25 km east of the Development Envelope. At the Exmouth Gulf sites five seagrass species were recorded; *Halodule uninervis*, *Halophila ovalis*, *Halophila spinulosa*, *Syringodium isoetifolium* and *Cymodocea angustata*. At Bundegi, two species were recorded; *H. ovalis* and *H. uninervis*. Bundegi and Exmouth Gulf had similar trends in cover, which tended to be highest in late summer (March 2015) and lowest in winter, though the peak density of different species varied from November (*H. ovalis*) to March (*H. spinulosa*) (Vanderklift *et al*. 2016).

The levels of photosynthetically active radiation (or PAR) near the seafloor were lowest at the Exmouth Gulf sites, with a maximum in summer (December) and a minimum in winter (June). To provide a biologically meaningful reference point for these measurements, the PAR was compared against reported values for the onset of saturating light intensities for photosynthesis in *H. uninervis* (Ek). At light intensities above Ek the plants will not be light-limited. For *H. uninervis*, reported Ek values span a wide range, from approximately 50 to 300 µmol $m^{-2}s^{-1}$ (Campbell *et al*. 2007, Lee *et al*. 2007, Collier *et al*. 2012, Ow *et al*. 2015). At the Exmouth Gulf sites PAR did not exceed 300 µmol $m^{-2}s^{-1}$ on approximately 30 days of the 529 day study (or 0.1% of the time) and light intensity failed to exceed 9 µmol $m^{-2}d^{-1}$ on 23 occasions. Six of these lasted for more than nine days and the longest event lasted for 31 days, indicating that seagrasses at these sites are naturally subject to long durations of low light levels (Vanderklift *et al*. 2016). In proximity to the Development Envelope a small area of sparse seagrass (*H. uninervis* and *H. ovalis*) has been recorded (Attachment 2B).

<u>Macroalgae</u>

Algae including Sargassum, Dictyopteris, Padina, Caulerpa, and Halimeda have been recorded within Exmouth Gulf and across the Dampier Archipelago to the north (Huisman and Borowitzka 2003) (Attachment 2B). In terms of biomass (abundance), macroalgal communities in the Dampier Archipelago vary seasonally, but also show marked variation interannually when comparing within seasons (Chittleborough, 1983). Peak macroalgal biomass in Exmouth Gulf is expected to similarly occur during summer.

<u>Soft Sediment</u>

Limited information is available on the extent and type of soft sediment that covers a large part of the central seabed in Exmouth Gulf, or its associated fauna. Additionally, no published surveys have covered the benthic regions where commercial trawling is carried out. It is reported in Kangas *et al*. (2006a) that an Apache Energy study reported that soft sediment regions above (i.e. shallower than) 20 m depth outside commercial trawl areas have extensive invertebrate communities, of which the most abundant are echinoderms including sand dollars, Diadema urchins, heart urchins, and crinoids.

<u>Filter Feeders</u>

Well developed filter feeder communities (those communities comprising species such as sponges, tunicates and cnidarians other than hermatypic corals) occur in the northern part of Exmouth Gulf around North West Cape and the Muiron Islands (CALM 2005). A survey of the filter feeding communities adjacent to North West Cape (Bancroft 2003) found that the greatest density and diversity of filter feeding communities occurred in the waters adjacent to tip of the North West Cape. Surveys by the Australian Institute of Marine Science (AIMS) during 2004 in depths between 20 m and 200 m have recorded extensive areas of filter feeding communities in Ningaloo Marine Park and the Muiron Islands Marine Management Area (CALM 2005).

The channel between the Muiron Islands and North West Cape was reported to have only a thin veneer of coarse sediment overlying limestone pavement. This area was reportedly rich in gorgonians, sea whips, bryozoans, some hard corals, crinoids, ascidians and hydroids, but few fish species were recorded (Kangas *et al*. 2006a).

The Department of Conservation and Land Management (CALM, now the Department of Biodiversity Conservation and Attractions) (1994) noted that the invertebrate fauna along the western shore of Exmouth Gulf was diverse and abundant, with an area of hard substrate to the north of the Bay of Rest supporting extensive soft corals and sponges.

Corals

Ningaloo Reef is the largest fringing barrier coral reef, and the second largest coral reef system, in Australia. The most diverse coral communities in the reserves (Ningaloo Marine Park and the Muiron Island Marine Management Area) are in the relatively clear water, high energy environment of the fringing barrier reef and low energy lagoonal areas to the west of North West Cape. The reserves are characterised by a high diversity of hard corals with at least 217 species representing 54 genera of hermatypic (reef building) corals recorded to date. All 15 families of hermatypic corals are represented in the reserves, however species diversity and community structure vary with environmental conditions such as exposure to wave action, currents, depth and water clarity. Natural events that impact on coral communities include cyclones, extreme low tide events, anoxic conditions resulting from coral spawning, bleaching and predation by the gastropod, *Drupella cornus* (CALM 2005).

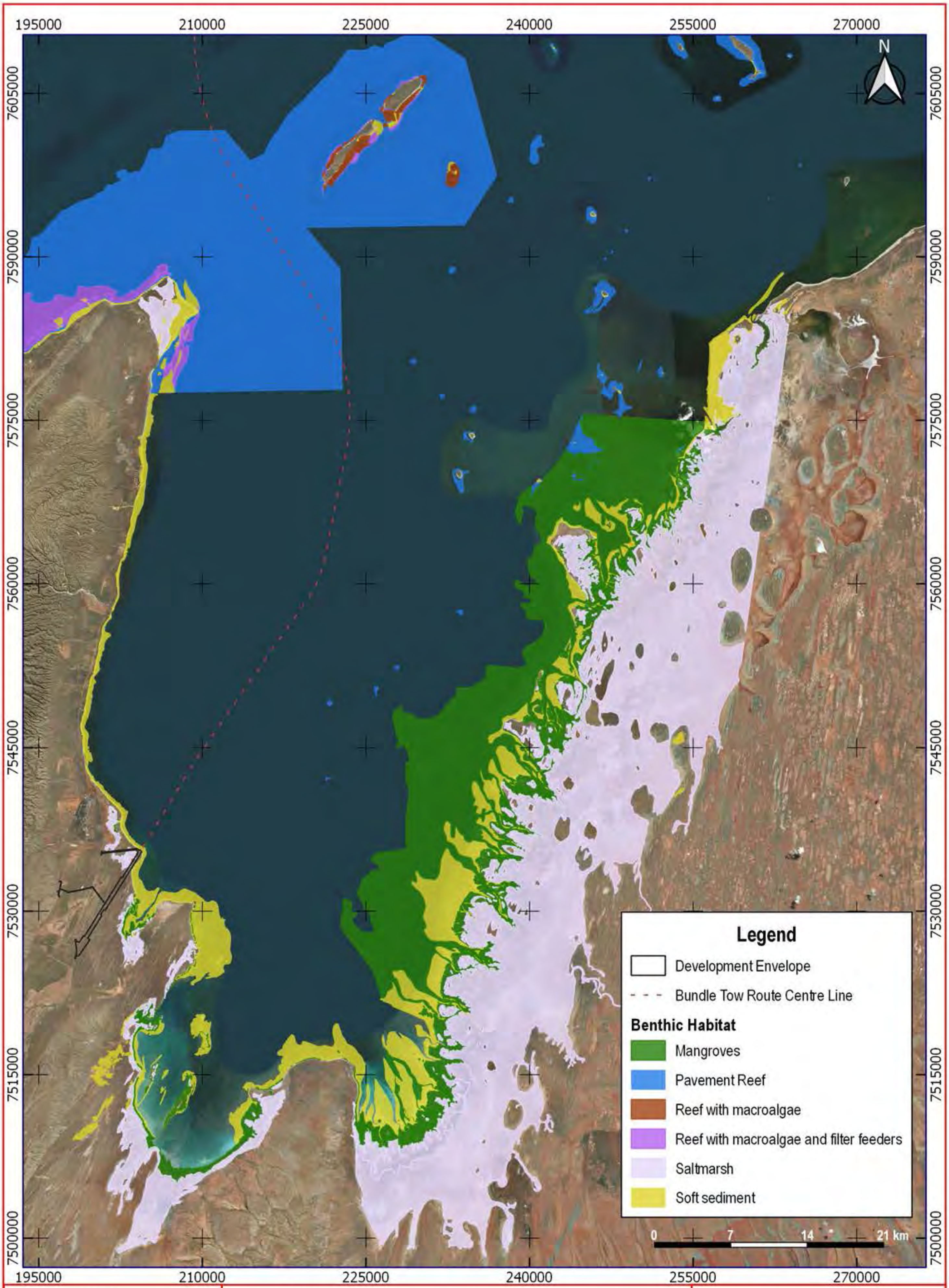
Coral reefs within the Exmouth Gulf are incipient, being submerged reefs that lack defined reef flat zones, unlike the Ningaloo Reef on the western side of the Cape Range Peninsula. This morphology reflects the low energy conditions within the Gulf and the higher turbidity which affects coral community composition (Twiggs and Collins 2010, Fitzpatrick *et al*. 2019). Within the Proposal's Offshore Operations Area coral cover was low and restricted to BCH types 'Pavement reef with filter feeders' and 'Pavement reef with macroalgae and filter feeders' (Attachment 2C). Coral cover was slightly higher offshore at Wapet, Stewart, Bennett and Cooper shoals (Figure 2-8, Attachment 2C). Cooper Shoal had the greatest abundance of corals.

Large-scale mass-spawning events have been reported among corals on WA reefs in the autumn period involving synchronous spawning by up to 24 coral species from a wide range of genera and families (Simpson 1988, Babcock *et al*. 1994). Some of the most abundant species of coral, including species of *Porites*, *Pavona* and *Turbinaria*, have been found to not participate in the mass spawning events and their patterns of reproduction remain uncertain (Stoddart and Gilmour 2005). More recent research on some WA coastal and offshore reefs has confirmed a smaller multispecific spawning period involving fewer species and colonies occurring during late spring or early summer (Rosser and Gilmour 2008, Gilmour *et al*. 2009, Rosser and Baird 2009). Between the release of gametes into the water by adult corals and the growth of newly settled coral spat lie three stages of development: fertilisation and embryonic development, larval growth, and settlement and metamorphosis. The natural percentage survival at each of these stages is likely to be very low and influenced by a wide range of physical (e.g. wind, waves, salinity) and biological (e.g. predator abundance) factors (Gilmour 1999).

Habitat Mapping

Regional habitat types recorded along the western margin of Exmouth Gulf and within the Ningaloo Marine Park were as follows (Bancroft 2003, SeaMap 2017) (refer Figure 5-1):

- Biota present.
- Consolidated hard substrate.
- Coral biota.
- Hard substrata.
- Invertebrates.
- Macroalgae.
- Mangroves.
- Pavement.
- Saltmarsh.
- Sand.
- Soft substrata.



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Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Bancroft (2003) and SeaMap (2017).

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Figure 5-1: Regional BCH Mapping in Exmouth Gulf

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5.1.3.2 Local Benthic Communities and Habitats

Intertidal and subtidal habitats off Heron Point were surveyed in December 2016 (Attachment 2B). A follow-up survey, to map all BCH off Heron Point, was completed in May/June 2017. Three intertidal BCH types were recorded (refer Table 1 in Attachment 2B):

- Fine sand (Fine sand within upper littoral zone).
- Pavement reef (Unvegetated pavement reef within the upper littoral zone).
- Reef with macroalgae:
  - Pavement reef within the mid-littoral zone with mud veneer and sparse macroalgae (*Sargassum* sp.).
  - Pavement reef within the lower-littoral zone with macroalgae (*Halimeda* sp., *Padina* sp., *Sargassum* sp.) and occasional hard corals (*Turbinaria* spp.) and soft corals (*Lobophytum* spp.)

The intertidal habitats surveyed at Heron Point are consistent with those known for the broader area, being described as '*largely algal-dominated with the benthos including macroalgae (Sargassum, Padina, Halimeda and Dictyota) and turf algae. In some areas, non-reef-building corals occur on exposed reef surfaces, including minor corymbose and tabulate Acropora and domal Favid corals*' (Fitzpatrick *et al*. 2019).

Mangroves were recorded within the Bay of Rest (Attachment 2C). Six subtidal BCH types were recorded off Heron Point (Figure 5-2, Attachment 2B, and Attachment 2C):

- Soft sediment (Mud and sand dominated habitats with sparse turf algae).
- Soft sediment with turf algae (Mud and sand dominated habitats with turf algae/ microphytobenthos (MPB)).
- Seagrass (Mud and sand dominated habitats with sparse *H. uninervis* and *H. ovalis*).
- Soft sediment with filter feeders (Soft sediment veneer overlying low relief reef. Sparse cover of filter feeders (sponges and soft corals)).
- Reef with macroalgae (Low relief reef with macroalgae (brown)).
- Reef with macroalgae and filter feeders (Low relief reef with macroalgae (brown) and filter feeders (sponges, soft corals, hard corals)).

A towed video survey of the original Bundle laydown area (now termed the Parking area) was completed in September 2017. This survey was augmented by the completion of 114 towed video transects across the Offshore Operations Area including along the proposed tow route within the Ningaloo Marine Park. Unvegetated habitats were recorded across the entire Bundle Parking area (Attachment 2C). Within Ningaloo Marine Park, within the Surface tow area, three BCH types were recorded (Attachment 2C):

- Soft sediment.
- Pavement Reef with filter feeders.
- Pavement reef with macroalgae and filter feeders.

To facilitate the development of a consolidated map of BCH within Exmouth Gulf, the Bancroft (2003) and SeaMap (2017) data were reclassified to align with the BCH classifications developed for the Proposal (Figure 5-2).

Mangroves

Within the Bay of Rest several mangrove species were recorded; Grey Mangrove (*Avicenna marina*), Stilted Mangrove (*Rhizophora stylosa*) and Club mangrove (*Aegialitis annulata*) (Attachment 2B).

Soft Sediment Communities

Multi-Dimensional Scaling (MDS) and dendrogram analysis of subtidal infauna samples collected from sites off Heron Point indicated that no site was clearly different from the rest, nor were any sites particularly similar to each other. The inshore sites at Heron Point (IS-1 and IS-2) were around 38% similar and sites IS-7 and IS-11 (both ~3.5 km offshore) were approximately 60% similar (Attachment 2B).

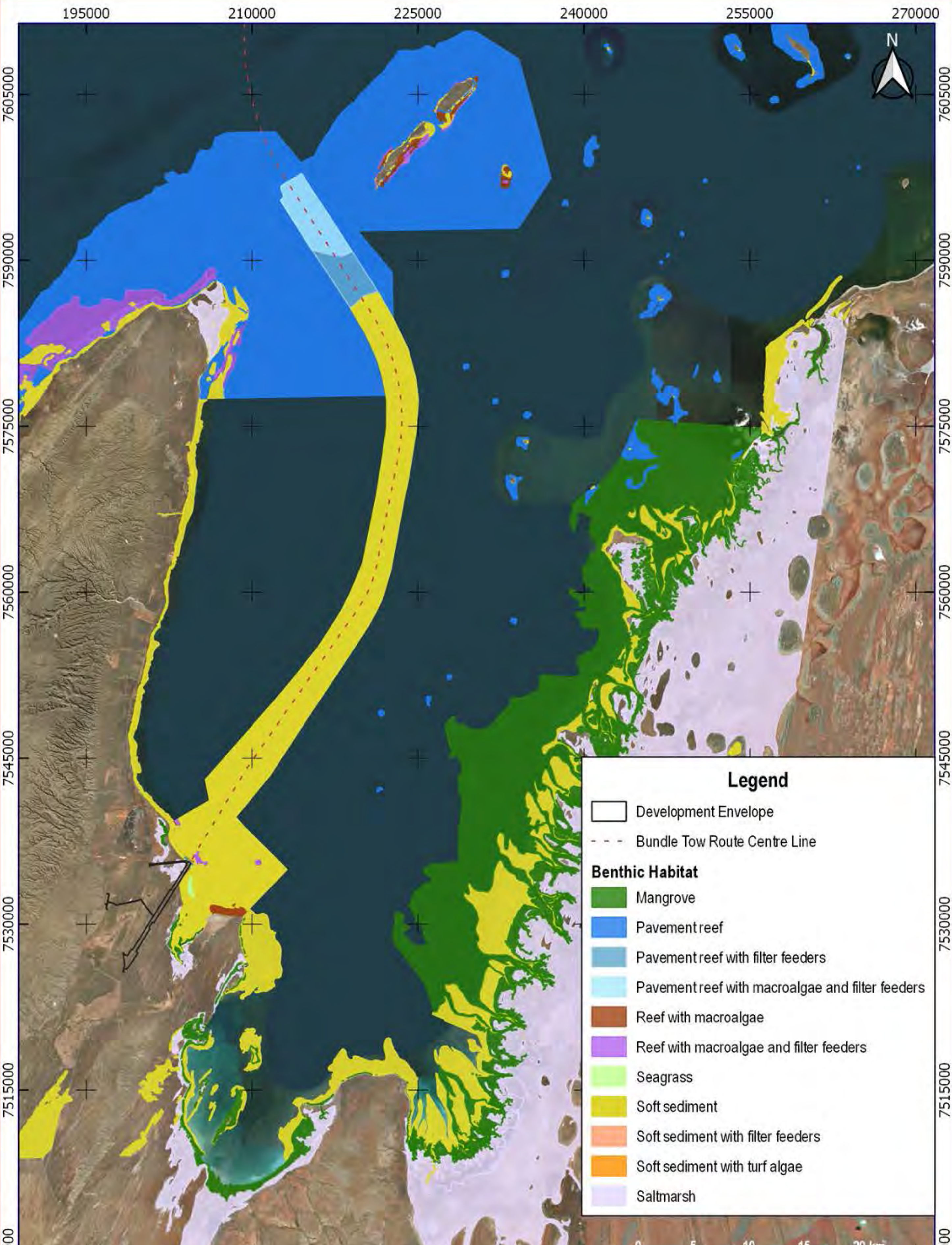
The most abundant infauna species recorded in the soft sediment off Heron Point were *Sipuncula* sp. (unsegmented worm), *Ampleliscidae* sp. (amphidod [shrimp]) and Spionidae (polychaete worm). Sipunculids were recorded at all sites within the Bundle laydown area, Ampleliscidae were recorded in most samples and Spionids were the second most dominant group, by individuals. A principal difference between the communities off Heron Point and within the Bundle laydown area was the higher abundance of Capitellidae and Lumbrineridae (polychaete worms) and lower abundance of Corophiidae (Amphipod shrimp) at the Bundle laydown area.

5.1.3.3 Benthic Communities and Habitats of Importance to Marine Fauna

Australian humpback dolphins have been recorded in various habitat types including dredged channels, reefs, seagrass flats, and mangroves. Foraging behaviour has been observed mainly in nearshore habitats over intertidal rocky reefs and over shallow sub-tidal reef habitats (Parra and Cagnazzi 2016). During aerial surveys undertaken for the Proposal, dolphins were recorded throughout Exmouth Gulf (Figure 5-23) (Attachment 2J).

Dugong activity is thought to be focused on the east coast of the Gulf associated with the shallow seagrass habitat in this area (Figure 5-25). There is a lack of understanding regarding fine-scale movements and the importance of various habitats for resting, breeding or feeding (Oceanwise 2005). During aerial surveys undertaken for the Proposal, Dugong were primarily recorded adjacent to the southern and eastern shores of Exmouth Gulf, with only small numbers (13) recorded adjacent to the western shore to the north of Heron Point and only isolated individuals were recorded over deeper soft sediment habitats in proximity to the tow route (Figure 5-26) (Attachment 2J).

Aerial surveys have shown that turtles occur throughout Exmouth Gulf, with densities greatest in the shallow southern and eastern portions of the Gulf. The majority of animals sighted were identified as Green turtles (Oceanwise 2005, Oceanica 2006). During aerial surveys undertaken for the Proposal, marine turtles were widely recorded. The greatest numbers were recorded adjacent to the southern and eastern shores of Exmouth Gulf, with only isolated individuals recorded over deeper soft sediment habitats in proximity to the tow route (Figure 5-29) (Attachment 2J). Female turtles may use the soft sediment habitat within and adjacent to Exmouth Gulf as internesting habitat (an area to rest on the seabed between nesting attempts).



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Aerial Photo: ESRI Satellite
Original Size: A4
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Bancroft (2003), SeaMap (2017), 360 Environmental (2017), and MBS Environmental (2018).

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Figure 5-2: Combined Local and Regional BCH Mapping in Exmouth Gulf

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5.1.3.4 Benthic Communities and Habitats of Importance to Commercial Fisheries

The Exmouth Gulf prawn fishery utilises a large portion of the soft sediment habitat within the deeper basin of Exmouth Gulf (refer Section Figure 2-14). A designated prawn fishery nursery area has been defined within the eastern and southern portions of Exmouth Gulf (Figure 2-11).

It is difficult to reconcile the habitats of most importance to aquarium specimen collectors and charter fishing operators due to the coarse nature of the information available from DPIRD (Figure 5-31, Figure 5-32). A single aquarium specimen collector has identified the filter feeder habitat off Heron Point as a key fishing area, and potential impacts to this habitat have been discussed with this operator, and are assessed in Section 5.4.6.4.

5.1.4 Potential Impacts

Construction and operation of the Proposal has the potential to directly and indirectly impact BCH. Table 5-3 summarises the potential impacts during each project phase.

Project Phase	Potential Impact
Construction	Direct loss of BCH during launchway construction
	Indirect loss or degradation of BCH due to turbidity created during launchway construction
Operations	Direct loss of BCH during Bundle launch and tow
	Indirect loss or degradation of BCH during Bundle launch and tow
	Direct loss of BCH during Bundle tow in the event of a loss of control of the Bundle
	Indirect loss of BCH during Bundle tow in the event of a loss of control of the Bundle or support vessel (e.g. from physical contact or a chemical spill)
	Indirect loss of BCH due to altered water flows and sediment movement as a result of the presence of the launchway
Closure	Impacts to BCH as a result of maintenance or removal of the launchway

Table 5-3: Potential Impacts to BCH

5.1.5 Potential Cumulative Impacts

Several third party projects or proposals (refer Section 2.5.8) have resulted in, or have the potential to result in, impacts to BCH within Exmouth Gulf. Given the EPA framework for the assessment of cumulative impacts to BCH, involving the use of Local Assessment Units (refer Section 5.1.6.1), only those projects or proposals impacting BCH within the same Local Assessment Units as potentially impacted by the Proposal need to be considered. Cumulative impacts to BCH within Exmouth Gulf are addressed in Section 5.1.6.11.

5.1.6 Assessment of Impacts

5.1.6.1 Local Assessment Units

The EPA uses a spatial assessment framework for evaluating cumulative temporary and irreversible loss of and/or serious damage to BCH. The evaluation scheme is based on cumulative changes within a defined area and includes determining the spatial extent of benthic communities and their habitats:

- Prior to all human-induced disturbance.

- Existing at the time of the proposal.
- Remaining after implementation of the proposal (EPA 2016d).

To apply this assessment approach a number of LAUs have been defined offshore of Heron Point, and along the proposed Bundle launch and tow route, to facilitate the quantitative assessment of potential direct and indirect impacts on BCH.

EPA (2016e) states that '*Local assessment units (LAUs) are location specific and should be configured to take into account aspects of the local marine environment such as bathymetry and position of offshore reefs/islands, substrate type, water circulation patterns, exposure to waves and currents and biological attributes such as habitat types'.* The LAUs were defined taking account of this guidance and in consultation with DWER.

Given the location of the launchway at Heron Point within the area previously nominated for reservation, and within the Bay of Rest mangrove area (EPA 2001) (Figure 2-11), a single LAU (LAU 'Heron Point') was initially developed based on these datasets (Figure 5-3). The LAU was developed to be broadly consistent with the general guidance presented in Section 4.2 of EPA (2016e), and utilises the existing mapped boundaries of the above proposed conservation zones. LAU 'Heron Point' was discussed with the Marine Ecosystems Branch of the EPA, and endorsed, prior to completion of habitat mapping across this area (Attachment 2B).

Subsequently, following definition of the Offshore Operations Area including the Bundle Parking area and tow route, a number of additional LAUs were defined to encompass the areas within which direct or indirect impacts to BCH could occur (Table 5-4).

LAU No.	LAU Name	Area (km^2)	Proposal Risk Aspect
1	Heron Point	83	Launchway and Bundle chains
2	Offshore Operations Area (Off bottom tow)	84	Bundle chains
3	Parking area	32	Bundle chains
4	Offshore Operations Area (Surface tow)	77	Potential for seabed disturbance in the event of loss of control of Bundle during tow

Table 5-4: Local Assessment Unit Areas and Short Descriptions

The sub-sections below provide an assessment of potential direct and indirect impacts to BCH resulting from construction and/or operation of the Proposal.

5.1.6.2 Impact Zonation Scheme

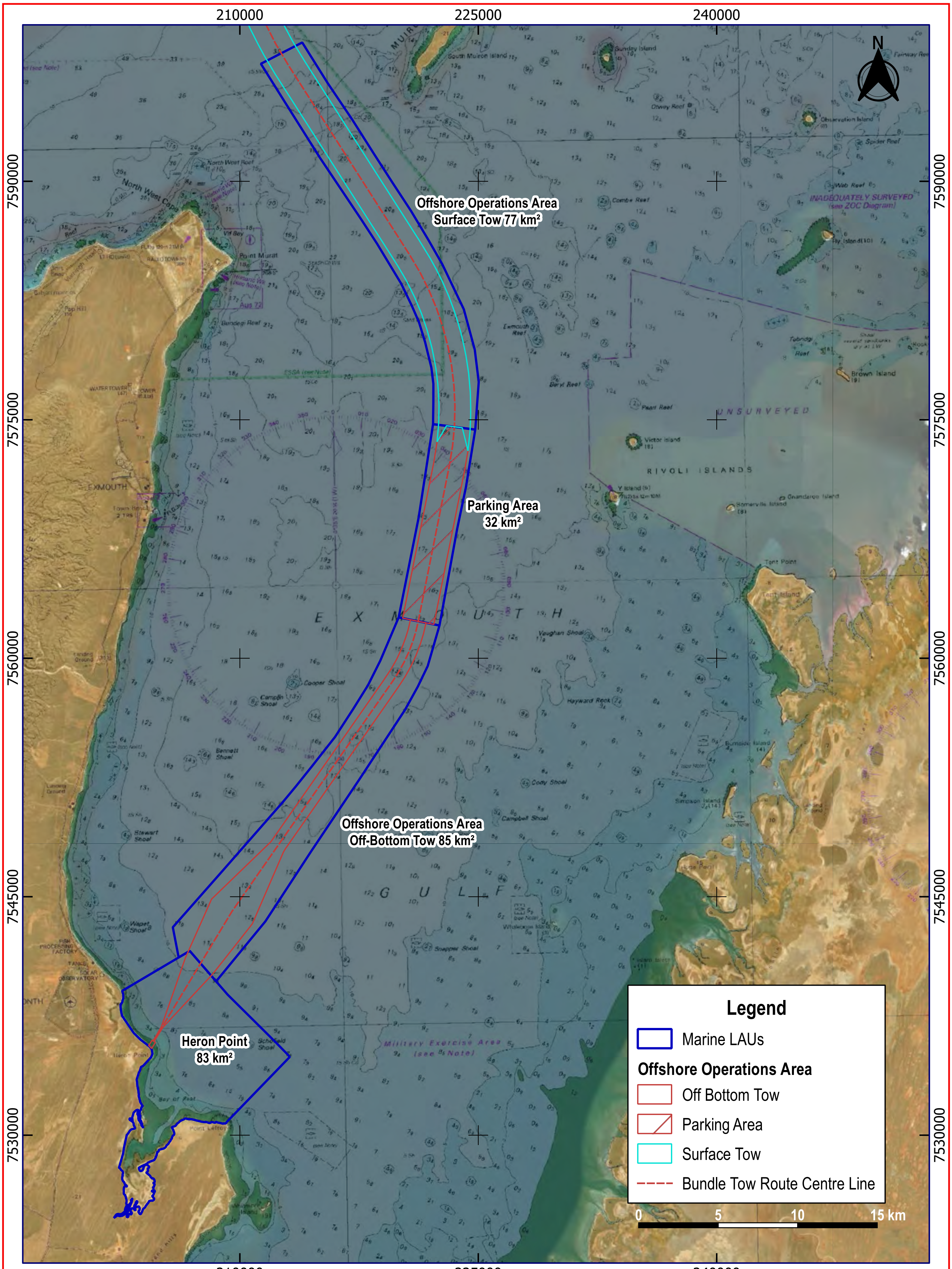
The EPA has developed a spatially-based zonation scheme for proponents to use as a common basis to describe the predicted extent, severity, and duration of impacts associated with dredging proposals (EPA 2016v).

The scheme consists of three zones that represent different levels of impact:

- The Zone of High Impact (ZoHI) is the area where impacts on benthic communities or habitats are predicted to be irreversible. The term irreversible means 'lacking a capacity to return or recover to a state resembling that prior to being impacted within a timeframe of five years or less'.

- The Zone of Moderate Impact (ZoMI) is the area within which predicted impacts on benthic organisms are recoverable within a period of five years.
- The Zone of Influence (ZoI) is the area within which changes in environmental quality are predicted and anticipated at some point, but where these changes would not result in a detectible impact on benthic biota. These areas can be large, but at any point in time impacts to water quality are likely to be restricted to a relatively small portion of the Zone of Influence.

While the Proposal does not involve dredging, it does involve marine construction (launchway), a small amount of seabed excavation (offshore end of launchway) and the generation of turbidity associated with Bundle launch and tow. Thus the approach outlined above has been referenced to assist in the spatial representation of the zones of potential impact to BCH.



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Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Subsea 7 (2018) and Commonwealth of Australia (2018).

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Figure 5-3: Local Assessment Units used for the assessment of the Proposal

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5.1.6.3 Direct Loss of BCH during Launchway Construction

The Bundle launchway will be 380 m long (measured from the dune line) and up to 15 m wide.

The following construction sequence is expected during launchway construction:

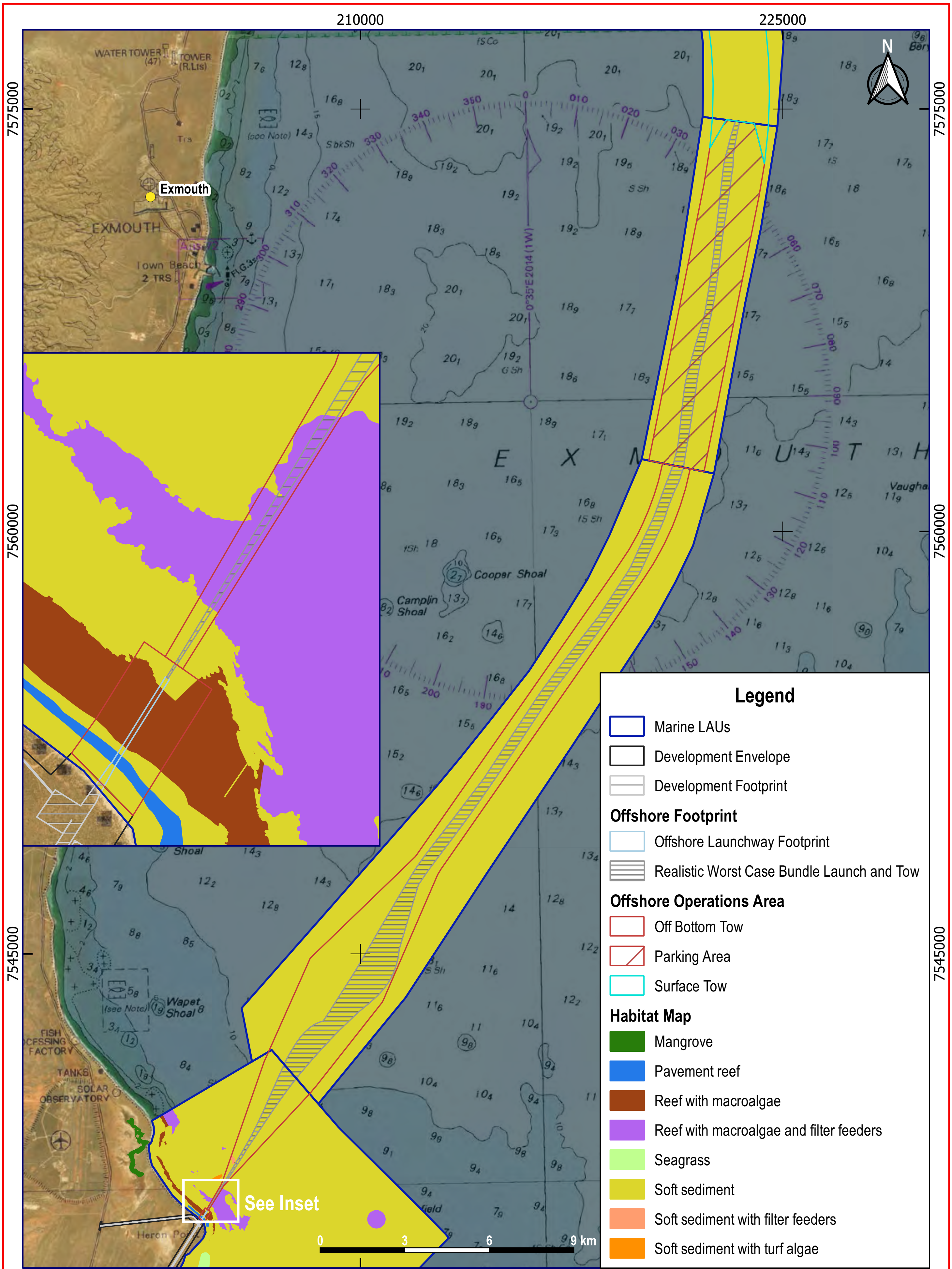
- Shallow excavation of sand on land including the area through the sand dunes.
- Shallow excavation or compaction of sand on the beach.
- Progressively construct the launchway from the landward extent to the seaward extent, by repeating the following steps:
  - Place rock fill.
  - Place concrete panels.
  - Place concrete mattress or rock armour.

Rock fill will be placed from the shoreline, being pushed seaward down the onshore end of the launchway. For the offshore end of the launchway, the rock fill will be placed from a barge.

The launchway footprint has been used to define the ZoHI for BCH in this area, where impacts on benthic communities or habitats are predicted to be irreversible. Predicted BCH losses (permanent) as result of the launchway footprint are as follows:

- Soft sediment (0.2 ha) (< 0.1% of that mapped within the Heron Point LAU).
- Reef with macroalgae (0.3 ha) (0.1% of that mapped within the Heron Point LAU).
- Pavement reef (0.1 ha) (3.2% of that mapped within the Heron Point LAU) (refer Figure 5-4).

Under some circumstances a 'halo' can occur immediately adjacent (usually within 50 m) of coastal infrastructure, such as a groyne, where local changes in hydrodynamic conditions prevent the survival and/or recruitment of BCH, particularly seagrass, within this area. This can, for example, be observed adjacent to the rock walls of the Success Boat Harbour in Fremantle, where seagrass is absent immediately adjacent to the seaward side of the rock walls. No 'halo' effect is expected surrounding the launchway given the BCH in this area is Soft sediment and Reef with macroalgae. Macroalgae is routinely recorded on and immediately adjacent to built structures.



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Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Subsea 7 and Commonwealth of Australia (2018).

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Figure 5-4: Direct losses of BCH

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5.1.6.4 Indirect Loss or Degradation of BCH due to Turbidity Created during Launchway Construction

Launchway construction will occur during daylight hours only, so any sediment resuspended during a shift will be likely to dissipate prior to commencement of the next shift.

Sediment may be resuspended, resulting in elevated turbidity, as a result of:

- Disturbance of the seabed in areas of soft sediment (i.e. when the rock fill material makes contact with the seafloor and displaces superficial material).
- Any rock 'fines'[7] contained within the rock fill, or generated as the fill is placed and rocks come into contact with each other.
- Disturbance of the seabed by construction equipment, including when an approximately 300 mm layer of sediment is removed from the last 24 m length of the launchway footprint.

The inshore BCH at Heron Point are likely to be tolerant to short-term extremes in water column turbidity as such events occur under natural conditions (refer Section 5.3.3). The macroalgae (*Halimeda* sp., *Padina* sp., *Sargassum* sp.) and occasional hard corals (*Turbinaria* spp.) and soft corals (*Lobophytum* spp.) recorded within the lower-littoral pavement reef habitat are known to occur widely across North West Australia (Hanley and Morrison 2012).

Brown algae within the genus *Sargassum* (as recorded as a dominant component of the Reef with macroalgae habitat inshore adjacent to the launchway (Attachment 2B)), are common and important features in benthic ecosystems around the world. It is thought that these species have an advantage in higher sediment environments due to their abundance in turbid, inshore reef habitats (e.g. on the Great Barrier Reef). Schaffelke (1999) observed an increase in rates of *Sargassum* growth of up to 180% when particulate matter (i.e. suspended sediment) was present on the thallus surface, potentially due to the creation of a nutrient-rich boundary layer. It appears that this group is resistant to the negative effects of sedimentation if it is already established in a system (Short *et al*. 2017).

In studies to investigate the tolerance of sponges in the north west of Western Australia, it has been noted that '*most sponges survived under low to moderate turbidity scenarios (suspended sediment concentrations of ≤ 33 mg/L, and a daily light integral of ≥0.5 mol photons/m^2/day) for up to 28 days*' and '*all three sponge species exhibited mechanisms to effectively tolerate dredging-related pressures in the short-term (e.g. oscula closure, mucus production and tissue regression)*' (Pineda *et al*. 2017). Coral communities recorded adjacent to the Port of Dampier, at Port Hedland, at Cape Preston and throughout the wider Dampier Archipelago are generally similar, with Faviid, Porites and Turbinaria coral groups making up ~70% of all hard corals (WorleyParsons 2009). *Turbinaria* spp. corals were by far the most dominant of the corals present within the nearshore habitats off Heron Point, though their absolute density was low (Attachment 2B). These coral groups are all relatively resistant to bleaching, are able to withstand strong wave action and can cope with high levels of sedimentation (Ayling and Ayling 2006, Berkelmans and Oliver 1999, GHD 2008). Post-construction monitoring of coral communities adjacent to the Coral Bay Boating Facility, which was constructed over eight months in 2007, and involved significant rock (limestone) dumping, concluded that the construction works had not impacted coral communities noticeably at distances of more than 50 m from the physical structure (MScience 2007). Thus impacts to less sensitive, turbidity tolerant, corals at Learmonth are not expected beyond the immediate vicinity (50 m) of the launchway footprint.

[7] Particles with a diameter of less than 63 µm

Given the short-term and 'pulse' nature of the expected sediment resuspension, significant losses of BCH are not expected. Local and minor changes to BCH health could occur, dependent upon the effectiveness of the mitigation measures. As such, the area within the immediate vicinity of the launchway footprint (<50 m) has been defined as a ZoMI within which impacts on benthic organisms may occur, but are recoverable within a period of five years following completion of construction. In reality, given the tolerance of such BCH types (refer above), any impacts resulting from the up to six months' construction duration are expected to be more short-term (<1 year).

Predicted indirect BCH impacts (recoverable) as a result of the launchway construction are as follows:

- Reef with macroalgae (2.5 ha) (0.7% of that mapped within the Heron Point LAU).
- Soft sediment (2.0 ha) (< 0.1% of that mapped within the Heron Point LAU).
- Pavement reef (0.4 ha) (12.9% of that mapped within the Heron Point LAU).

Given the absence of significant coral cover in the vicinity of the launchway (the nearest appreciable coral cover was recorded 24 km north of the launchway at Cooper Shoal), the likelihood of impacts to coral spawning, due to locally elevated suspended sediment concentrations, is considered negligible. As such, no suspension of construction activities is proposed during the regional autumn or spring coral spawning periods, though in the event of elevated turbidity beyond the nominated ZoMI additional management measures will be implemented, including potential suspension of the works (refer Table 5-8, MCMMP in Attachment 3).

5.1.6.5 Direct impacts to BCH during Bundle Launch and Tow

During launch the Bundle rolls down the track, which extends across the beach and along the launchway, and into the shallow subtidal area. As the Bundle towheads (both lead and trailing towheads) enter the water and gain depth, they will become buoyant.

Ballast chains are attached at intervals along the length of the Bundle to provide stability control during the launch and lift during the offshore Controlled Depth Tow Method (CDTM) tow out to the production field. Typically the ballast chains that hang beneath the Bundle vary between short and long lengths, typically alternating in a short-long-short-long configuration. The longer Bundle chain lengths will have some contact (4-5 links or approx 1 to 1.5 m) in contact with the seabed along the length of the tow route out to the Bundle Parking area.

To address this seabed disturbance, an Offshore Operations Area (Off bottom tow) has been defined (Figure 2-4). This area, which overlaps the Heron Point and Offshore Operations Area (Off bottom tow) LAUs, represents an envelope within which any and all disturbance associated with Bundle launches, over the life of the facility, will occur. The whole of the Offshore Operations Area (Off bottom tow) lies within the Exmouth Gulf Prawn Fishery area (Figure 2-14). The effect of the chains touching the seabed within this already disturbed, primarily soft sediment habitat, a maximum of three times per year, is not expected to have a significant impact on BCH. However, to define the potential impacts associated with the chain footprint, a number of potential scenarios were assessed (refer Section 5.1.6.11 for details).

A 'realistic best case' (or 'most likely best case') disturbance footprint associated with a Bundle launch is 501.8 ha. This disturbance footprint represents the seabed disturbance that would result from the launch of a 4 km Bundle under mean current velocity (i.e. mid-way between neaps and springs). On this basis, predicted BCH impacts (expected to be recoverable well within one year, but repeat impacts expected) as a result of a Bundle launch are as follows:

- Soft sediment (500.4 ha).
- Reef with macroalgae and filter feeders (0.9 ha).
- Soft sediment with filter feeders (0.4 ha).

A 'realistic worst case' (or 'most likely worst case') disturbance footprint associated with a Bundle launch is 1,817.7 ha (Figure 5-4). This disturbance footprint represents the seabed disturbance that would result from the launch of an 8 km Bundle under mean current velocity (i.e. mid-way between neaps and springs). The launch of an 8 km Bundle, under mean tidal conditions, is considered the realistic worst case as Bundles of this length, or longer, would generally be launched during neap tide conditions, leading to reduced tidal forcing and a reduced footprint. On this basis, predicted BCH impacts (expected to be recoverable well within one year, but repeat impacts expected) as a result of a Bundle launch are :

- Soft sediment (1815.8 ha) (9.6% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).
- Reef with macroalgae and filter feeders (1.5 ha) (0.7% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).
- Soft sediment with filter feeders (0.4 ha) (5.9% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).

No impacts to BCH within the Surface tow portion of the Offshore Operations Area are predicted as the Bundle will be on the sea surface and the chains well clear of the seabed (refer Section 2.3.8). The targets for filter feeders within the Ningaloo Marine Park of '*no loss of filter feeding community diversity*' and '*no loss of living filter feeding community biomass*' (CALM 2005) will not be compromised as a result of the Proposal.

5.1.6.6 Indirect Loss or Degradation of BCH during Bundle Launch and Tow

To predict potential indirect impacts to BCH during Bundle launch and tow operations, a sediment fate model was setup and interrogated to accurately predict the magnitude and duration of water quality impacts associated with suspended sediment (leading to increased turbidity)[8] (Attachment 2H).

<u>Field Data Collection</u>

To assist in defining sediment source terms (such as the sediment flux rate, particle-size distribution (PSD) and vertical distribution of suspended sediments) related to the Bundle launch operations, which are the greatest drivers of changes in plume dispersion patterns, a field experiment was conducted. This involved towing a single chain (76 mm diameter chain with a chain link length of 304 mm, as will be attached to each Bundle) along a 2 km section of soft sediment habitat off Heron Point, in proximity of the path to be followed during proposed future Bundle launches. It was determined that 4-5 links (or approximately 1.5 m) of chain had been in contact with the seabed at the offshore end of the transect. Concurrent measurements of water quality were taken to determine the

[8] Total suspended sediment (TSS) concentrations are measured in mg/L while the resulting reduction in water clarity is measured as turbidity in 'Nephelometric Turbidity Units (NTU)'. Site-specific relationships between TSS and turbidity can be determined through concurrent measurements. In the sections below the terms are used interchangeably depending upon the units referred to in the relevant papers and reports.

sediment flux rate, PSD and vertical distribution of sediments resuspended by the chain as it was towed along the seabed at a speed of 3 knots (MBS Environmental 2018c). The data obtained from the single chain tow trial were used to inform assumptions with regard to the sediment flux rate and behaviour (for example settling velocity) associated with many chains in sequence (Attachment 2H).

Sediment Fate Modelling

The Delft3D suite was used to complete the modelling of turbidity associated with a Bundle launch and tow. Delft3D is a fully integrated computer software package composed of several modules (e.g. flow, waves, sediment, water quality, and ecology) grouped around a common interface. This software suite has been developed to carry out studies with a multi-disciplinary approach and multi-dimensional calculations (e.g. 2D and 3D) for a range of systems, such as oceanic, coastal, estuarine and river environments. It can simulate the interaction of flows, waves, sediment transport, morphological developments, water quality and aquatic ecology. The Delft3D suite of models adheres to the International Association for Hydro-Environment Engineering and Research guidelines for documenting the validity of computational modelling software, closely replicating an array of analytical, laboratory, schematic, and real-world data. The D-FLOW model, which is the hydrodynamic component of the Delft3D suite, has been used for a vast array of applications all over the world and is considered to be a reliable and robust model for oceanic, coastal, estuarine, riverine, and flooding applications (Attachment 2H).

A hydrodynamic model framework for the Exmouth Gulf area was constructed and validated. A three-dimensional hydrodynamic model was established over a domain covering the Exmouth Gulf and surrounding areas. A number of sub-domains, with horizontal resolutions becoming finer towards the Bundle tow route, were developed to allow increased resolution around the Bundle tow route while optimising model run times by having coarser resolution further from the site (Attachment 2H). The hydrodynamic model predictions of water level and current were validated against site-specific ADCP data collected near the proposed launchway site and further offshore near the Bundle Parking area (GHD 2018a).

To model the potential field of effect of sediments suspended by Bundle launch and tow operations, the specialised sediment fates model, DREDGEMAP, was used. This model is designed to calculate suspended sediment loads and sedimentation (above background levels) resulting from more than one concurrent source of input. The model is suited to long-run simulations using parallel inputs of wave and current data to calculate for transport, dispersion, settlement and resuspension of sediments. Both settlement and resuspension take account of local wave and current forces. This model has previously been applied to dredging investigations at Port Hedland, Mermaid Sound, Cockburn Sound, Ocean Reef, Alkimos, Darwin Harbour, Gladstone Port, Keppel Bay, and other locations (Attachment 2H).

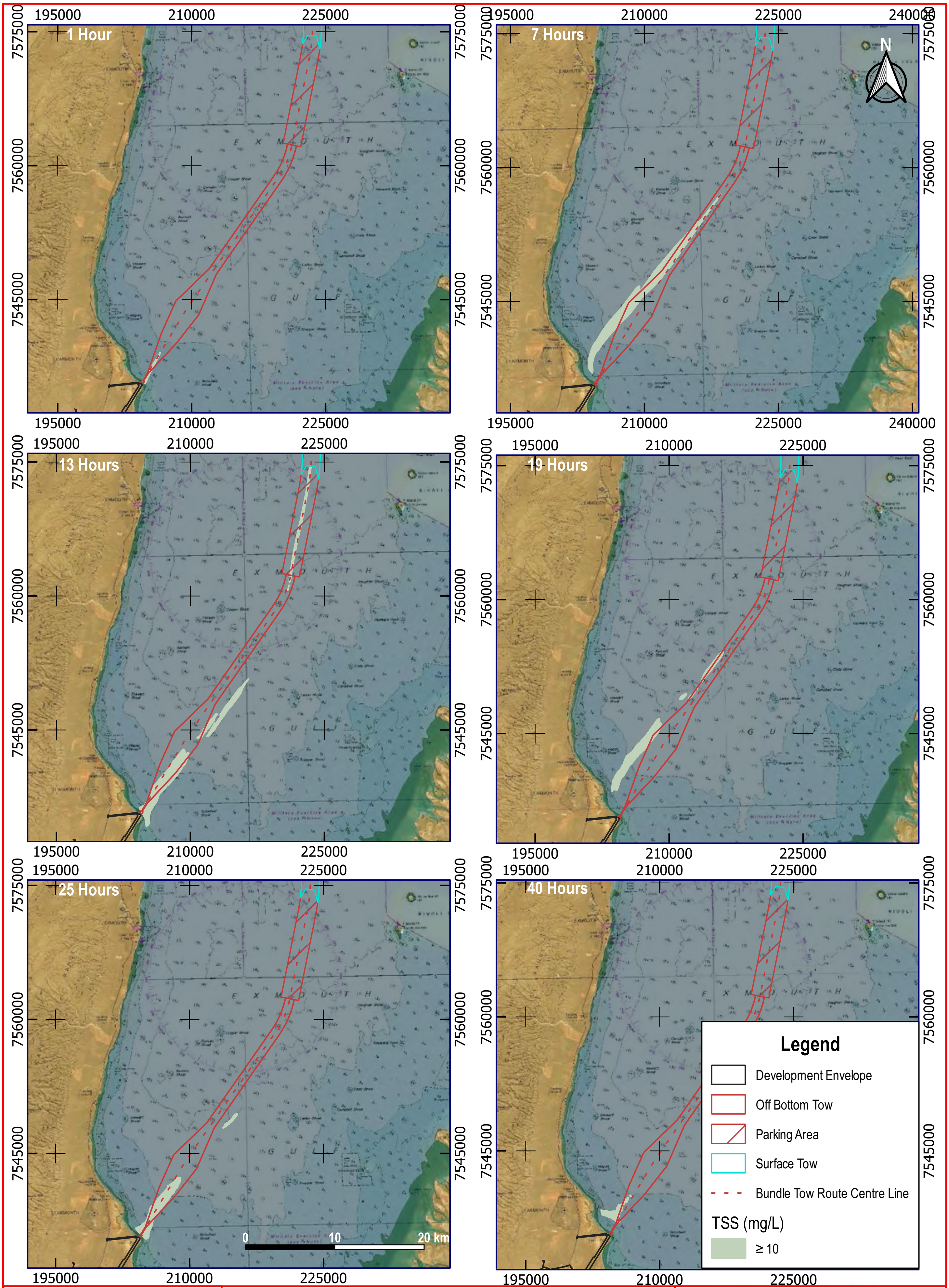
The sediment fate modelling was based on the worst-case potential seabed disturbance associated with a 10 km Bundle with long chains spaced at 20 m intervals (noting that to date Subsea 7 has not designed or built such a long Bundle).

To model the sediment suspended as a result of the Bundle chains, during a Bundle launch, the tow route was split into seven sections based on bathymetry, and the number of chain links assumed to be in contact with the seabed was varied depending on the average depth within each section of the route. In the innermost section (nearshore), it was assumed that six chain links would usually be in contact; in the outermost section (including the laydown area), it was assumed that two chain links would be in contact. The sediment flux rate for one chain was calculated as the volume of material on the seabed likely to be disturbed by the dragging chain, multiplied by a rate of suspension of this material into the water column. The volume of material disturbed by each chain link was calculated as the cross-sectional area of contact, multiplied by the length of the route section under consideration, multiplied further by the number of chain links in contact with the seabed within the route section (Attachment 2H).

The period simulated in the model commenced on 3 January 2017, during spring tides. The sediment fate model produced contours representing the median (or 'middle value'), 80th percentile (the value below which 80% of records occur), and 95th percentile (the value below which 95% of records occur) maximum water column turbidity[9], and depth-averaged water column turbidity[10], during a Bundle launch and the period immediately following when resuspended sediments are transported within the water column prior to settlement (Attachment 2H).

The general pattern of suspended sediment movement predicted by the modelling was that the sediment suspended in the lower layers of the water column will drift to one side of the tow route (north during an ebb tide or south during a flood tide), before a proportion is deposited on the seabed during the next slack tide period. The remaining suspended sediments will then be transported by subsequent tidal currents back and forth (north-south) across the tow route, with deposition occurring steadily. Figure 5-5 presents the modelled suspended sediment plume at intervals following the commencement of a Bundle launch, during an ebb tide. The suspended sediment 'plume' generated during the launch and tow (only concentrations ≥ 10 mg/L displayed) drifts to the north during ebb tide conditions for the initial seven hours before drifting south under flood tide conditions for the next six hours, before changing direction and returning northwards. As the suspended sediments drift back and forth they gradually resettle onto the seabed, leading to a decrease in the spatial extent of the plume, until only a small area immediately offshore of Heron Point exhibits concentrations > 10 mg/L) after 40 hours (Figure 5-5, Attachment 2H).

[9] Maximum value recorded anywhere in the water column (in the majority of instances this will be immediately adjacent to the seabed)
[10] Average value through the water column between the seabed and sea surface



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Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from RPS (2019).

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Figure 5-5: Snap Shots of Predicted Depth Averaged TSS Following a Bundle Launch

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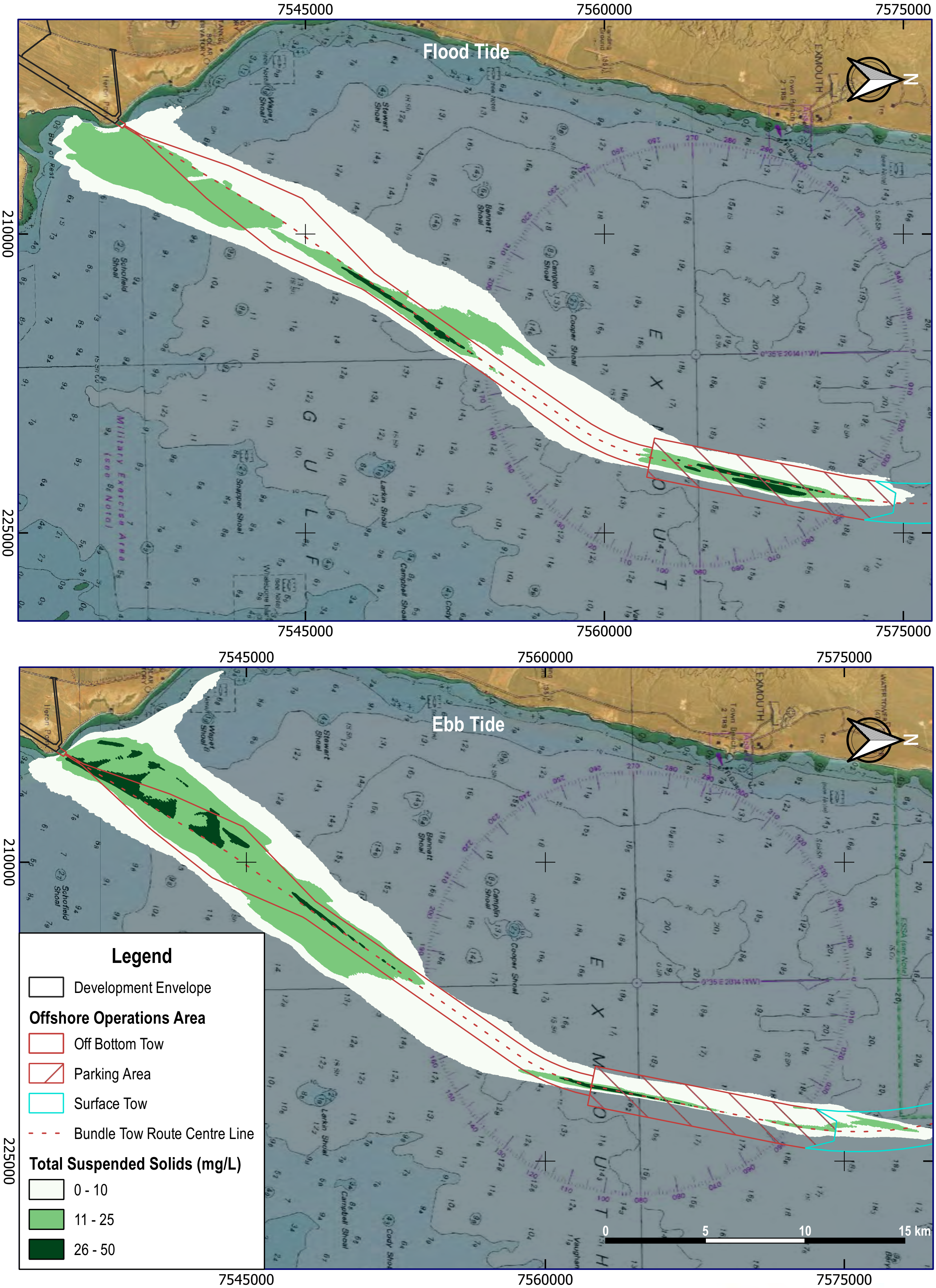
The 95th percentile values, representing the near worst-case turbidity occurring during a Bundle launch (values above these 95th percentile values will only occur for 5% of the time) are presented for the maximum water column turbidity (Figure 5-6), and depth-averaged water column turbidity (Figure 5-7). The difference between the modelled maximum water column turbidity and depth-averaged water column turbidity demonstrates that the high turbidity values are primarily limited to waters adjacent to the seabed, resulting in reduced depth-averaged values compared to the maximum values.



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Notes: Data sourced from Commonwealth of Australia (2018) and RPS (2019).

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Figure 5-6: Predicted Maximum Water Column Turbidity During a Bundle Launch and Tow (95th Percentile Values)

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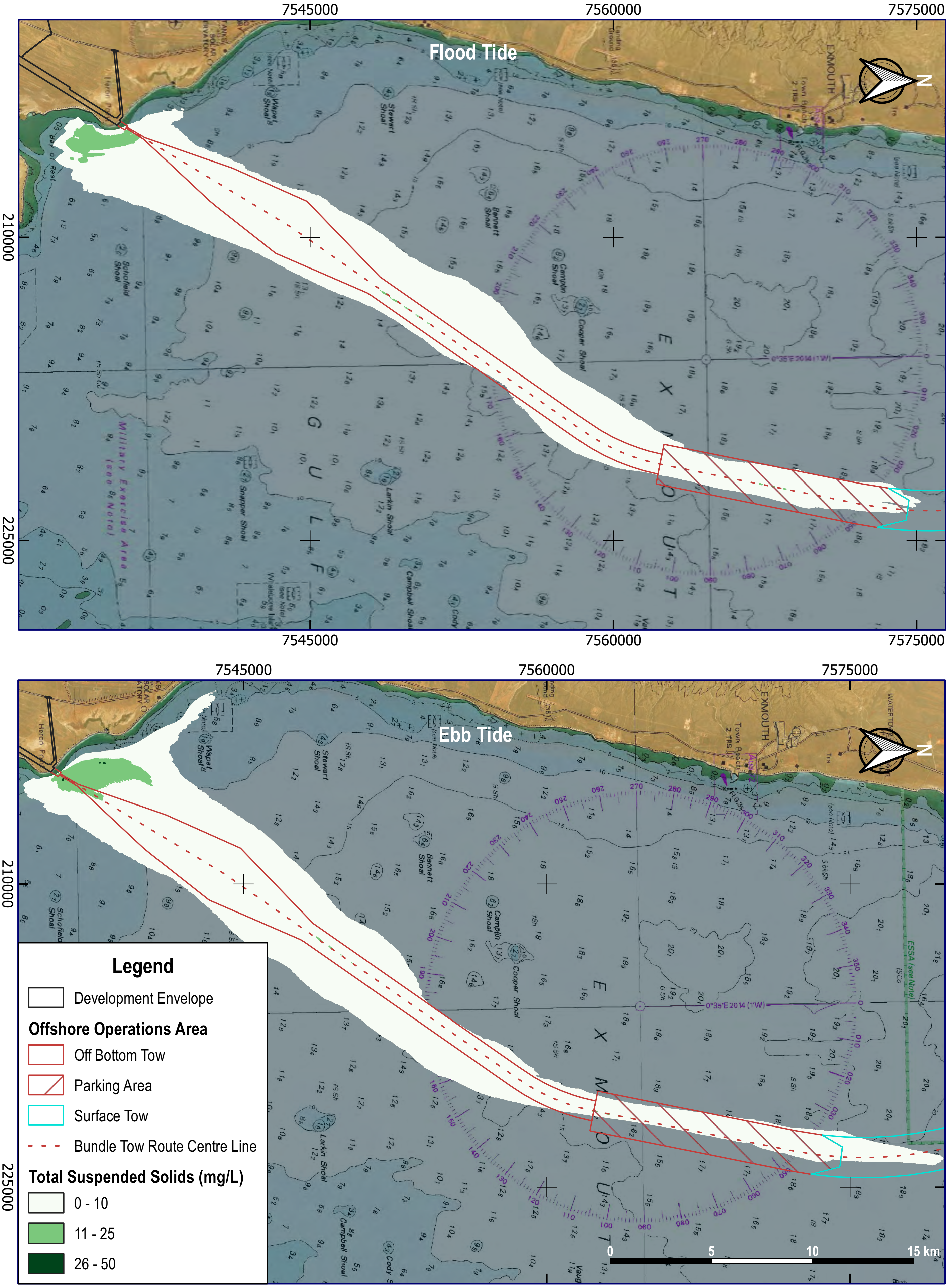

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Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Commonwealth of Australia (2018) and RPS (2019).

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Figure 5-7: Predicted Depth Averaged Water Column Turbidity During a Bundle Launch and Tow (95th Percentile Values)

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Impact Thresholds

Brown algae within the genus Sargassum (as recorded as a dominant component of the Reef with macroalgae habitat inshore (Attachment 2B)) is resistant to the negative effects of sedimentation if it is already established in a system (Short *et al*. 2017).

An area of sparse seagrass (*H. uninervis* and *H. ovalis*) was recorded approximately 1 km south of Heron Point (Figure 5-2), in water depths of 2.5 m to 4 m (at the time of survey, being immediately before a high tide of 2.46 m) (Attachment 2B). A key driver of seagrass distribution is the amount of sunlight reaching the seabed, which is affected by seabed depth and water clarity. It is expected that the seagrass in this area is depth limited, meaning that there is insufficient light at greater depths to support growth. This would be broadly consistent with the findings of other studies (Section 5.1.3).

Given the short-term, and intermittent, nature of potential shading of the mapped sparse seagrass habitat during and immediately following a Bundle launch, and the reported recovery of seagrass biomass over weeks following light reduction treatments (Lavery *et al*. 2017), no impact is expected.

In studies to investigate the tolerance of sponges in the north west of Western Australia, it has been noted that '*most sponges survived under low to moderate turbidity scenarios (suspended sediment concentrations of ≤ 33 mg/L) for up to 28 days*' and '*all three sponge species exhibited mechanisms to effectively tolerate dredging-related pressures in the short-term (e.g. oscula closure, mucus production and tissue regression)*' (Pineda *et al*. 2017).

A generally accepted model for how corals tolerate turbidity is that they survive short-term periods of high suspended sediment concentrations by shifting between phototrophic and heterotrophic dependence, by relying on energy reserves, and by rapidly replenishing reserves in periods between turbidity events (Jones *et al*. 2017). The ephemeral nature of plumes and the potential for corals to recover from individual turbidity events, means dredging programs can be managed by considering cumulative pressure. Implicit in this concept is that natural turbidity events (or periods of low light), are an integral component of the total pressure (Jones *et al*. 2017). It is noted that experience from large scale dredging programmes in the Pilbara has shown that impacts have generally been limited to areas close to the dredging activity (<500 m), and that impacts have been consistently over-estimated (MScience 2009, Hanley 2011). The recently published WAMSI Science Dredging Node Theme 4 Synthesis report (Jones *et al*. 2019) proposes, based on observations and laboratory experiments on a clear water and high diversity shallow water coral reef ecosystem, a threshold for possible coral mortality of 'mean total suspended sediment (TSS) concentration > 27.9 mg/L over 24 hours'.

Given the above information regarding the tolerance of sponges and filter feeders to shorter 'bursts' of turbidity and the lack of coral or seagrass habitats in proximity to the Bundle tow route (the nearest coral habitat is located at Cooper Shoal, over 2 km from the tow route, the nearest sparse seagrass is located 3 km south of the launchway), no specific impact thresholds have been developed for these BCH types. Instead, a threshold for the ZoI was developed based on the modelled change to baseline turbidity, to identify areas likely to experience short-term changes in environmental quality, but where these changes would not result in a detectible impact on benthic biota. The threshold developed was 'the median depth-averaged turbidity over 24 hours exceeds the 80^{th} percentile of baseline data'. This approach is similar to that recommended for the seagrass *H. ovalis* which is to compare the median value at an 'impact' site to the 20^{th} percentile at a 'non-impact' site (Lavery *et al*. 2017). The baseline monitoring period used in the assessment of this threshold extended from 22 May – 21 June 2018 and included two full tidal cycles (refer Section 5.3.3). The average turbidity recorded at the launchway location was 4.3 NTU (equivalent to a TSS of approximately 7.5 mg/L).

Impact Calculation

Areas of BCH within the area predicted to experience short-term elevated turbidity, beyond the threshold nominated above (refer Figure 5-8), are as follows[11]:

- Soft sediment with turf algae (6.2 ha).
- Soft sediment with filter feeders (6.7 ha).
- Reef with macroalgae (0.4 ha).
- Reef with macroalgae and filter feeders (112.1 ha).
- Seagrass (7.2 ha).

The time-series data presented in Figure 5-9 shows the modelled duration of elevated TSS, associated with a Bundle launch at two points adjacent to the tow route, under a flood tide launch scenario (top panel) and an ebb tide launch scenario (bottom panel). As can be seen from the graphs, elevated TSS concentrations of up to 72 mg/L during a flood tide launch and 382 mg/L during an ebb site launch were predicted. The forecast duration of these elevated concentrations is limited, with the cumulative (modelled plus background) TSS predicted to be greater than 4.10 mg/L (the value representing the 80th percentile of baseline data (Attachment 2H)) for a period of six hours (flood tide) and two hours (ebb tide) (Figure 5-9). The second and third peaks in TSS represent the 'return' of the suspended sediment plume over the sites following a change in tidal direction (refer Figure 5-5). The magnitude of TSS concentrations is reduced due to the ongoing settlement of the suspended sediment particles following their initial disturbance. The predicted 24 hour average TSS concentrations during a Bundle launch were 9.2 mg/L (16.7 mg/L including background) over seagrass habitat to the south of the launchway during a flood tide (Figure 5-9) and 21.8 mg/L (29.3 mg/L including background) over the filter feeder habitat immediately adjacent to the tow route during an ebb tide (Figure 5-9).

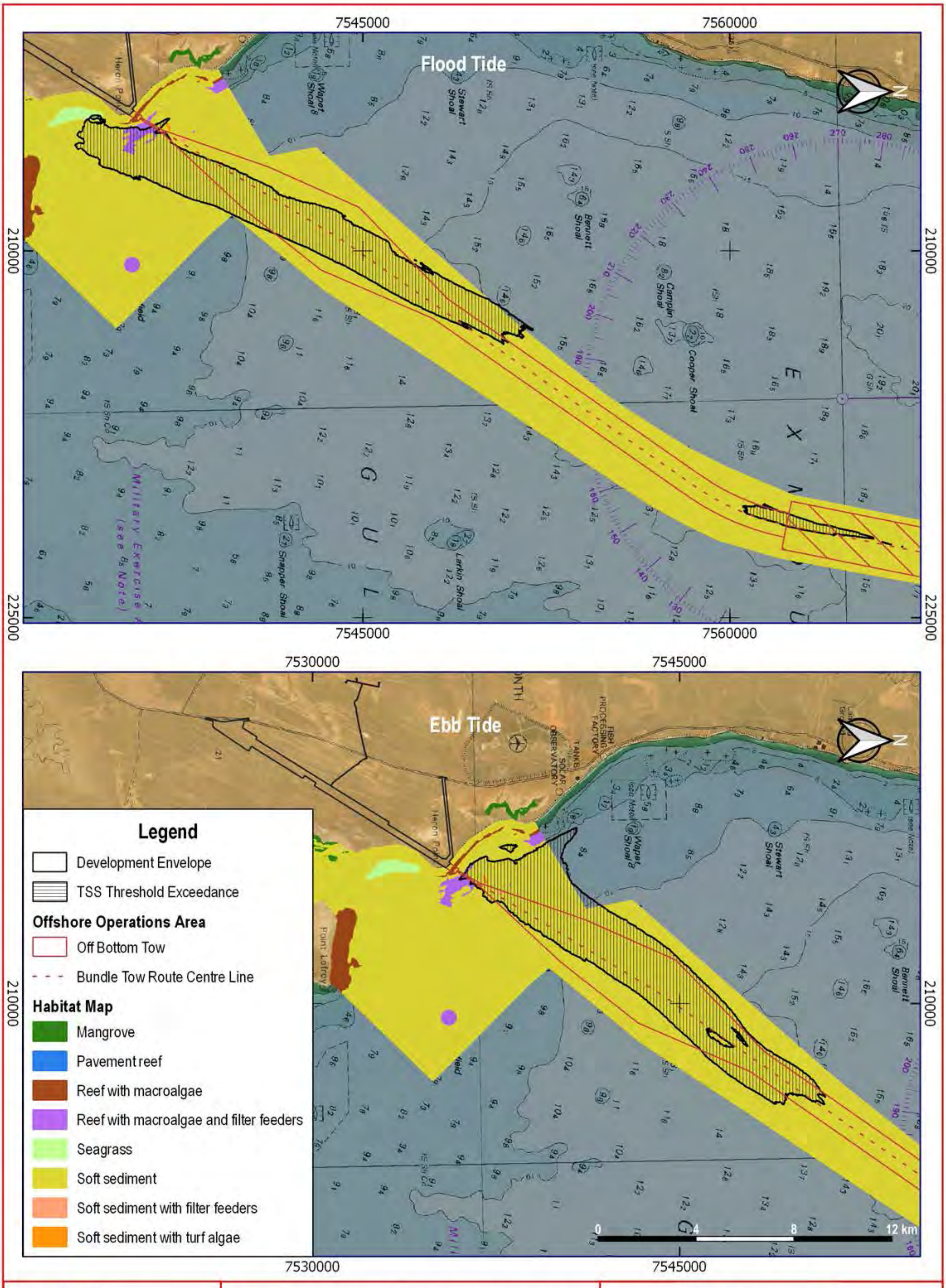
Based on the expected tolerance of the local BCH to short-term increases in turbidity (as occur naturally), the area of exceedance of the threshold (under both flood and ebb tide) has been classified as a ZoI, within which temporary minor changes in environmental quality are predicted and anticipated, but where these changes would not result in a detectible impact on benthic biota.

Studies recently completed under the Western Australian Marine Science Institution (WAMSI) Dredging Science Node have revealed a threat to coral reproductive success, whereby suspended sediments adhered to the mucous membrane of the egg-sperm bundles, reducing their ascent or preventing them from reaching the water surface. Further studies investigated how elevated suspended sediments may directly impact the fertilisation of coral eggs at the water's surface (Negri *et al*. 2019). Some early life stages were sensitive (i.e. fertilization), very sensitive (i.e. settlement) and others were quite insensitive (embryogenesis and larval development) to suspended sediments. Activities that generate suspended sediment concentrations of tens of mg/L could affect the egg–sperm bundles and cause sperm limitation effects. Under some circumstances the use of the coral spawning 'critical windows of environmental sensitivity' could be adopted to protect spawning and fertilisation under the precautionary principle. However, where coral spawning occurs at a distance from activities and developing embryos and larvae drift into a turbid plume, there

[11] Unvegetated 'soft sediment' has been excluded given no impact is considered plausible.

is comparatively little risk of negative effects on embryo and larval survivorship (Negri *et al*. 2019).

Given the absence of significant coral cover in the vicinity of the Off bottom tow area (the nearest appreciable coral cover was recorded at Cooper Shoal, located 4.5 km to the west, where minimal changes to water column suspended sediment concentrations were predicted (Figure 5-5, Figure 5-6)), the likelihood of impacts to coral spawning, due to locally elevated suspended sediment concentrations, is considered negligible. Bundle launches during the secondary regional coral spawning period in spring will be avoided due to the proposed no launch period associated with the Humpback whale southern migration (refer Section 5.4.7).



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Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Commonwealth of Australia (2018) and RPS (2019).

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Figure 5-8: Area of Exceedance of the 80th Percentile of Baseline Depth Averaged Turbidity (over 24 hours)

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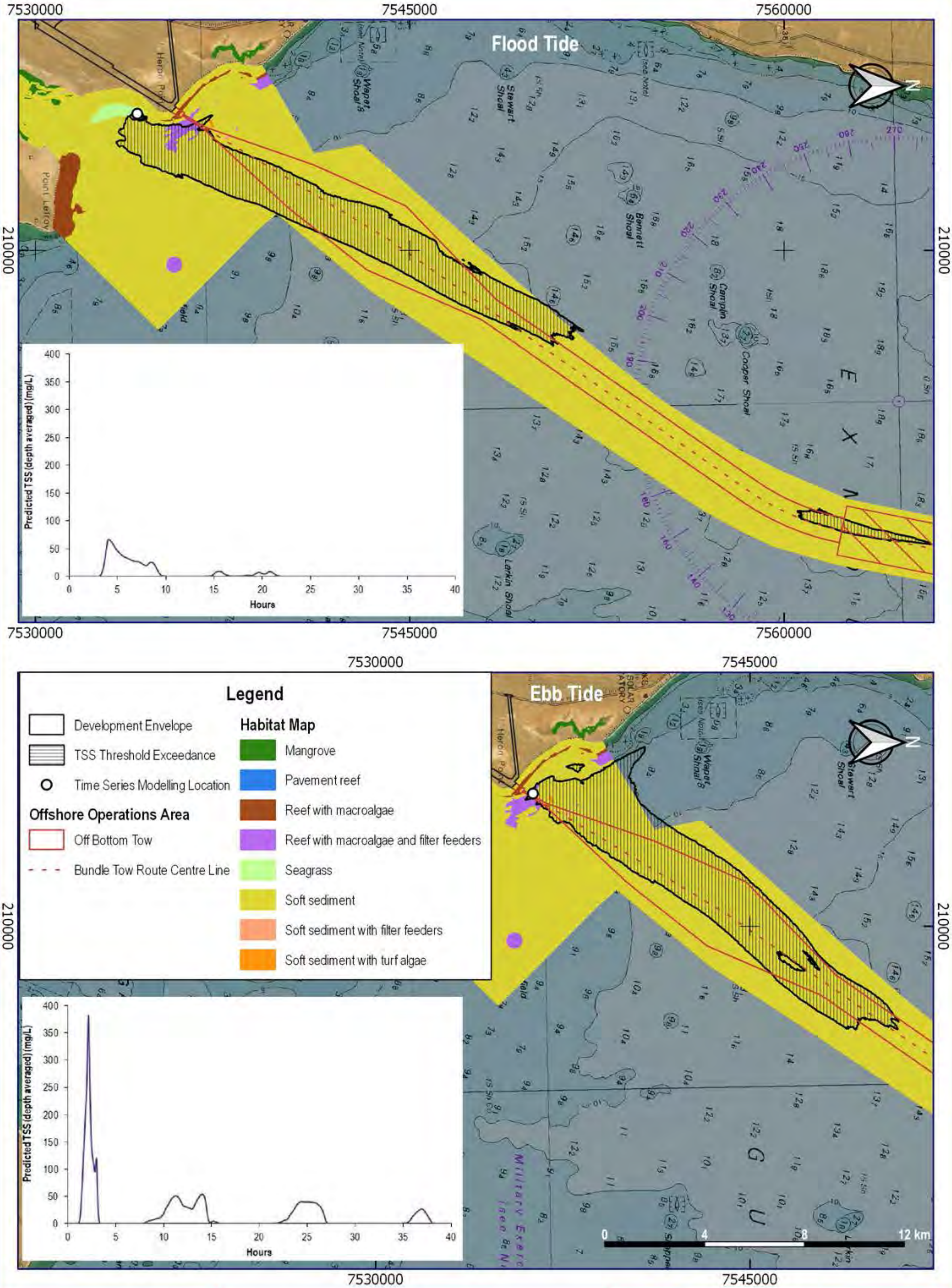

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Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Commonwealth of Australia (2018) and RPS (2019).

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Figure 5-9: Time-Series of Predicted Depth Averaged TSS Following Bundle Launch

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5.1.6.7 Direct Loss of BCH during Bundle Tow in the Event of a Loss of Control of the Bundle

A number of measures are proposed to minimise the likelihood of the loss of control of a Bundle during launch and tow (Table 5-8). With these measures in place, the likelihood of such an event is considered negligible (in over 80 Bundle launches at Wick no such event has occurred).

The Marine Emergency Response Plan (Attachment 3) includes a risk assessment and provides details on the management actions and control measures in place to minimise the likelihood of a loss of control of the Bundle or support vessel (under various scenarios) leading to an indirect loss of BCH during Bundle tow.

5.1.6.8 Indirect Loss of BCH during Bundle Tow in the Event of a Loss of Control of the Bundle or Support Vessel (from Physical Contact or a Chemical Spill)

A number of measures are proposed to minimise the likelihood of the loss of control of a Bundle during launch and tow (Table 5-8). With these measures in place, the likelihood of such an event is considered negligible (in over 80 Bundle launches at Wick no such event has occurred).

The Bundle pipelines can be split in two categories, the internal pipelines, and the outside carrier pipe that sleeves the internal pipelines. The internal Bundle pipelines are designed for high-pressure, high-temperature environments, and therefore have a pipe wall thickness and design strength much higher than what is required for the Bundle launch and tow. The carrier pipe is designed to physically protect these internal pipelines, provide an environmental barrier, and transfer the loads from the launch and tow from the towheads, dissipating these forces along the length of the Bundle.

All fabrication processes of the internal pipelines and the carrier pipe sections are subject to extensive material selection, production and testing criteria, in accordance to a number of Subsea 7 and industry standards, such as:

- DNV-OS-F101 (Submarine Pipeline Systems, DNV).
- ASME IX (Welding and Brazing Operations, American Society of Mechanical Engineers).
- AS 1554 (Structural steel welding Set, Standards Australia).

Subsea 7 conducts many preliminary tests on materials before each batch is used in production to ensure that no material defects exist prior to fabrication. Any material that has failed testing will be immediately quarantined and replaced. All welders will be individually qualified to a specific Weld Procedure Specification (WPS) to confirm welder competency and the repeatability of the WPS. Each completed weld is subject to non-destructive testing (NDT), with specific weld repair procedures in place should a weld be found to be defective. Finally, a full system hydrostatic pressure test is completed, to verify that the line volumes can contain pressure as per the pipeline design.

The likelihood of material damage or loss of containment of the internal pipelines is considered to be low, due to the high-pressure design and the regulated control of the fabrication process. The risk of material damage or failure of the carrier pipe, that has a lower strength capacity than the internal pipelines, is also considered low.

The Bundle pipeline will contain no hydrocarbons during fabrication, launch and tow activities. The carrier pipe will be charged with nitrogen gas, and this allows the Bundle to be positively buoyant during the tow. The carrier pipe will contain solid chemical packs, designed to dissolve in the seawater that floods the carrier pipe once the Bundle is in the final position offshore. These chemical packs create a non-corrosive environment for the internal pipelines.

It is difficult to envisage a circumstance where sufficient force is imparted to the carrier pipe to cause a leak or rupture. This notwithstanding, material damage to the carrier pipe, leading to a leak would result in a release of nitrogen gas. The carrier pipe internal pressure is monitored during the launch and tow, and any change in pressure will be immediately reported. Such a leak would result in the Bundle becoming positively buoyant (as the weight of nitrogen is reduced) and it would rise to the water surface. If left untreated, the carrier pipe could eventually take on enough seawater to cause the Bundle to become negatively buoyant and sink (depending on the extent of the damage). The seawater within the carrier pipe would mix with the solid chemical packs, but any discharge would be limited and localised. Significant impacts to water or sediment quality, leading to an impact to BCH, are considered extremely unlikely.

Tow vessels will be high specification tow vessels equipped with 'Dynamic Positioning' (DP) systems, with a suitable level of system redundancy. In addition, vessel assurance suitability surveys will be conducted prior to the commencement of tow operations. In the event of a vessel breakdown the Tow Master will communicate a controlled 'All-Stop' of the Bundle Tow. The Bundle would be put into Off bottom tow configuration and the support vessels would provide assistance to the compromised vessel. The breakdown would then be fully assessed by the vessel's Chief Engineer and repairs completed. Therefore the likelihood of significant impacts to BCH as a result of the loss of control of a support vessel is considered negligible.

The Marine Emergency Response Plan (Attachment 3) includes a risk assessment and provides details on the management actions and control measures in place to minimise the likelihood of a loss of control of the Bundle or support vessel leading to an indirect loss of BCH during Bundle tow.

5.1.6.9 Indirect loss of BCH due to altered water flows and sediment movement as a result of the presence of the launchway

Due to the relatively small size and low elevation of the launchway relative to the seabed, the launchway is not expected to have any significant impact on the local wave or current conditions at or adjacent to the site (Attachment 2E).

There is a net longitudinal migration of sediment from north to south along the beach at Heron Point (Attachment 2E). It is anticipated that sediment transport over the launchway would be limited until the beach has accreted to the point that the beach berm roughly aligns with the top of the launchway rail. Once this occurs sediment would begin to be transported over the structure during high water level and wave energy conditions. Once sediment begins to be transported past the structure, the rate of beach accretion on the northern side would slow. It would be expected that the beach would continue to accrete until such time as the shoreline on the northern side is sufficiently advanced that the sediment will transport past the launchway at the same rate as it is transported into the area (Attachment 2E). The area of potential sediment accretion, in relation to mapped BCH, is shown in Figure 5-10. In the absence of any mitigation measures, sediment accretion is predicted to occur across existing beach sands and across intertidal, unvegetated, pavement reef habitat.

Sediment deposition on the northern side of the launchway would temporarily impact the quantity of sediment available to the south. Temporary impacts to the south of the launchway are likely to be limited to a narrowing or possible loss of the small perched beach formations that exist seaward of the onshore rock platforms and bluffs (Attachment 2E), which occur above sea level and do not support BCH (Figure 5-10).

5.1.6.10 Impacts to BCH as a Result of Maintenance or Removal of the Launchway

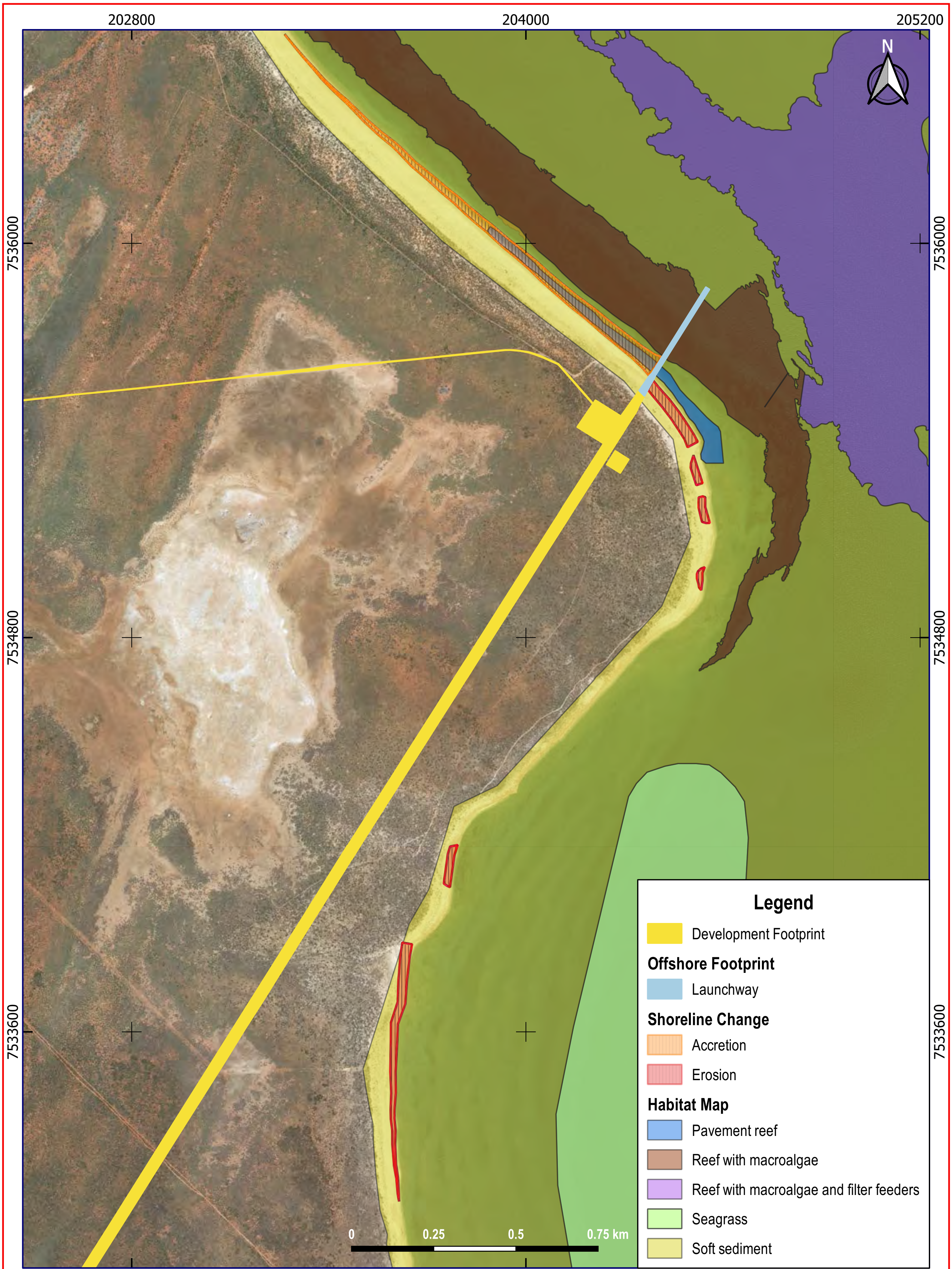
The works associated with the removal of the launchway are likely to generate localised turbidity associated with disturbance of surface sediments. However, the turbidity levels and spatial extent are unlikely to exceed those expected during launchway construction and the duration of works will be significantly shorter than the launchway construction program.

Given the short-term and 'pulse' nature of the expected sediment resuspension, losses of BCH are not expected. Local and minor changes to BCH health could occur, dependent upon the effectiveness of the mitigation measures. As for the construction phase, the area within the immediate vicinity of the launchway footprint (<50 m) has been defined as the ZoMI within which impacts on benthic organisms may occur, but are recoverable within five years. In reality, given the tolerance of such BCH types (refer Section 5.1.6.4), any impacts are expected to be more short-term (<1 year).

Potential indirect BCH impacts (recoverable) as result of the launchway removal are as follows:

- Reef with macroalgae (2.5 ha) (0.7% of that mapped within the Heron Point LAU).
- Soft sediment (2.0 ha) (< 0.1% of that mapped within the Heron Point LAU).
- Pavement reef (0.4 ha) (12.9% of that mapped within the Heron Point LAU).

Prior to a Bundle launch, any sand that has accreted between the two launchway rails will be removed. The portion of the launchway above sea level, where the majority of sand is expected to accrete (Attachment 2E), will be excavated using an excavator, with sand placed immediately south of the launchway to promote the natural southwards migration of beach sands. The small volumes of displaced sediment are expected to be rapidly redistributed and no impacts to BCH are expected.



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Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from MP Rogers (2019).

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Figure 5-10: Predicted Indirect Impacts to BCH Adjacent to Launchway

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5.1.6.11 Potential Cumulative Impacts

Historic Impacts

EPA 2016e advises that the approach to determine cumulative losses within a defined LAU includes determining the spatial extent of BCH:

- Prior to all human-induced disturbance.
- Existing at the time of the proposal.
- Remaining after implementation of the proposal.

Given the lack of information regarding the habitats within deeper waters prior to European habitation, it has been assumed, given that the key driver of habitat types are the substrate type and depth, that the general habitat types have remained the same.

It is likely that some areas of filter feeder habitat within the deeper parts of Exmouth Gulf were lost during development of the prawn fishery. The Exmouth Gulf Prawn Managed Fishery has impacted on some shallow water areas (less than 12 m in depth) containing sponge habitats, but the trawling has focused in the deeper central and north western sectors of Exmouth Gulf since the 1980's (Kangas *et al*. 2015).

The quantification of these historic losses is only required, under the EPA framework, when additional losses of the same habitats are predicted to occur, as a result of the Proposal, within the same LAUs.

Impacts from Third Party Projects or Proposals

The risk of environmental impacts due to turbidity generated by prawn trawling activities was considered 'negligible' (Kangas *et al*. 2006b). This conclusion was made on the basis that the trawl gear design is such that it is not in direct and consistent contact with the substrate and therefore does not disturb the substrate to any significant degree, and that the ground trawled in Exmouth Gulf is typically comprised of coarse sediments that do not readily 'silt'.

The quantification of these third party impacts is only required, under the EPA framework, when additional losses of the same habitats are predicted to occur, as a result of the Proposal, within the same LAUs.

Potential cumulative impacts following multiple Bundle launches

To take account of the impact from multiple Bundle launches, Figure 5-11 presents the cumulative footprint following a number of Bundle launches. The modelled scenarios were as presented in Table 5-5.

The lateral movement of a Bundle during a launch was modelled using the information from the current measurements obtained in May/June 2018 (Attachment 2G) and Subsea 7's extensive experience of Bundle behaviour during launch and tow. The tidal speed and direction changes through the flood-ebb cycle, and the resulting effects on the movement of a Bundle, can be seen by the modelled footprints swinging from one side of the tow centreline to the other during the duration of the inshore part of a tow (when the tidal currents are more perpendicular to the direction of the tow route). As the tow route turns to the north, tidal currents run more parallel to the Bundle and the lateral deflection is significantly reduced.

Scenario No.	Bundle Length (km)	Tidal Condition
1	6	Mean
2	6	Mean
3	6	Neap
4	4	Mean
5	4	Spring
6 (Realistic Worst Case)	8	Mean

Table 5-5: Bundle Chain Footprint Modelling Scenarios

As stated in Section 5.1.6.2, while the Proposal does not involve dredging, the approach outlined within the EPA's '*Technical Guidance - Environmental Impact Assessment of Marine Dredging Proposals*' (EPA 2016v) has been referenced to assist in the spatial representation of the zones of potential impact to BCH.

In relation to the prediction of impacts associated with suspended sediments, the EPA (2016v) states '*Uncertainty is a factor inherent in all predictions and there is an array of sources of uncertainty associated with dredging impact predictions. In order to take account of this uncertainty in the EIA process, the final set of predictions may describe the lower and upper ends of the likely range of impacts associated with the proposal (i.e. the likely best case and the likely worst case). This range should be realistic and based on understanding of probable scenarios and their associated environmental outcomes. For the majority of proposals, the range of predictions to be considered should be conservative but not include unrealistic best or worst case (or other improbable) predictions*'. It is further stated that '*the upper end of the range should reflect a likely worst case outcome that the proponent is both confident of achieving and prepared to be conditioned to*'.

To assess the potential impacts associated with multiple Bundle launches a 'realistic best case' (or 'most likely best case') and a 'realistic worst case' (or 'worst case') were defined and assessed.

A 'realistic best case' disturbance footprint associated with a Bundle launch is 501.8 ha. This disturbance footprint represents the seabed disturbance that would result from the launch of a 4 km Bundle under mean current velocity (i.e. mid-way between neaps and springs) (Scenario 4 within Table 5-5 and Figure 5-11). On this basis, predicted BCH impacts (recoverable) as a result of a Bundle launch are as follows:

- Soft sediment (500.4 ha).
- Reef with macroalgae and filter feeders (0.9 ha).
- Soft sediment with filter feeders (0.4 ha).

Scenario 6 (Table 5-5, Figure 5-11) was assessed as the 'realistic worst case' given that this Bundle length (8 km) is approaching the maximum Bundle length (refer Section 5.1.6.5), and a Bundle of this length would generally be launched under neap tide conditions (so the modelling of a launch under mean tidal conditions is an over-estimate of impacts). On this basis, predicted BCH impacts as a result of a Bundle launch are as follows:

- Soft sediment (1815.8 ha) (9.6% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).
- Reef with macroalgae and filter feeders (1.5 ha) (0.7% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).

- Soft sediment with filter feeders (0.4 ha) (5.9% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).

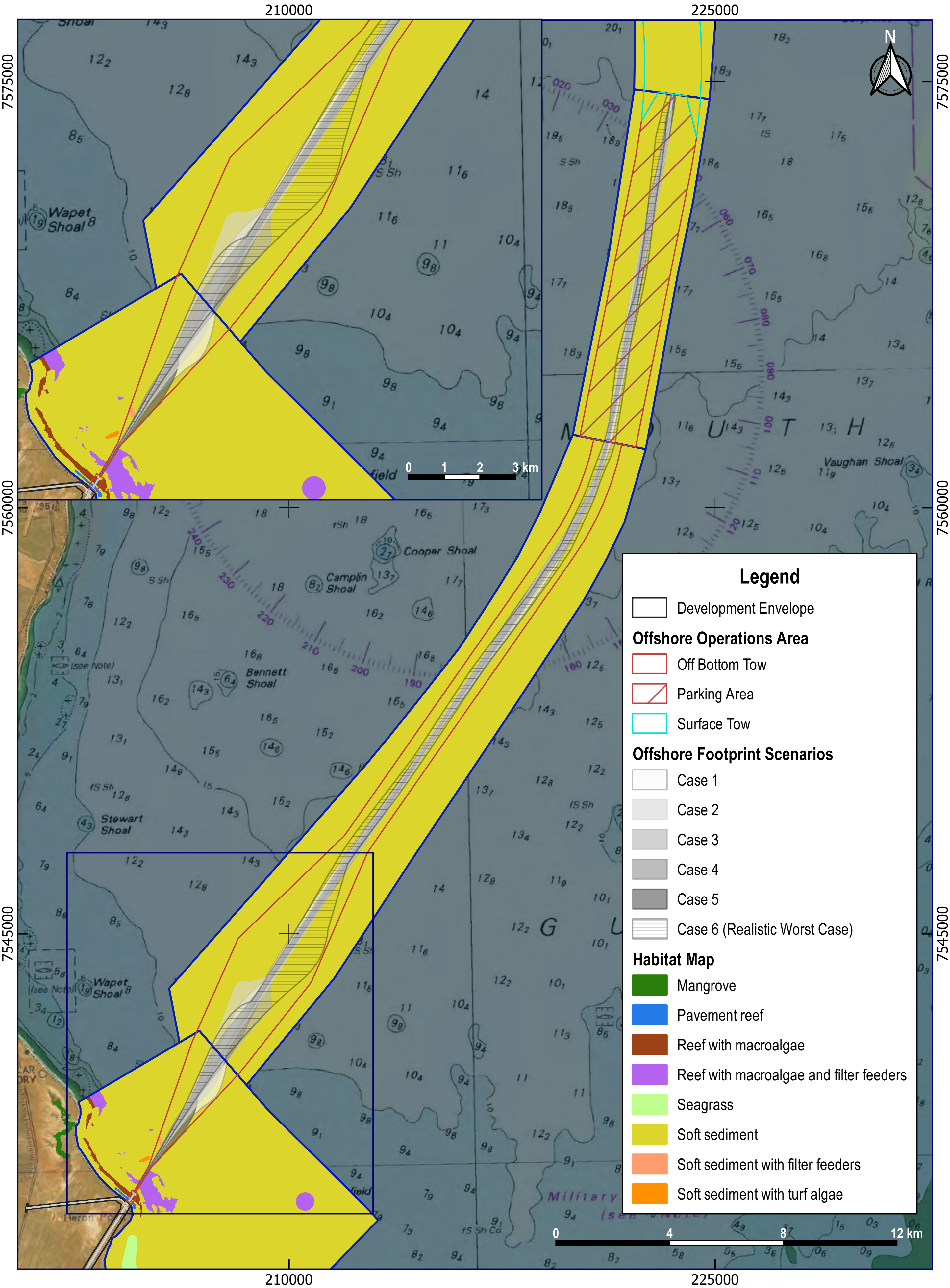
In the event that six different Bundles (ranging from 4 km to 8 km in length) are launched under differing tidal conditions (neap, mean and spring), over a period of several years, a total of 2,120 ha of soft sediment habitat could be disturbed. Disturbance would occur intermittently (nominally once every four to six months, for up to one day per launch) and restoration of the natural seabed topography would be expected to occur between events, with little to no trace of physical disturbance expected within four weeks of a Bundle launch. Based on the expected minimal impact to Soft sediment habitat from a Bundle launch, and anticipated rapid recovery, Scenario 6 was used to define a 'realistic worst case' for potential cumulative impacts following multiple Bundle launches (refer Table 5-6). The premise behind the use of this scenario is that it describes the maximum area of BCH likely to exhibit impacts from Bundle launch activities at any time during the life of the Proposal.

Impacts across the whole of the cumulative impact footprint (6 launches) are unlikely to ever occur, as the modelled scenarios include a launch under spring tides (unlikely), and no recovery of BCH between launches, over multiple (minimum three) years. As stated in Section 5.1.6.5 and above, the effect of the chains touching the seabed within this already disturbed, primarily soft sediment habitat is not expected to have a significant impact. However, to quantify the potential (but highly unlikely) 'absolute worst case' outcome following multiple Bundle launches, and assuming no recovery of BCH between Bundle launches, calculations have been completed based on the total area potentially impacted by all six scenarios as outlined in Table 5-5 and Figure 5-11. This area has been designated a potential ZoHI. On this basis, potential cumulative impacts as a result of the Proposal are as follows (refer also to Table 5-7):

- Soft sediment (2213.6 ha) (9.9% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).
- Reef with macroalgae (0.1 ha) (< 0.1% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).
- Reef with macroalgae and filter feeders (3.6 ha) (1.8% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).
- Soft sediment with filter feeders (0.7 ha) (10.3% of that mapped within the Heron Point, Offshore Operations Area (Off bottom tow) and Parking area LAUs).

Table 5-7 presents the predicted cumulative losses of BCH as a result of the Proposal, and presents the 'absolute worst case' cumulative loss total for each BCH type within each of the LAUs (as requested by the EPA).

The ZoHI associated with multiple Bundle launches, as presented in Figure 5-12, was derived from the 'absolute worst case' scenario described above. Figure 5-12 also presents the ZoHI associated with the launchway footprint, the ZoMI associated with launchway construction and potential altered sediment transport adjacent to the launchway, and the ZoI associated with Bundle launch.



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Aerial Photo: ESRI Satellie
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Subsea 7 and Commonwealth of Australia (2018).

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Figure 5-11: Potential Direct Impact to BCH Following Multiple Bundle Launches

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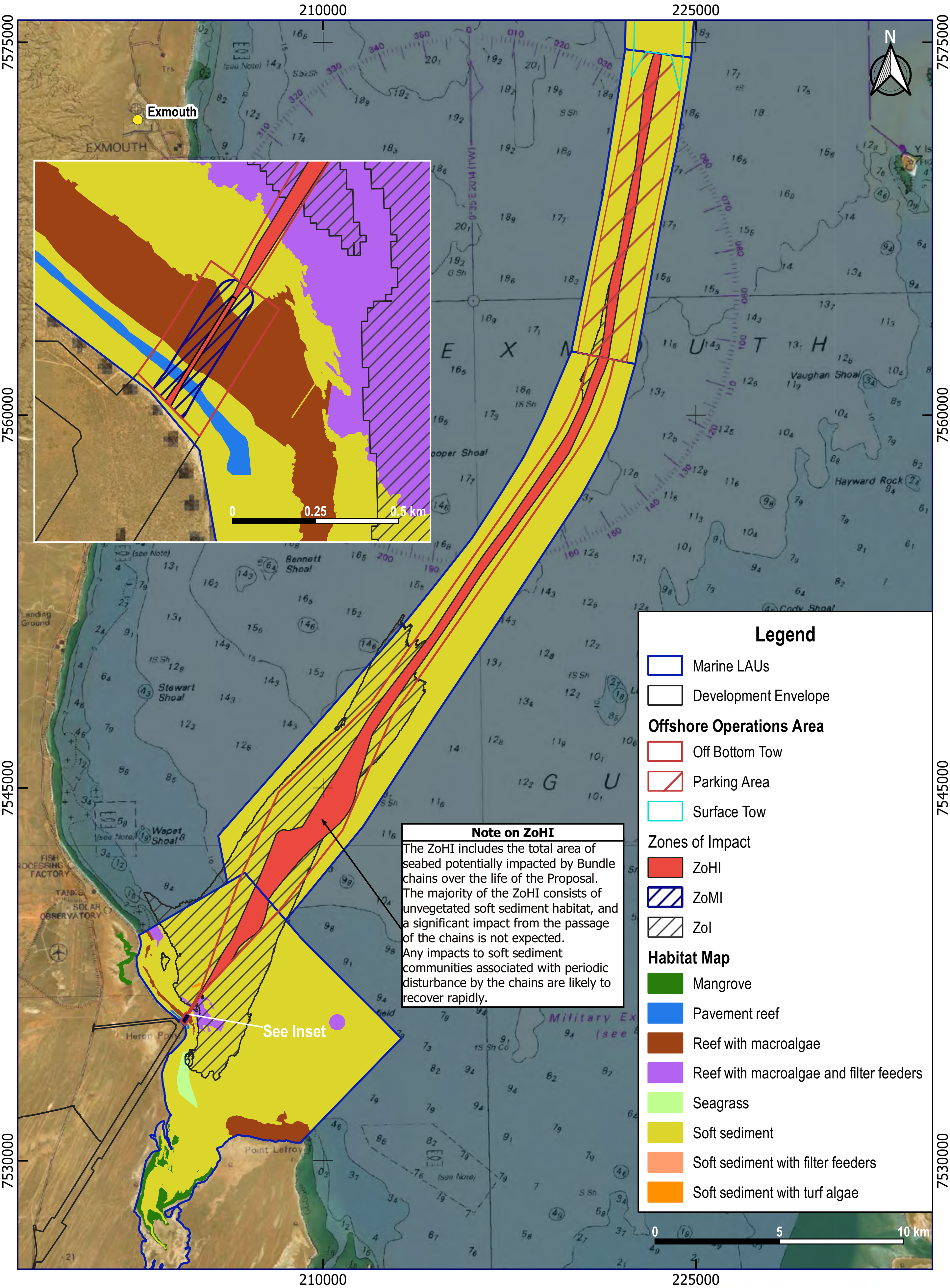

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Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Commonwealth of Australia (2018) and RPS (2019).

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Figure 5-12: Zones of High and Moderate Impact and Zone of Influence (Worst Case)

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Calculations

Table 5-6 presents the estimated pre-European habitation coverage of BCH within Exmouth Gulf, the historic loss of BCH, the predicted direct and indirect loss of BCH as a result of the Proposal (realistic worst case), and the cumulative loss total for each BCH type within each of the LAUs.

BCH Type	Pre-European Habitation Coverage (ha)	Historic Losses (ha)	Direct Proposal Impacts (ZoHI) (ha)[12]	Direct Proposal Impacts (ZoHI) (%)	Cumulative Impacts (%)
Heron Point LAU					
Soft sediment	6,930.7	0.0	110.3	1.6	1.6
Reef with macroalgae	347.8	0.0	0.3	0.1	0.1
Pavement reef	3.1	0.0	0.1	3.2	3.2
Reef with macroalgae & filter feeders	203.4	0.0	1.5	0.7	0.7
Soft sediment with filter feeders	6.8	0.0	0.4	5.9	5.9
Soft Sediment with turf algae	6.3	0.0	0.0	0.0	0.0
Seagrass	109.7	0.0	0.0	0.0	0.0
Mangrove	261.3	0.0	0.0	0.0	0.0
Offshore Operations Area (Off bottom tow) LAU					
Soft sediment	8,553.1	0.0	1,338.5	15.6	15.6
Parking area LAU					
Soft sediment	3,259.0	0.0	367.2	11.3	11.3
Offshore Operations Area (Surface tow) LAU					
Soft sediment	3,676.5	0.0	0.0	0.0	0.0
Pavement reef	389.9	0.0	0.0	0.0	0.0
Pavement reef with	1,414.1	0.0	0.0	0.0	0.0

[12] Launchway footprint and Bundle chain footprint (realistic worst case)

BCH Type	Pre-European Habitation Coverage (ha)	Historic Losses (ha)	Direct Proposal Impacts (ZoHI) (ha)[12]	Direct Proposal Impacts (ZoHI) (%)	Cumulative Impacts (%)
filter feeders					
Pavement reef with macroalgae & filter feeders	2,239.8	0.0	0.0	0.0	0.0

Table 5-6: Cumulative Impacts to BCH ('Realistic Worst Case')

Table 5-7 presents the estimated pre-European habitation coverage of BCH within Exmouth Gulf, the historic loss of BCH, the predicted direct and indirect loss of BCH as a result of the Proposal (absolute worst case), and the cumulative loss total for each BCH type within each of the LAUs.

BCH Type	Pre-European Habitation Coverage (ha)	Historic Losses (ha)	Direct Proposal Impacts (ZoHI) (ha)[13]	Direct Proposal Impacts (ZoHI) (%)	Cumulative Impacts (%)
Heron Point LAU					
Soft sediment	6,930.7	0.0	707.5	10.2	10.2
Reef with macroalgae	347.8	0.0	0.4	0.1	0.1
Pavement reef	3.1	0.0	0.1	3.2	3.2
Reef with macroalgae & filter feeders	203.4	0.0	3.6	1.8	1.8
Soft sediment with filter feeders	6.8	0.0	0.7	10.3	10.3
Soft Sediment with turf algae	6.3	0.0	0.0	0.0	0.0
Seagrass	109.7	0.0	0.0	0.0	0.0
Mangrove	261.3	0.0	0.0	0.0	0.0
Offshore Operations Area (Off bottom tow) LAU					
Soft sediment	8,553.1	0.0	1,506.30	17.6	17.6
Parking area LAU					
Soft sediment	3,259.0	0.0	458.8	14.1	14.1
Offshore Operations Area (Surface tow) LAU					
Soft sediment	3,676.5	0.0	0.0	0.0	0.0
Pavement reef	389.9	0.0	0.0	0.0	0.0
Pavement reef with filter feeders	1,414.1	0.0	0.0	0.0	0.0

[13] Launchway footprint and Bundle chain footprint (absolute worst case)

BCH Type	Pre-European Habitation Coverage (ha)	Historic Losses (ha)	Direct Proposal Impacts (ZoHI) (ha)[13]	Direct Proposal Impacts (ZoHI) (%)	Cumulative Impacts (%)
Pavement reef with macroalgae & filter feeders	2,239.8	0.0	0.0	0.0	0.0

Table 5-7: Cumulative Impacts to BCH ('Absolute Worst Case')

Overall the potential cumulative impacts to BCH are minor and the EPA Objective will be met.

5.1.7 Mitigation, Monitoring, and Predicted Outcome

The proposed mitigation measures to address potential impacts to BCH as a result of the Proposal, the predicted outcome, and monitoring (where proposed to verify the outcome), are provided in Table 5-8.

Potential Impact	Mitigation Measures	Predicted Outcome
Direct loss of BCH during launchway construction	Measures to avoid: • NA Measures to minimise: • Launchway designed to minimise footprint (including extent of rock fill). • Use of pre-cast concrete panels will reduce seabed disturbance. Measures to rehabilitate: • Removal of launchway at the end of the project life.	Habitats within the launchway footprint are well represented elsewhere and the predicted losses represent a small proportion of the habitat present within the Heron Point LAU, as follows: • Soft sediment – 0.2 ha (< 0.1%) of mapped habitat. • Reef with macroalgae – 0.3 ha (0.1%) of mapped habitat. The biological diversity and ecological integrity of BCH will be maintained. <u>Monitoring</u> Habitat mapping of BCH adjacent to launchway within one year of construction being completed (refer to the Marine Construction Monitoring and Management Plan (MCMMP) in Attachment 3).
Indirect loss or degradation of BCH due to turbidity created during launchway construction	Measures to avoid: • NA Measures to minimise: • Launchway designed to minimise footprint (including extent of rock fill) thus reducing seabed disturbance and duration of construction. • Use of pre-cast concrete panels will reduce seabed disturbance and duration of construction.	Construction of the Bundle launchway is estimated to take up to six months. Elevated turbidity is expected to be limited to the immediate surrounds (<50 m) of the work site. The adjacent habitats are expected to be tolerant of short-term pulses in turbidity and suspended sediment. Potential reversible impacts could

Potential Impact	Mitigation Measures	Predicted Outcome
	• Construction material to be screened and washed to remove 'fines' (particles <63 µm in diameter). • Silt curtains deployed during turbidity-generating construction activities (refer MCMMP).. • Suspension of turbidity-generating construction activity in the event elevated turbidity is recorded beyond the ZoMI (refer MCMMP). Measures to rehabilitate: • NA	occur as follows: • Soft sediment 2.0 ha (< 0.1%) of mapped habitat. • Reef with macroalgae 2.5 ha (0.7%) of mapped habitat. The biological diversity and ecological integrity of BCH will be maintained. <u>Monitoring</u> Monitoring of water quality adjacent to launchway (refer to the MCMMP in Attachment 3). Quantitative survey of BCH adjacent to launchway before construction, and within one year of construction being completed (refer to the Marine Construction Monitoring and Management Plan (MCMMP) in Attachment 3).

Potential Impact	Mitigation Measures	Predicted Outcome
Direct loss of BCH during Bundle launch and tow	Measures to avoid: • Surface tow operations within Ningaloo Marine Park to avoid impacts to BCH. Measures to minimise: • All launch and tow operations will occur within the nominated Offshore Operations Area to minimise cumulative impacts to BCH. • Bundle tethered to 'Leading Tug' and 'Trailing Tug' at all times, including within Parking area, to ensure minimal lateral movement of Bundle. • Chains arranged and connected to the Bundle provide lateral stability during the initial launch and off-bottom tow to ensure operations remain within the Offshore Operations Area. Measures to rehabilitate: • NA	An average of two Bundle launches will occur per year with a maximum of three. Soft sediment communities are expected to rapidly recover from what will be a short-term, periodic, superficial physical disturbance of the top sediment layer. Direct impacts to Reef with microalgae and Reef with macroalgae and filter feeder habitats will be limited to a narrow corridor adjacent to the end of the launchway. These habitats are well represented to the north and south of the launchway alignment. On the basis of the 'realistic worst case' scenario, predicted BCH impacts as a result of a Bundle launch are as follows: • Soft sediment (1815.8 ha). • Reef with macroalgae and filter feeders (1.5 ha). • Soft sediment with filter feeders (0.4 ha). Localised loss will not result in significant impacts on biological diversity or ecological integrity of the local or regional ecosystem.
Indirect loss or degradation of BCH		An average of two Bundle launches will occur per year with a maximum

Potential Impact	Mitigation Measures	Predicted Outcome
during Bundle launch and tow	Measures to avoid: • A maximum of three launches per year, for a nominal duration of two days per launch, is unlikely to lead to indirect impacts to BCH. Measures to minimise: • NA Measures to rehabilitate: • NA	of three. It is expected that the macroalgae and filter feeders on reefs adjacent to the inshore section of tow route will be tolerant of isolated, short-term, 'pulses' of elevated turbidity (as occur naturally) and as such will not be significantly impacted. Thus the area of potential elevated turbidity has been deemed a ZoI, where no impacts to BCH are expected. Biological diversity and ecological integrity of BCH will be maintained. <u>Monitoring</u> Water quality monitoring adjacent to sensitive BCH outside of the Offshore Operation Area during initial Bundle launch to validate sediment fate modelling predictions (refer Marine Operational Environmental Monitoring Plan (MOEMP) in Attachment 3). Quantitative survey of BCH within and outside of the Offshore Operation Area before and following initial Bundle launch to validate impact predictions (refer Marine Operational Environmental Monitoring Plan (MOEMP) in Attachment 3).

Potential Impact	Mitigation Measures	Predicted Outcome
Direct loss of BCH during Bundle tow in the event of a loss of control of the Bundle	Measures to avoid: • Weather forecast/seasonal data reviewed to inform launch schedule to avoid tow in adverse conditions. • Weather forecast monitored ahead of launch operations and launch window defined to avoid tow in adverse conditions. • Defined limiting weather criteria. • Bundle tethered to 'Leading Tug' and 'Trailing Tug' at all times, including within Parking area. • High specification tow vessels used for launch operations. • Secondary system/redundancy design in Bundle monitoring system. • Tow vessels to be equipped with 'Dynamic Positioning' (DP) systems, with a suitable level of system redundancy. • Full tow vessel position monitoring system verification prior to leaving Bundle Parking area. • Secondary tow vessel position keeping system in place for passage through Ningaloo Marine Park. • Vessel Assurance Suitability Surveys conducted prior to commencement of operations. • Notice to mariners supporting information issued prior to tow to inform local vessels of operations. • Guard vessel to monitor/enforce exclusion zones. • Each vessel operating in adherence to International Regulations for Preventing Collisions at Sea (COLREGs). • Vessel intervention if required (as described in guard vessel procedure for engaging 3rd party vessels). • Visual monitoring of Bundle on surface (surface buoys and	Given the controls in place during each Bundle launch, the likelihood of a loss of control of a Bundle, leading to an impact to BCH beyond the defined Offshore Operations Area (Off bottom tow) is considered negligible (refer Marine Emergency Response Plan (Attachment 3)). Biological diversity and ecological integrity of BCH will be maintained. Monitoring In the event of a loss of control of the Bundle leading to seabed contact outside the Offshore Operation Area (Off bottom tow) or Offshore Operation Area (Parking area), habitat mapping of BCH adjacent to site(s) of contact within one month.

Potential Impact	Mitigation Measures	Predicted Outcome
	lights). • Timing of Surface tow through Ningaloo Marine Park chosen to coincide with benign sea, tidal and weather conditions. Measures to minimise: • Community engagement and announcements locally. • Broadcasting on VHF as required. Measures to rehabilitate: • NA.	
Indirect loss of BCH during Bundle tow in the event of a loss of control of the Bundle or support vessel (e.g. from physical contact or a chemical spill)	Measures to avoid: • Bundle fully pressure tested and leak tested prior to launch. • Ongoing monitoring of Bundle pressures prior to and during launch. • Weather forecast/seasonal data reviewed to inform launch schedule. • Weather forecast monitored ahead of launch operations and launch window defined. • Weather conditions monitored during launch operations. • Defined limiting weather criteria. • High specification tow vessels used for launch operations. • System confirmation check completed prior to departing Parking area. • Secondary system/redundancy design in bundle monitoring system. • Tow vessels to be equipped with 'Dynamic Positioning' (DP) systems, with a suitable level of system redundancy. • Full tow vessel position monitoring system verification prior to	Given the controls in place during each Bundle launch, the likelihood of a loss of control of a Bundle, and of a resulting chemical leak or spill and an impact to BCH, is considered negligible (refer Marine Emergency Response Plan (Attachment 3)). Biological diversity and ecological integrity of BCH will be maintained.

Potential Impact	Mitigation Measures	Predicted Outcome
	leaving Bundle Parking area. • Secondary tow vessel position keeping system in place for passage through Ningaloo Marine Park. • Vessel Assurance Suitability Surveys conducted prior to commencement of operations. • Notice to mariners supporting information issued prior to tow to inform local vessels of operations. • Guard vessel to monitor/enforce exclusion zones. • Each vessel operating in adherence to International Regulations for Preventing Collisions at Sea (COLREGs) • Vessel intervention if required (as described in guard vessel procedure for engaging 3rd party vessels). • Community engagement and announcements locally. • Broadcasting on VHF as required. • Visual monitoring of Bundle on surface (surface buoys and lights). • Timing of Surface tow through Ningaloo Marine Park chosen to coincide with benign sea, tidal and weather conditions. Measures to minimise: • Bundle carrier pipe does not contain any hydrocarbons (filled with inert nitrogen gas plus solid corrosion inhibitors). • Any chemical to be used within flow lines must have: o An OCNS Hazard Quotient rating of Gold, Silver, E or D and have no substitution or product warning; or o Further assessment is to be undertaken to ensure the environmental risk is ALARP.	

Potential Impact	Mitigation Measures	Predicted Outcome
	Measures to rehabilitate: • Each vessel equipped with a vessel specific Shipboard Oil Pollution Emergency Plan (SOPEP) or equivalent, and will follow response actions to incidental pollution in accordance with the vessel's emergency plan. • Emergency Response Plan (Attachment 3).	
Indirect loss of BCH due to altered water flows and sediment movement as a result of the presence of the launchway	Measures to avoid: • NA Measures to minimise: • Design of launchway to minimise height of structure above surrounding beach or seabed. • Periodic bypassing of sand during launchway maintenance to limit sand accumulation to the north of the launchway and associated sand depletion to the south of the launchway. Measures to rehabilitate: • Management of onshore sediment accretion via monitoring and, when management triggers are exceeded, sand bypassing.	Due to its relatively small size and low elevation of the launchway relative to the seabed, the launchway is not expected to have any significant impact on the local wave or current conditions at or adjacent to the site. Sediment accretion is predicted to occur adjacent to the north side of the launchway, across existing beach sands and across intertidal pavement reef habitat. This pavement reef habitat does not support any macroalgae or fauna, and the biological diversity and ecological integrity of BCH will not be affected. Biological diversity and ecological integrity of BCH will be maintained. <u>Monitoring</u> The following monitoring is proposed: • Survey of beach profiles adjacent to launchway

Potential Impact	Mitigation Measures	Predicted Outcome
		(annual). • Inspections, including photographic monitoring of shoreline adjacent to launchway (annual). • Shoreline mapping (every 3-6 years).
Impacts to BCH as a result of removal of the launchway	Measures to avoid: • NA Measures to minimise: • Silt curtains deployed during turbidity generating construction activities (refer MCMMP). • Suspension of turbidity-generating construction activity in the event elevated turbidity is recorded beyond the ZoMI (refer MCMMP). Measures to rehabilitate: • NA	No permanent impacts to BCH expected. Elevated turbidity is expected to be limited to the immediate surrounds (<50 m) of the work site. Potential reversible impacts could occur as follows: • Soft sediment 2.0 ha (< 0.1%) of mapped habitat. Reef with macroalgae 2.5 ha (0.7%) of mapped habitat.Biological diversity and ecological integrity of BCH will be maintained.

Table 5-8: Proposed Mitigation Measures and Predicted Outcome for BCH

5.1.8 Assessment of Residual Impacts to Biological Diversity and Ecological Integrity

In the context of this objective 'Ecological integrity' is the composition, structure, function, and processes of ecosystems, and the natural variation of these elements. The objective for this factor recognises that marine benthic communities are important components of almost all marine ecosystems, and are fundamental to the maintenance of ecological integrity and biological diversity of the marine environment as a whole.

As defined by the EPA, '*Ecosystem integrity is considered in terms of structure (e.g. the biodiversity, biomass and abundance of biota) and function (e.g. food chains and nutrient cycles)*' (EPA 2000). Habitat structure varies from the two-dimensional habitats of unvegetated soft sediment areas to the complex three-dimensional habitat available on reefs, with the latter offering more ecological 'niches' for colonisation by macroalgae and fauna. Habitat function includes the following:

- Primary production: a measure of the growth rates and therefore potential contribution to food webs of the main groups of aquatic plants on the seabed (benthic primary production).
- Secondary production: a measure of the growth rates of invertebrates.
- Water filtering capacity: a measure of the rate at which particulate organic matter (phytoplankton, zooplankton, detritus) in the water column is removed by filter-feeding organisms (e.g. bivalves, sponges, soft corals).
- Biogeochemical cycling: an estimate of the rate at which biologically significant materials (in this case nitrogen) are converted from inorganic forms into organic forms (nitrogen cycling by plants), or cycled within the sediments (e.g. as represented by the degree of sediment bioturbation by invertebrates, as this affects sediment oxygen levels that in turn affect nitrogen cycling within sediments).

For the assessment of the potential impacts to biological diversity and ecological integrity, the maximum cumulative impact to each habitat type under the 'realistic worst case' scenario has been considered. Where an impact to less than 1% of a particular BCH type is predicted within an LAU, it is considered that the risk of a significant impact to the biological diversity or ecological integrity within the LAU is unlikely. This is based on the previous guidance from the EPA that, for areas defined as 'High Protection Areas', which included areas recommended for inclusion in WA's marine reserve system (i.e. 'Wilson Report areas, CALM 1994), a cumulative loss threshold of 1% be applied. This guidance suggests that losses of less than 1% are considered unlikely to significantly affect the ecological integrity of the wider ecosystem.

Where a loss of more than 1% of a particular BCH type is predicted, further analysis of the potential impacts to biological diversity and ecological integrity has been undertaken. The following impacts to > 1% of a BCH type for each LAU are predicted, in order of impact:

- Heron Point LAU: Pavement reef (3.2%), Soft sediment with filter feeders (5.9%) and Soft sediment (1.6%).
- Offshore Operations Area (bottom tow) LAU: Soft sediment (15.6%).
- Parking area LAU: Soft sediment (11.3%).

The Pavement reef habitat was described as '*Unvegetated pavement reef within the upper littoral zone*' (Attachment 2B). Given the lack of macroalgae or fauna, likely due to the position of this habitat in the upper littoral zone and periodic smothering by beach sediment, the loss of this habitat will not result in an impact to biological diversity and ecological integrity.

The Soft sediment with filter feeders habitat was described as '*Soft sediment veneer overlying low relief reef. Sparse cover of filter feeders (sponges and soft corals)*' (Attachment 2B). Given the sparse nature of the fauna within this habitat, the habitat is not considered a key contributor to biological diversity or ecological integrity.

Within the Heron Point LAU, impacts to Soft sediment habitat occur as a result of the launchway footprint (0.2 ha) and due to periodic disturbance associated with the Bundle chain footprint (110.1 ha). The periodic (on average two, maximum of three per year) Bundle launches will result in physical disturbance of the top sediment layers. This may result in a minor, short-term displacement of infauna, although as no material is being removed, it is expected that the infauna community will remain relatively stable.

Within the Offshore Operations Area (bottom tow) LAU and the Parking area LAU, impacts to 1,338.5 ha and 367.2 ha, respectively, of Soft sediment habitat are predicted as a result of the Bundle chains. The periodic (on average two, maximum of three per year) Bundle launches will result in physical disturbance of the top sediment layers. This may result in a minor, short-term displacement of infauna, although as no material is being removed it is expected that the infauna community will remain relatively stable.

Infauna communities living in fine mobile deposits are characterised by large populations of a restricted variety of species that are well adapted to rapid recolonisation of deposits that are subject to frequent disturbance. Recolonisation of disturbed sediment is initially by 'opportunistic' species and the community is subsequently supplemented by an increased species variety of long-lived and slow-growing 'equilibrium' species that characterise stable undisturbed deposits. Recovery times following disturbance have been reported as shorter in warmer waters, but may be extended in colder waters at high latitudes where communities typically comprise large slow-growing species (Newell *et al*. 1998). It is generally understood that muddy or sandy sediment communities recover more quickly than coarser sediment communities (Ferns *et al*. 2000), which may take 2-3 years to recover from full removal, although this is not always the case (Dernie *et al*. 2003). Given the lack of physical removal of sediment, the muddy nature of the sediments and the tropical location of the site, the infauna communities are expected to recover rapidly, if indeed there is any impact. No impact to biological diversity and ecological integrity is expected as a result of the predicted impacts to soft sediment.

Overall the potential cumulative impacts to BCH are low and no impact to biological diversity and ecological integrity is predicted. The EPA objective '*to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained*' will be met.

5.2 KEY ENVIRONMENTAL FACTOR 2 – COASTAL PROCESSES

5.2.1 EPA Objective

To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.

5.2.2 Policy and Guidance

Subsea 7 has taken into consideration relevant policy and guidance in the design of the Proposal, completion of the environmental impact assessment and through the development of this ERD.

A summary of the policy and guidance relevant to Coastal Processes, and how Subsea 7 has considered these, is presented in Table 5-9.

Policy/Guidance	Consideration for Proposal
Statement of Environmental Principles, Factors and Objectives (EPA 2016c, 2018c)	Referred to in the identification and assessment of Preliminary Key Environmental Factors.
Environmental Factor Guideline – Coastal Processes (EPA 2016f)	This guidance was consulted in the consideration of potential impacts to geophysical processes and how these may impact natural coastal dynamics causing an impact to coastal ecosystems and associated values such as landforms, recreation and tourism. Consideration of this factor in the context of climate change was also completed.
State Planning Policy No. 2.6 – State Coastal Planning Policy (WA Planning Commission 2006)	This policy was consulted in the assessment of potential impacts to coastal processes.
Sea Level Change in Western Australia – Application of Coastal Planning (Department of Transport 2010)	This document was consulted in the assessment of potential impacts to coastal processes under future sea level scenarios.
WA Environmental Offsets Policy (Government of Western Australia 2011)	These policies were considered as part of the determination of the need for offsets.
WA Environmental Offsets Guidelines (Government of Western Australia 2014)	
Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (DSEWPAC 2012a)	

Table 5-9: Policy and Guidance Relevant to Coastal Processes

5.2.3 Receiving Environment

A number of marine studies have been undertaken within the region, as outlined in Table 5-10. Subsea 7 has augmented the information from previous studies by commissioning additional, Proposal-specific studies, to ensure an appropriate level of information is available to support completion of the environmental impact assessment and development of environmental management plans.

The Proposal-specific studies, as listed in Table 5-10, were undertaken by various technical specialists, and are included in full within Attachment 2. They are also referred to, as appropriate, in the assessment of potential impacts and proposed management measures.

Survey Date	Researcher/Consultant	Study Description/Title
Regional Studies		
2012	Eliot *et al*. (Damara WA Pty Ltd) and Geological Survey of Western Australia	The Coast of the Shires of Shark Bay to Exmouth, Gascoyne, Western Australia: Geology, Geomorphology & Vulnerability
Project-specific Studies		
2017	MP Rogers	Subsea 7 Bundle Facility Shoreline Movement Assessment
2017	360 Environmental	Learmonth Habitat Surveys
2017	GHD	WA Bundle Fabrication Facility – Site Designs. Design Report (Drainage & Coastal Engineering)
2018	MP Rogers	Subsea 7 Bundle Facility Coastal Processes Assessment

Table 5-10: Overview of Local and Regional Coastal Processes Studies

Limited regional studies have been conducted within Exmouth Gulf. Eliot *et al*. (2012) described the Exmouth Gulf region's susceptibility to change and landform instability as low. This was concluded from the following regional attributes including:

- Partial sheltering from swell.
- Presence of subtidal terraces and rocky features.
- Sheltered beach faces.
- Perching of beaches on inshore rock and moderately stable foredunes.

Several project-specific studies, conducted by MP Rogers, 360 Environmental, and GHD, have been carried out to provide further information for the Development Envelope.

A shoreline movement assessment was undertaken by MP Rogers (2017) (Attachment 2D) evaluating the sediment transport regimes and erosion patterns adjacent to the Learmonth Jetty over the past 60-70 years. This jetty provides a useful case study for what could be expected adjacent to the proposed Bundle launchway, given the similarities in exposure, aspect, and nearshore bathymetry.

The shoreline movement assessment for the Learmonth Jetty site shows a degree of change in the adjacent shoreline between 1949 and 2013. The shoreline adjacent to the northern side of the jetty abutment has averaged 70-100 m of accretion, measured as a seaward movement in shoreline position, of over a 800 m length of shoreline, while the average accretion on the southern side was in the order of 20 m over 700 m. The assessment concluded that although some impediment to longshore sediment transport does occur, there has been no net erosion over the long-term (Attachment 2D). However, short-term erosion of the southern shoreline occurred for a period of years after construction of the jetty with erosion peaking in 1968. The erosion extent during this time may have peaked at 40 m in certain areas.

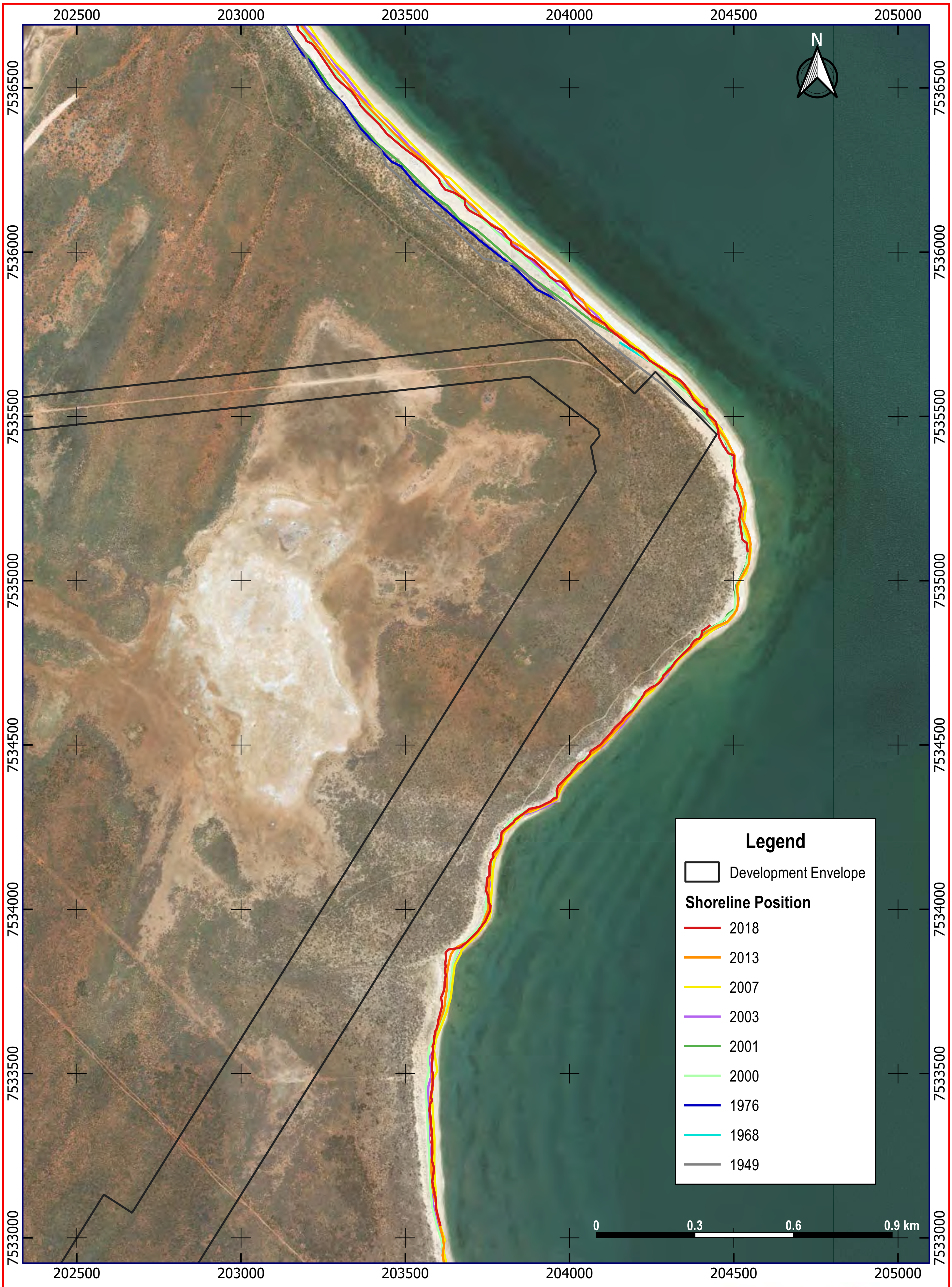
The main findings from the shoreline movement assessment were:

- A varying degree of fluctuation in the shoreline position, with an overall net accretion trend.
- A long-term accretion trend between 1949 – 2001, with an average net accretion of 30 m.
- A predominately medium grain sand shoreline, with median grain sizes ranging from 0.15 to 0.5 mm (diameter). Due to the sandy nature of these materials, longshore transport processes would be expected along these shorelines, however small sediment transport quantities are predicted as a result of the calm nature of the site.

Of note, the total net accretion average of 30 m may be influenced by the ephemeral vegetation during a calm period when the 2013 aerial imagery was taken. Discounting the 2013 shoreline position, the average net accretion from 1949-2001 was approximately 20 m (Attachment 2D).

A subsequent study was completed to improve the understanding of existing coastal dynamics so that potential impacts of the Proposal could be assessed with greater certainty, and to inform the development of appropriate monitoring and management measures (M P Rogers 2019; Attachment 2E). Shoreline movement plans show that the shoreline north of the launchway site has experienced accretion over the period between 1949 and 2018, although this overall trend has been interspersed with periods of apparent erosion (Figure 5-13). The most significant accretion appears to have occurred between 1976 and the early 2000s. Thereafter the shoreline has appeared to erode slightly. South of the launchway site the shoreline has experienced far less movement, although available aerial imagery in these areas generally only extends back to 2000. The limited movement of the shoreline south of the launchway site may be attributable to the extent of visible rock in this area (Attachment 2E). For the shoreline at the launchway site there is potential for both northerly and southerly sediment transport to occur due to the difference in wave exposure angle that is possible. For the shoreline south of Heron Point it is expected that sediment could only be transported in a southerly direction, since there is insufficient fetch length from the south west to generate any significant transport of sediment in a northerly direction.

Seasonal, inter-annual and episodic changes in the shoreline position have not been specifically studied. While such shorter-term variations may occur, particularly following the passage of a cyclone, the longer-term record demonstrates that any such changes are relatively short lived, with the shoreline position returning to its ambient state (Attachment 2E).



Scale: 1:15000
Original Size: A4
Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from MP Rogers (2017).

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Figure 5-13: Longterm Changes in Shoreline Position Adjacent to Heron Point (1949-2018)

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5.2.4 Potential Impacts

Development of the proposed Bundle site launchway has potential to directly and indirectly impact coastal processes within the immediate and surrounding areas at Heron Point during operations and closure. Table 5-11 summarises the potential impacts during each project phase.

Project Phase	Potential Impact
Operations	Direct impact to sediment transport leading to seabed, beach or dune erosion on downdrift side of launchway
	Indirect impacts to coastal morphology by altered wave climate, water flows and sediment movement as a result of the presence of the launchway
	Altered wave overwash and drainage due to launchway leads to dune instability during extreme flooding events
Closure	Permanent change altering water flows and sediment movement as a result of the presence of the launchway

Table 5-11: Potential impacts to Coastal Processes

5.2.5 Potential Cumulative Impacts

Several third party projects or proposals (refer Section 2.5.8) have resulted in, or have the potential to result in, impacts to coastal processes within Exmouth Gulf. However, such impacts would be restricted to the immediate vicinity of the coastal infrastructure, and no third party project or proposal is situated in proximity to the Development Envelope (Figure 2-15). Cumulative impacts to coastal processes as a result of the Proposal, and a third party project or proposal, are considered unlikely.

5.2.6 Assessment of Impacts

5.2.6.1 Direct Impact to Sediment Transport Leading to Seabed, Beach or Dune Erosion on Downdrift Side of Launchway

Previous investigations have determined that the sediment transport along this section of the coastline is predominately from north to south. There will be periods where this trend may reverse, most likely associated with the passage of tropical cyclones; however, over the longer-term an accretion on the northern side of the launchway would be expected (Attachment 2E). It is anticipated that sediment transport over the launchway would be limited until such time as the beach has accreted to the point that the beach berm roughly aligns with the top of the rail. Once this occurs sediment would begin to be transported over the structure during high water level and wave conditions. Once sediment begins to be transported past the structure, the rate of beach accretion on the northern side would slow. It would be expected that the beach would continue to accrete until such time as the shoreline on the northern side is sufficiently advanced that the sediment will transport past the launchway at the same rate as it is transported into the area (Attachment 2E). The area of potential 'worst case' sediment accretion is shown in Figure 5-14.

Sediment deposition on the northern side of the launchway would temporarily impact the quantity of sediment available to the south. However, the response of the southern shoreline will be limited by the presence of rock on Heron Point and along the shoreline further south. Due to the presence of this rock, limited changes to the shoreline are expected to the south of the launchway (Attachment 2E). Any changes that do occur are likely to be limited to a narrowing or possible loss of the small perched beach formations that exist seaward of the onshore rock platforms and bluffs (Attachment 2E). The area of potential 'worst case' sediment erosion is shown in Figure 5-14.

The assessment of alternative 'best' and 'most likely' cases is presented in Table 6.1 of Attachment 2E.

It is anticipated that average sand bypassing rates of 2,500 to 5,000 m^3/year could be required, though this could vary depending on prevailing weather conditions. In the event that any erosion, attributable to the construction of the launchway, causes recession of the vegetation line by > 5 m then sand bypassing will be initiated.

5.2.6.2 Indirect Impacts to Coastal Morphology by Altered Wave Climate, Water Flows, and Sediment Movement as a Result of the Presence of the Launchway

Due to the relatively small size and low elevation of the launchway, it is not expected to have any significant impact on the local wave or current conditions at or adjacent to the site (Attachment 2E). Thus no significant indirect impacts to coastal morphology as a result of altered wave climate, water flows and sediment movement, following launchway construction, are expected.

5.2.6.3 Altered Wave Overwash and Drainage due to Launchway leads to Dune Instability during Extreme Flooding Events

The construction of the launchway will necessitate a cut through the dune system. The construction of the launchway will reduce the elevation of the coastal dune in this area from approximately 5 mAHD down to an elevation of around 2.5 mAHD at the foundation level. Such a reduction in the elevation could result in a localised increase in erosion risk and inundation vulnerability to the land side of the dune.

Wapet Creek and the connection of this system to the salt flats inland from the site already provide an avenue for ingress of seawater during extreme events. It is expected that this area would be at least partially inundated prior to any breach of the launchway cut. Nevertheless, for more severe events, or those that cause more rapid fluctuations in sea level, the ingress of seawater through the launchway cut could occur, potentially resulting in scour of the adjoining area (Attachment 2E). Such an event might be associated with the nearby passage of a cyclone.

Following any event that causes significant re-profiling of the dune system, the dune structure would be reinstated and the cut embankments stabilised. This reinstatement will be stabilised to an appropriate standard to prevent wind generated sediment transport and would match the shape and structure of the adjacent, non-impacted, dunes.

5.2.6.4 Permanent Change to Water Flows and Sediment Movement as a Result of the Presence of the Launchway

At the end of the service life of the facility, decommissioning will be completed including full removal of the launchway. The dune system will also be reinstated to match the shape and structure of the adjacent dunes. Thus a permanent change to water flows and sediment movement will not occur.

Upon decommissioning of the facility it is anticipated that the shoreline would realign (revert to pre-construction state) following removal of the launchway. This realignment would likely result in some erosion of accumulated sediment to the north of the launchway location, where accretion has occurred in response to the presence of the structure.

Concurrent sediment accretion along the southern shoreline would occur as the sediment is transported southwards (Attachment 2E). It is anticipated that such changes would occur over a relatively short duration (months).

Scale: 1:15000
Original Size: A4
Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from MP Rogers (2019)

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Figure 5-14: Potential Changes in Sediment Transport Adjacent to the Bundle Launchway

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5.2.7 Mitigation, Management, and Predicted Outcome

The proposed mitigation measures to address potential impacts to coastal processes as a result of the Proposal, the predicted outcome, and monitoring (where proposed to verify the outcome) are provided in Table 5-12.

Overall the changes to coastal processes will be localised and minimal and the EPA objective '*to maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected*' will be met.

Potential Impact	Mitigation Measures	Predicted Outcome
Direct impact to sediment transport leading to seabed, beach or dune erosion on downdrift side of launchway	Measures to avoid: • NA Measures to minimise: • Design of launchway to minimise height of structure above surrounding beach or seabed. • Periodic bypassing of sand during launchway maintenance to limit sand accumulation to the north of the launchway and associated sand depletion to the south of the launchway. Measures to rehabilitate: • Management of onshore sediment accretion (north of launchway) and depletion (south of launchway) via monitoring and sand bypassing. Note: Governance Arrangements During construction and operations, Subsea 7 will be responsible for the implementation of the nominated monitoring and mitigation measures. For three years post closure Subsea 7 will be responsible for the implementation of the nominated monitoring and mitigation measures. After this time, if the monitoring of shoreline position demonstrates a stable shoreline (in comparison to adjacent unimpacted sections of shoreline), Subsea 7's monitoring and mitigation commitments will cease.	It is predicted that sand would accumulate along the northern side of the launchway, above the low tide mark, until sediment on the beach berm starts to move across the structure. Due to the temporary reduction in sand migrating to the shoreline to the south, some narrowing or possible loss of the small perched beach formations to the south of the launchway could occur. Given the relatively slow rates of sediment transport, the proposed monitoring program, and the implementation of sand bypassing in the event that trigger values are exceeded, the geophysical processes that shape coastal morphology will be maintained so that the environmental values of the coast are protected. Monitoring The following monitoring is proposed: • Survey of beach profiles adjacent to launchway (annual). • Inspections, including photographic monitoring of shoreline adjacent to

Potential Impact	Mitigation Measures	Predicted Outcome
		launchway (annual). • Shoreline mapping (every 3-6 years).
Indirect impacts to coastal morphology by altered wave climate, water flows and sediment movement as a result of the presence of the launchway	Measures to avoid: • NA Measures to minimise: • Design of launchway to minimise height of structure above surrounding beach or seabed. • Periodic bypassing of sand during launchway maintenance to limit sand accumulation to the north of the launchway and associated sand depletion to the south of the launchway. Measures to rehabilitate: • Management of onshore sediment accretion (north of launchway) and depletion (south of launchway) via monitoring and sand bypassing. • Removal of the launchway at the end of the project life.	Due to its relatively small size and low elevation of the launchway relative to the seabed, the launchway is not expected to have any significant impact on the local wave or current conditions. Thus no significant indirect impacts to coastal morphology as a result of altered wave climate, water flows and sediment movement following launchway construction are expected. The geophysical processes that shape coastal morphology will be maintained so that the environmental values of the coast are protected. <u>Monitoring</u> The following monitoring is proposed: • Survey of beach profiles adjacent to launchway (annual). • Inspections, including photographic monitoring of shoreline adjacent to launchway (annual).

Potential Impact	Mitigation Measures	Predicted Outcome
		• Shoreline mapping (every 3-6 years).
Altered wave overwash and drainage due to launchway leads to dune instability during extreme flooding events	Measures to avoid: • NA Measures to minimise: • Design of launchway to minimise height of structure above surrounding beach or seabed. • Stabilisation of cut embankments. Measures to rehabilitate: • Management of onshore sediment accretion via monitoring and sand bypassing. • Reinstatement of the dune following any significant re-profiling following an extreme weather event.	The construction of the launchway will necessitate a cut through the dune system. The construction of the launchway will reduce the elevation of the coastal dune in this area from approximately 5 mAHD down to an elevation of around 2.5 mAHD at the foundation level. Such a reduction in the elevation could result in a localised increase in erosion risk and inundation vulnerability. For more severe events, or those that cause more rapid fluctuations in sea level, the ingress of seawater through the launchway cut could occur, potentially resulting in scour of the adjoining area. With the commitment to reinstate the dune structure following any significant re-profiling of the dune system, it is considered that the environmental values of the coast will be protected. <u>Monitoring</u> Inspections, including photographic monitoring, of the shoreline and dunes adjacent to the launchway will be undertaken annually.

Potential Impact	Mitigation Measures	Predicted Outcome
Permanent change to water flows and sediment movement as a result of the presence of the launchway post closure	Measures to avoid: • Full removal of the launchway will occur.	At the end of the service life of the facility, decommissioning will be completed including full removal of the launchway and reinstatement of the dune system will occur. The geophysical processes that shape coastal morphology will be maintained so that the environmental values of the coast are protected. Monitoring Annual monitoring of the shoreline position for a period of three years to monitor recovery of pre-development beach alignment.

Table 5-12: Proposed Mitigation Measures and Predicted Outcome for Coastal Processes

5.3 KEY ENVIRONMENTAL FACTOR 3 – MARINE ENVIRONMENTAL QUALITY

5.3.1 EPA Objective

To maintain the quality of water, sediment and biota so that environmental values are protected.

5.3.2 Policy and Guidance

Subsea 7 has taken into consideration relevant policy and guidance in the design of the Proposal, completion of the environmental impact assessment and through the development of this ERD.

A summary of the policy and guidance relevant to marine environmental quality, and how Subsea 7 has considered these, is presented in Table 5-13.

Policy/Guidance	Consideration for Proposal
Statement of Environmental Principles, Factors and Objectives (EPA 2016c, 2018c, 2019)	Referred to in the identification and assessment of Preliminary Key Environmental Factors
Environmental Factor Guideline – Marine Environmental Quality (EPA 2016g)	Referred to in the assessment of potential impacts to marine water quality as a result of the Proposal
Technical Guidance – Protecting the quality of Western Australia's marine environment (EPA 2016h)	Referred to in the identification of the relevant environmental values and environmental quality objectives for the waters of Exmouth Gulf and in the assessment of potential impacts to marine environmental quality
Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006)	Referred to in the identification of the relevant environmental values and environmental quality objectives for the waters of Exmouth Gulf
Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005 – 2015 (MPRA and CALM 2005)	This management plan was reviewed during assessment of potential impacts on marine environmental quality within the Ningaloo Marine Park and Muiron Islands Marine Management Area, and in the development of management measures

Table 5-13: Policy and Guidance Relevant to Marine Environmental Quality

The 'Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives' (DoE 2006) recommends the Levels of Ecological Protection (LEPs), Environmental Values (EVs) and Environmental Quality Objectives (EQOs) for Pilbara waters, including Exmouth Gulf (Table 5-14).

Environmental Values	Environmental Quality Objectives (EQOs)
Ecosystem Health (ecological value)	EQO1: Maintain ecosystem integrity at a: • Maximum level of ecological protection. • High level of ecological protection. • Moderate level of ecological protection. • Low level of ecological protection. This means maintaining the structure (e.g. the variety and quantity of life forms) and functions (e.g. the food chains and nutrient cycles) of marine ecosystems.
Fishing and Aquaculture (social use value)	EQO2: Seafood (caught or grown) is of a quality safe for eating EQO3: Water quality is suitable for aquaculture purposes.
Recreation and Aesthetics (social use value)	EQO4: Water quality is safe for primary contact recreation (e.g. swimming and diving) EQO5: Water quality is safe for secondary contact recreation (e.g. fishing and boating) EQO6: Aesthetic values of the marine environment are maintained
Cultural and Spiritual (social use value)	EQO7: Cultural and spiritual values of the marine environment are protected.

Table 5-14: Environmental Values and Environmental Quality Objectives for the Marine Waters of Exmouth Gulf

5.3.3 Receiving Environment

A number of marine studies have previously been undertaken within the region, as outlined in Table 5-15. Subsea 7 has augmented the information from these previous studies by commissioning additional, Proposal-specific studies, to ensure an appropriate level of information is available to support completion of the environmental impact assessment and development of environmental management plans.

The Proposal-specific studies, as listed in Table 5-15, were undertaken by various technical specialists, and are included in full within Attachment 2. They are also referred to, as appropriate, in the assessment of potential impacts and proposed management measures.

Survey Date	Researcher/Consultant	Study Description/Title
Regional Studies		
2000	Department of Fisheries (Pearce *et al.*)	Review of productivity levels of Western Australian coastal and estuarine waters for mariculture planning purposes.
2001	Brunskill *et al.*	Geochemistry and particle size of surface sediments of Exmouth Gulf, North West Shelf, Australia.
2006	Department of Environment	Background water quality of the marine

Survey Date	Researcher/Consultant	Study Description/Title
	and Conservation	sediments of the Pilbara coast.
2006	Oceanica	Yannarie Salt Project: Marine and coastal environment of the eastern Exmouth Gulf.
2006	Wenziker *et al*.	Background quality for coastal marine waters of the North West Shelf, Western Australia.
2014	IMOS	West Australian Integrated Marine Observing System (WAIMOS) Node Science and Implementation Plan 2015-25.
2016	Vanderklift *et al*.	Western Australian Marine Science Institution (WAMSI) Dredging Science Node Project 5.3.
Project-specific Studies		
2017	360 Environmental	Baseline Water and Sediment Quality Assessment.
2018	GHD	Exmouth Gulf Current Monitoring Field Report.

Table 5-15: Overview of Local and Regional Marine Environmental Quality Studies

The Exmouth Gulf region has a limited number of studies carried out characterising the water and sediment quality. Therefore, along with the limited assessments undertaken within the region, general water and sediment quality documents have been reviewed and applied to the context of the Exmouth Gulf region.

Previous regional studies have characterised Exmouth Gulf as having a naturally turbid state due to wind, waves and tidal currents causing resuspension of the fine sediments found throughout the gulf. Primary productivity within the region from phytoplankton biomass is relatively low and is limited by the availability of nitrogen within the system. Water temperatures range from 18° to 30°C (tropical) depending on season, with salinity ranges similar to oceanic measurements (34 to 36 PSU).

A sediment quality survey to determine background concentrations of a range of selected heavy metals and organic chemicals in the Pilbara marine waters from Exmouth Gulf to Port Hedland found the sediments from five sites within Exmouth Gulf to exhibit relatively low levels of contaminants (DEC 2006), as follows:

- Arsenic (7-19 mg/kg).
- Cobalt (0.5-27 mg/kg).
- Copper (0.5-2.1 mg/kg).
- Nickel (1.0-4.8 mg/kg).
- Lead (<1-3 mg/kg).
- Zinc (1.2-9.8 mg/kg).

The differences between sites were predominantly driven by the sediment particle size, with contaminants known to bind to fine (<63 µm) particles. The percentage of fines recorded within the samples varied from 0.5 to 11.3% (DEC 2006).

360 Environmental (2017b) conducted a water and sediment quality assessment for the Proposal. The main findings of the assessment were:

- The physical parameters (temperature, salinity, and dissolved oxygen) were typical of the north western Australian coastline. No significant variation was observed vertically throughout the water column, except for measurements of higher turbidity nearer to the seabed.

- Turbidity was recorded to increase with distance from the shoreline (ranging from 1.1 to 2.4 NTU). This was attributed to the change in sediment composition with offshore locations characterised by a greater proportion of fine sediments (mud and sand). Even with this increased turbidity offshore, the levels of light attenuation fell well within regional measurements for the Exmouth Gulf.
- Consistent with results of previous regional studies, the total and dissolved nutrients within the gulf are limited and not readily available for benthic primary producers (BPP), but this may be due to them being utilised prior to measurements being taken. The chlorophyll and overall nutrient content measured was consistent within the regional and local context of the gulf area.
- Sediment within Exmouth Gulf was found to increase in fine sand proportion with increasing distance offshore.
- There was no indication of contamination within the study area, and therefore it was concluded that the likelihood of contaminant release from sediment disturbance was low.
- Short-term disturbances were concluded likely to have minimal impact on the local and regional environmental values (ecological and social).

A recent ocean current monitoring programme was completed by GHD (2018a) within Exmouth Gulf for the Proposal. The monitoring period included two full tidal cycles (22 May to 21 June 2018) and comprised two deployment locations. Additional instrumentation was deployed with the current monitoring equipment to record turbidity and photosynthetic available radiation (PAR) data. The average turbidity recorded at the launchway location was 4.3 NTU (or 3.6 if the storm of 5 June 2018 was excluded from the dataset) (Figure 5-15). The average turbidity recorded in the vicinity of the Bundle Parking area was 3.6 NTU (Figure 5-15). Generally there was a slight trend of increasing turbidity through the spring tidal cycle, although numerous short-term variations in turbidity were superimposed over this trend. There was no clear trend between wave height measured at the launchway location and turbidity.

Additional turbidity measurements were made in November/December 2018, at a site 2 km offshore along the tow route (site KP2) and at a site 4.5 km offshore along the tow route (site KP4.5). Numerous short-term turbidity peaks were recorded at up to approximately 30 NTU (Figure 5-16). Turbidities of above 10 NTU were recorded for longer durations (Figure 5-16).

A comprehensive analysis of the water quality data was completed, with observed turbidity peaks compared to available wave, wind and tidal data. No clear trend against any of these datasets was found. It is likely that the occurrences of elevated turbidity are related to a number of factors, including wind speed and direction, tidal state (both range and state during periods of strong wind) and potentially adjacent prawn trawling activity. It has been suggested, anecdotally, that elevated turbidity can occur a few days following the peak of a spring tide cycle, though such a trend was not clearly apparent from the available data.

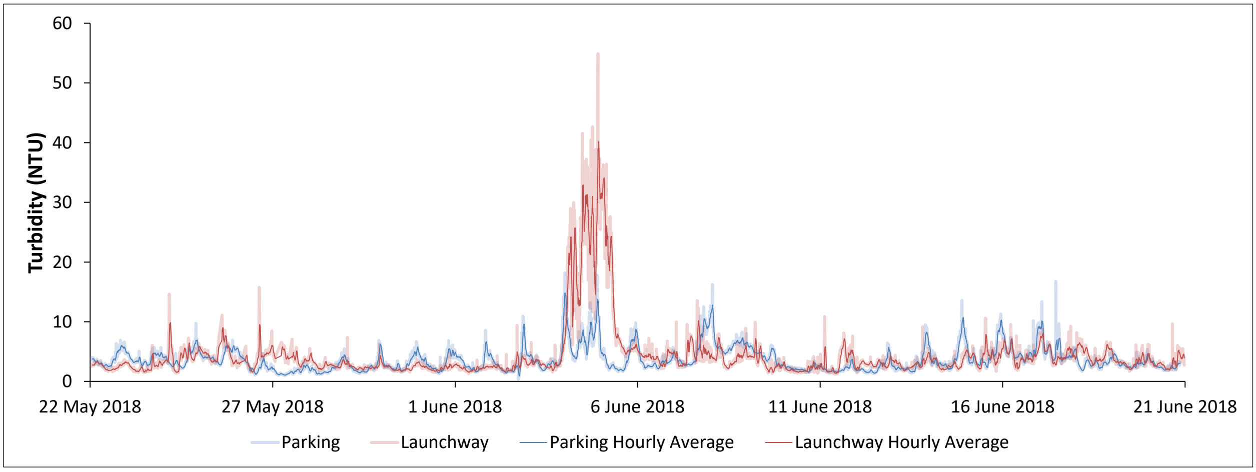


Figure 5-15: Background Turbidity within Exmouth Gulf (May/June 2018)

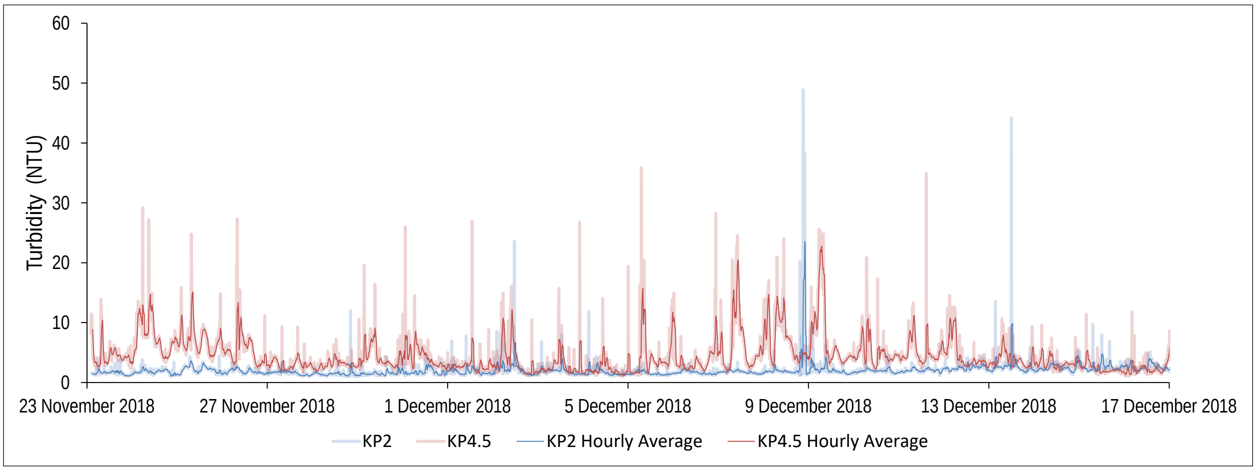


Figure 5-16: Background Turbidity within Exmouth Gulf (November/December 2018)

5.3.4 Potential Impacts

The construction and operation of the Proposal has the potential to directly and indirectly impact the marine environmental quality within the immediate and surrounding areas. Table 5-16 summarises the potential impacts during each project phase.

Project Phase	Potential Impact
Construction	Temporary impacts to water quality through release of fines, nutrients or contaminants from sediments during launchway construction
	Temporary impacts to water quality (turbidity) due to release of fines from launchway construction materials (quarry rock)
Operations	Temporary impacts to water quality during Bundle launch and tow due to chains on the seabed
	Impacts to water and/or sediment quality in the event of a loss of control of the Bundle or support vessel (e.g. from a chemical spill)

Table 5-16: Potential Impacts to Marine Environmental Quality

5.3.5 Potential Cumulative Impacts

Several third party projects or proposals (refer Section 2.5.8) have resulted in, or have the potential to result in, impacts to marine environmental quality within Exmouth Gulf. To date the Exmouth Marina and several mariculture operations have resulted in a reduced level of ecological protection being applied in the immediate vicinity of these projects (Figure 2-11). Cumulative impacts to marine environmental quality are addressed in Section 5.3.6.5.

5.3.6 Assessment of Impacts

5.3.6.1 Temporary Impacts to Water Quality through the Release of Fines, Nutrients or Contaminants from Sediments during Launchway Construction

During construction the following sequence of activities is expected:

- Excavate sand on land including the area through the sand dunes.
- Excavate or compact sand on the beach.
- Progressively construct the launchway from the landward extent to the seaward extent, by repeating the following steps:
  - Place rock fill.
  - Place concrete panels.
  - Place concrete mattress or rock armour.

Rock fill will be placed from the shoreline, being pushed seaward down the onshore end of the launchway. For the offshore end of the launchway, the rock fill will be placed from a barge. Sediment may be resuspended as a result of:

- Disturbance of the seabed in areas of soft sediment (i.e. when the rock fill material makes contact with the seafloor and displaces superficial material).
- Disturbance of the seabed by construction equipment, including when an approximately 300 mm layer of sediment is removed from the last 24 m length of the launchway footprint.

The Bundle launchway construction will take up to six months, during which periodic, local, impacts to water quality will occur. A single daylight shift is proposed during launchway construction, so any sediment resuspended during a shift will be likely to dissipate prior to the commencement of the next shift.

The naturally low nutrient and contaminant status of sediments within the launchway and adjacent areas means that release of nutrients or contaminants from sediments during launchway construction, in concentrations above naturally occurring levels, is unlikely. Elevated TSS concentrations are expected in the immediate vicinity of the launchway during the construction period, with the area within 50 m of the launchway footprint nominated as a ZoMI (refer Section 5.1.6.4), due to potential impacts on benthic organisms (recoverable within a period of five years following completion of construction).

EPA guidance (EPA 2016h) states that '*in cases where 'short-term' non-compliance with an EQO or level of ecological protection over a 'small' area is predicted and appears to be unavoidable, proponents could consider proposing temporary exclusion of an EQO or lower level of ecological protection for the small area……'* and '*When determining the acceptability of such a proposal the EPA would consider the nature and reversibility of the effects, the spatial extent of the impact, timeframes for recovery and any other relevant matters.'*

Based on the approach adopted for other capital works programmes, it is proposed that the ZoMI remain as a maximum ecological protection area. As such, no ongoing impacts to ecosystem processes, biodiversity, abundance, and biomass of marine life, water or sediment quality are acceptable. Given the period of construction is short (six months) and the low concentrations of naturally occurring nutrients and other contaminants in sediments, it is considered unlikely there would be any significant adverse impact to marine environmental quality over the longer-term. Based on the predicted severity and duration of the elevated TSS concentrations, no persistent impacts to ecosystem processes, biodiversity, abundance and biomass of marine life are expected. The environmental quality objective, to maintain ecosystem integrity, will be met.

Refer to the Marine Construction Monitoring and Management Plan (MCMMP) and Environmental Quality Plan (EQP) in Attachment 3.

5.3.6.2 Temporary Impacts to Water Quality (Turbidity) due to Release of Fines from Construction Materials (Quarry Rock)

Rock fill will be placed from the shoreline, being pushed seaward down the onshore end of the launchway. For the offshore end of the launchway, rock fill will be placed from a barge.

Any rock 'fines' contained within the rock fill, or generated as the fill is placed and rocks come into contact with each other, could mix with the surrounding seawater and create localised turbidity. Such turbidity is likely to be minimal given that screened hard rock will be used as the rock fill material. Hard rock or concrete mattress will be used for the armour and pre-cast concrete panels will be used for the main structure of the launchway.

The likelihood of increased turbidity during construction resulting from construction materials is considered insignificant relative to turbidity generated by re-suspension of *in situ* sediments during launchway construction. Refer to the Marine Construction Monitoring and Management Plan (MCMMP) and Environmental Quality Plan (EQP) in Attachment 3.

5.3.6.3 Temporary Impacts to Water Quality during Bundle Launch and Tow due to Chains on Seabed

It is expected that chains, suspended at regular intervals along the Bundle to assist in stability and towing, will contact the seabed along the tow route out to the Bundle Parking area. Thus a degree of seabed (soft sediment) disturbance is expected along the length of the tow route from the launchway up to the northern extent of the Bundle Parking area.

Subsea 7 undertook a field study to quantify site-specific sediment characteristics and behaviour to define sediment source terms for utilisation in sediment fate modelling. These terms include the sediment flux rate, particle-size distribution (PSD) and vertical distribution of suspended sediments that are likely to be generated by the chains disturbing the local seabed environment. The accurate definition of these source terms is critical to production of an accurate sediment dispersion model. The field experiment was undertaken involving towing of a single chain (76 mm diameter with a chain link length of 304 mm as will be attached to each Bundle) along the seabed off Heron Point, in proximity of the path to be followed during proposed future Bundle launches. A range of environmental data were collected through the deployment of turbidity loggers, capture of multiple vertical turbidity profiles (sea surface to seabed), collection of multiple near-seabed water samples and collection of benthic grab samples of sediment within the vicinity of the trial. No elevated turbidity was visible at the sea surface during the trial. Turbidity levels of up to 10 NTU were recorded at 1 m off the seabed. TSS loads of 2 mg/L to 30 mg/L were recorded, with the resuspended sediments dominated by silts (2-63 µm diameter).

Sediment fate modelling was completed to predict the magnitude and extent of turbidity generated during a Bundle launch and tow (refer Section 5.1.6.6).

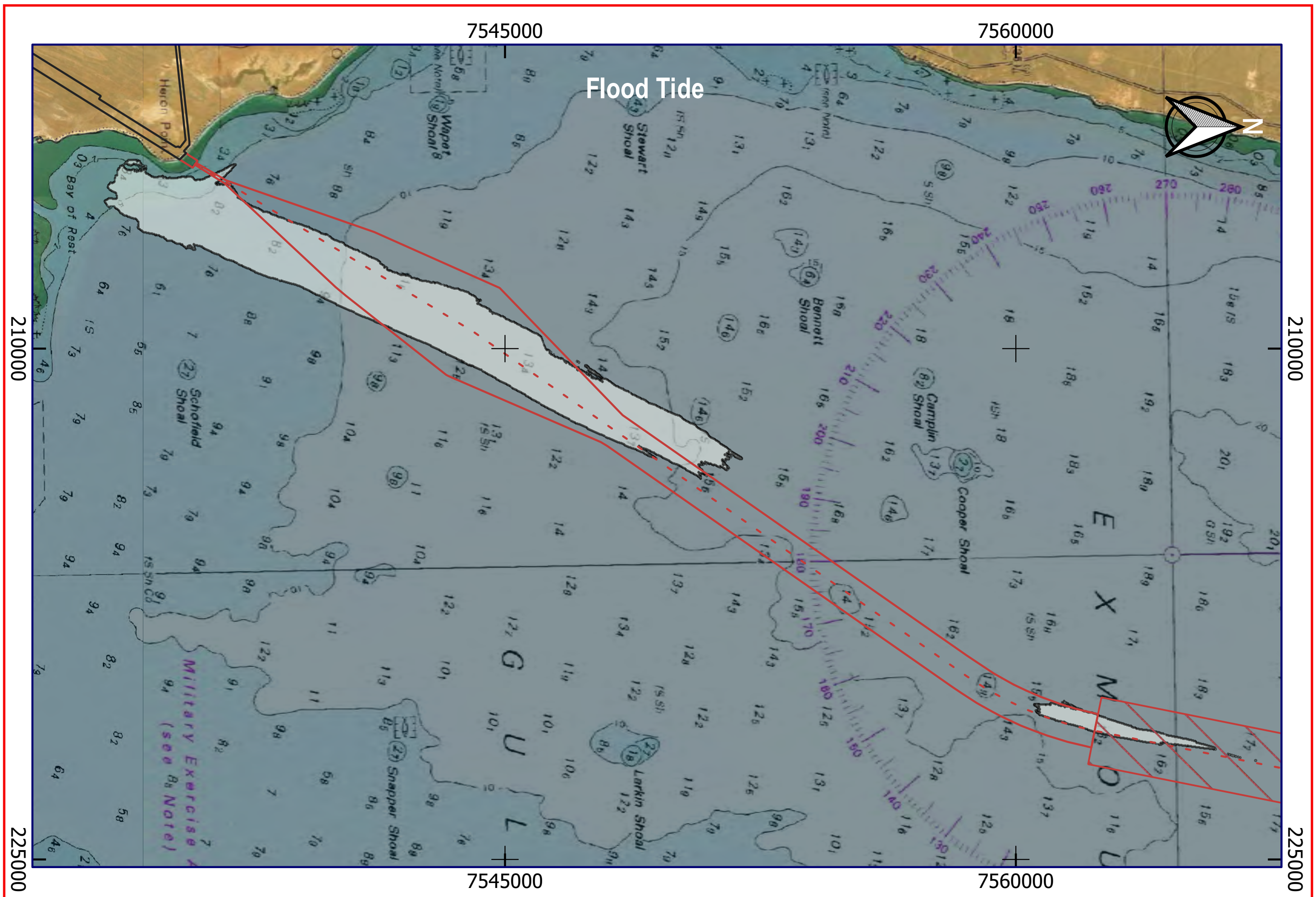
For most environmental quality indicators, the approach adopted for comparing monitoring data with the Environmental Quality Guidelines (EQG) and determining when a significant and unacceptable change has occurred, is consistent with ANZECC & ARMCANZ (2018). For physical stressors, such as turbidity or TSS, the approach for high ecological protection areas (the majority of Exmouth Gulf as shown in Figure 2-11) is to compare the median of the test site data (or modelled impact data) with the 80th percentile of the unimpacted reference distribution (EPA 2017). Thus the threshold, or EQG, relevant to the maintenance of ecosystem health within the high ecological protection area was defined as the 'median depth-averaged turbidity over 24 hours exceeds the 80th percentile of baseline data'.

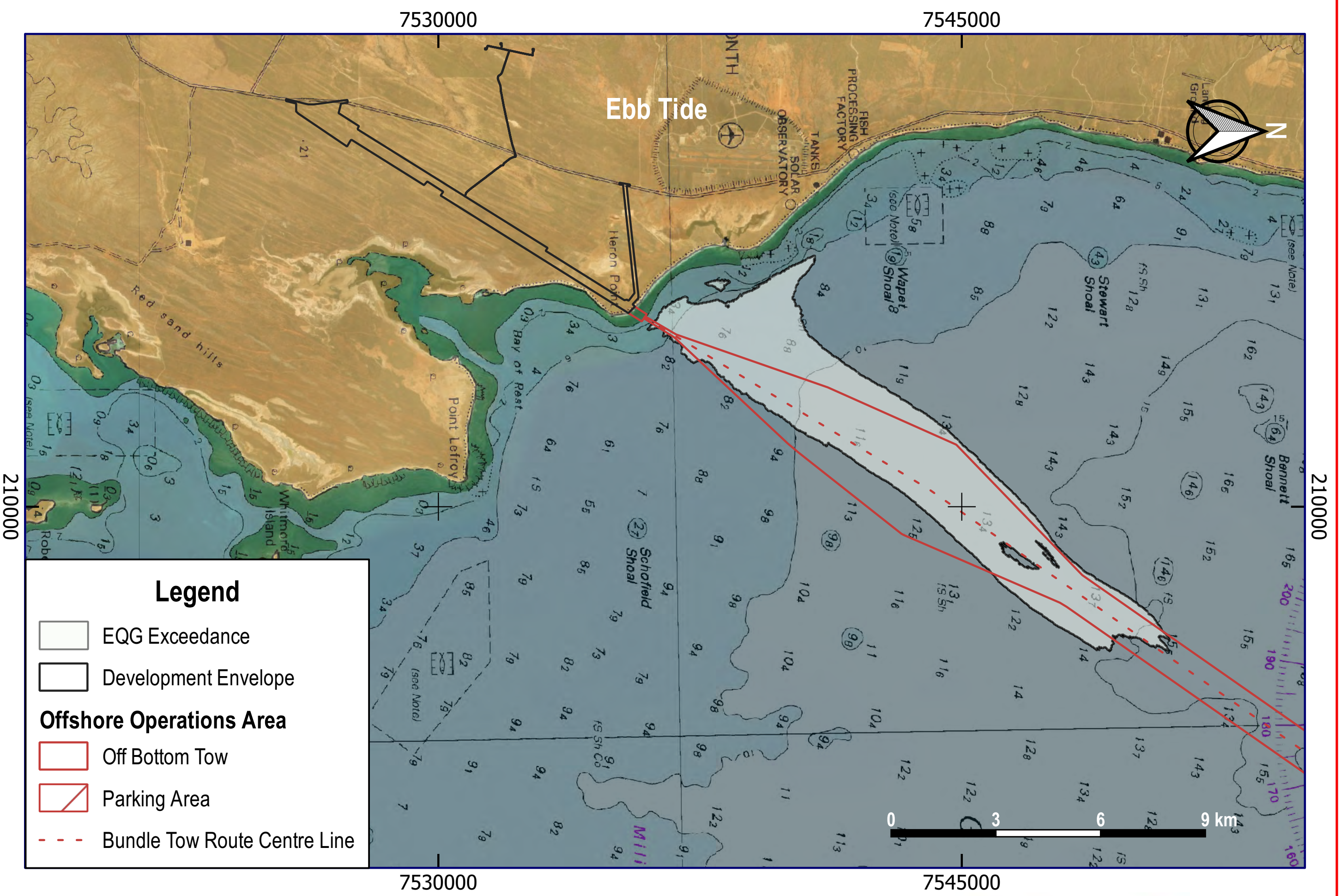
For maximum ecological protection areas (nearshore areas around the south and east coasts of Exmouth Gulf) no changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water sediment or biota are permitted.

In both the flood-tide and ebb-tide launch cases, the threshold (or EQG) was forecast to be exceeded in a zone mainly confined to the shallowest half of the Bundle tow route and its surroundings (Figure 5-17). The forecast duration of these elevated concentrations is limited, with the cumulative (modelled plus background) TSS greater than 4.10 mg/L (the value representing the 80th percentile of baseline data (Attachment 2H)) only predicted during the launch for a period of six hours (flood tide) and two hours (ebb tide) (Figure 5-9). The second and third peaks in TSS represent the 'return' of the suspended sediment plume over the sites following a change in tidal direction. Areas of BCH within this zone are presented in Section 5.1.6.6.

The inshore section of the Bundle tow route traverses a maximum ecological protection area, within which no changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment or biota are permitted. Based on the expected tolerance of the local BCH to short-term increases in turbidity (as occur naturally as shown in Figure 5-15 and Figure 5-16), temporary minor changes in environmental quality are predicted and anticipated (Figure 5-17), but these changes are considered unlikely to result in impacts to ecosystem processes, biodiversity, abundance and biomass of marine life. As stated in Section 5.3.6.1, EPA (2016h) states that '*in cases where 'short-term' non-compliance with an EQO or level of ecological protection over a 'small' area is predicted and appears to be unavoidable, proponents could consider proposing temporary exclusion of an EQO or lower level of ecological protection for the small area……..*' and '*When determining the acceptability of such a proposal the EPA would consider the nature and reversibility of the effects, the spatial extent of the impact, timeframes for recovery and any other relevant matters*.'

The environmental quality objective, to maintain ecosystem integrity, will be met for the area of maximum ecological protection and the area of high ecological protection.
Refer to the Marine Construction Monitoring and Management Plan (MCMMP) and Environmental Quality Plan (EQP) in Attachment 3.





Scale: 200000
Original Size: A4
Aerial Photo: ESRI Satellite
Grid: GDA 94 / MGA Zone 50

Notes: Data sourced from Commonwealth of Australia (2018) and RPS (2019).

Subsea 7 Pipeline Fabrication Facility

subsea 7

Figure 5-17: Modelled Exceedance of EQG for the Maintenance of Ecosystem Health During Bundle Launch and Tow

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5.3.6.4 Impacts to Water and/or Sediment Quality in the Event of a Loss of Control of the Bundle or Support Vessel (e.g. from a Chemical Spill)

A number of measures are proposed to minimise the likelihood of the loss of control of a Bundle during launch and tow (Table 5-8). With these measures in place, the likelihood of such an event is considered negligible (in over 80 Bundle launches at Wick no such event has occurred).

The Bundle pipelines can be split in two categories, the internal pipelines, and the outside carrier pipe that sleeves the internal pipelines. The internal Bundle pipelines are designed for high-pressure, high-temperature environments, and therefore have a pipe wall thickness and design strength much higher than what is required for the Bundle launch and tow. The carrier pipe is designed to physically protect these internal pipelines, provide an environmental barrier, and transfer the loads from the launch and tow from the towheads, dissipating these forces along the length of the Bundle.

All fabrication processes of the internal pipelines and the carrier pipe sections are subject to extensive material selection, production and testing criteria, in accordance with a number of Subsea 7 and industry standards (Section 5.1.6.8).

Subsea 7 conducts many preliminary tests on materials before each batch is used in production to ensure that no material defects exist prior to fabrication. Any material that has failed testing will be immediately quarantined and replaced. All welders will be individually qualified to a specific Weld Procedure Specification (WPS) to confirm welder competency and the repeatability of the WPS. Each completed weld is subject to non-destructive testing (NDT), with specific weld repair procedures in place should a weld be found to be defective. Finally, a full system hydrostatic pressure test is completed, to verify that the line volumes can contain pressure as per the pipeline design.

The likelihood of material damage or loss of containment of the internal pipelines is considered to be low, due to the high-pressure design and the regulated control of the fabrication process. The likelihood of material damage or failure of the carrier pipe, that has a lower strength capacity than the internal pipelines, is also considered as low.

The Bundle pipeline will contain no hydrocarbons during fabrication, launch and tow activities. The carrier pipe will be charged with nitrogen gas, and this allows the Bundle to be positively buoyant during the tow. The carrier pipe will contain solid chemical packs, designed to dissolve in the seawater that floods the carrier pipe once the Bundle is in the final position offshore. These chemical packs create a non-corrosive environment for the internal pipelines.

Material damage to the carrier pipe, leading to a leak would result in a release of nitrogen gas. The carrier pipe internal pressure is monitored during the launch and tow, and any change in pressure will be immediately reported. Such a leak would result in the Bundle becoming positively buoyant (as the weight of nitrogen is reduced) and it would rise to the water surface. If left untreated, the carrier pipe could eventually take on enough seawater to cause the Bundle to become negatively buoyant and sink (depending on the extent of the damage). The seawater within the carrier pipe would mix with the solid chemical packs, but any discharge would be limited and localised. Significant impacts to water or sediment quality are considered extremely unlikely.

The Marine Emergency Response Plan (Attachment 3) provides details on the management actions and control measures in place to minimise the likelihood of a loss of control of the Bundle or support vessel leading to an impact to marine environmental quality.

Several emergency scenarios were assessed, during a Preliminary Hazard Analysis (PHA) (refer to the Marine Emergency Response Plan in Attachment 3), to determine the risk of impact to marine environmental quality, including with Ningaloo Marine Park or the World Heritage Area.

A leak of Bundle corrosion inhibitor could occur following a loss of integrity of a Bundle. It was noted that the Bundle carrier pipe is completely filled with nitrogen, with solid corrosion inhibitors installed at intervals inside the pipe. If a leak occurs during a tow, the nitrogen would be displaced by seawater, which would cause the solid inhibitor packages to dissolve, creating a chemical concentration within the carrier pipe of up to 500 ppm. With no positive pressure in the carrier pipe at this stage, there will be no active transmission to the marine environment. A localised discharge ('weep') may occur in the immediate area surrounding the Bundle, with this discharge deemed to be low risk to marine environment quality. A number of control measures were identified and the residual risk (after the adoption of control measures) was assessed as a 'D' during Bundle launch, and a 'B' during Surface tow (Attachment 3). A 'D' risk is defined as '*Negligible: Low Technical Risk (slight or negligible consequences), Work can proceed with HSE Risk Assessment L1 (HIRA)*'. A 'B' risk is defined as '*Special Focus Required: Medium Technical Risk (serious consequences), Required mitigation actions including specific risk assessments/studies*'.

A vessel collision could potentially result in impacts to marine environment quality due to a spill of ship oil. It was noted that a major spill (e.g. due to the rupture of a fuel tank) is very unlikely to occur during a Bundle tow operation, and is no more likely to occur than in other normal tug marine operations due to the nature of the Bundle operations. A number of control measures were identified and the residual risk (after the adoption of control measures) was assessed as a 'C' during Bundle launch preparations and Off bottom tow mode, and a 'B' during Surface tow (Attachment 3). A 'C' risk is defined as '*Acceptable: Medium Technical Risk (moderate consequences), Work can proceed with HSE Risk Assessment L1 (HIRA)*'.

Given the outcomes of the PHA it is considered that the risk of a significant impact to marine environmental quality is very low. Additional, specific, risk assessments would be completed prior to each Bundle tow to address those risks assessed as a 'B' or 'C'.

5.3.6.5 Cumulative Impacts

To date the Exmouth Marina and several mariculture operations have resulted in a reduced level of ecological protection being defined in the immediate vicinity of these projects (Figure 2-11). However, the vast majority of Exmouth Gulf retains a maximum or high level of protection. The Exmouth Gulf Prawn Fishery is likely to cause local, short-term (hours), impacts to water quality (elevated turbidity) associated with the trawling operations but no impacts to environmental values have been identified as a consequence. The Proposal is not expected to cause any long-term impacts to marine environmental quality and, as stated in the Environmental Quality Plan (Attachment 3), no changes to the current levels of ecological protection are proposed. Given the very low frequency of marine operations associated with Bundle launching and the lack of cumulative turbidity impacts, cumulative impacts to marine environmental quality resulting in impacts to environmental values, as a result of the Proposal and third party projects or proposals, are considered unlikely.

5.3.7 Mitigation, Monitoring and Predicted Outcome

The proposed mitigation measures to address potential impacts to marine environmental quality as a result of the Proposal, the predicted outcome, and monitoring (where proposed to verify the outcome) are provided in Table 5-17. Refer also to the Marine Construction Monitoring and Management Plan (MCMMP) and Environmental Quality Plan (EQP) in Attachment 3.

The EPA objective '*to maintain the quality of water, sediment and biota so that environmental values are protected*' will be met.

Potential Impact	Mitigation Measures	Predicted Outcome
Temporary impacts to water quality through the release of fines, nutrients or contaminants from sediments during launchway construction	Measures to avoid: • NA Measures to minimise: • Launchway designed to minimise footprint (including extent of rock fill) thus reducing seabed disturbance and duration of construction. • Use of pre-cast concrete panels will reduce seabed disturbance and duration of construction. • Construction methods to minimise the disturbance of sediments. • Silt curtains deployed to ensure environmental objectives are achieved. • Construction occurs during single shift allowing time for settling and/or dissipation of fines. Measures to rehabilitate: • Suspension of turbidity-generating construction activity in the event a persistent turbidity plume is observed beyond the silt curtain(s).	Construction of the Bundle launchway is estimated to take up to six months. Elevated turbidity is expected to be limited to the immediate surrounds (<50 m) of the work site. Sediments do not contain elevated concentrations of nutrients or contaminants. Any changes in marine water quality as a result of the project are likely to affect an extremely small area. The magnitude of such changes is considered likely to be consistent with short-term increases in suspended solids associated with natural processes such as large storms. Implementation of management measures during construction will ensure that the quality of marine water, sediment and biota will be maintained and the EQOs will be met. Monitoring Twice daily (during works: approximately 10am and 2pm) visual monitoring during construction. In the event of persistent turbidity, assessment of water quality at the 50 m boundary (refer to Attachment 3).

Potential Impact	Mitigation Measures	Predicted Outcome
Temporary impacts to water quality (turbidity) due to release of fines from construction materials (quarry rock)	Measures to avoid: • NA Measures to minimise: • Construction material to be screened and washed to remove 'fines' (particles <63 µm in diameter). • Silt curtains deployed as required to ensure environmental objectives are achieved. Measures to rehabilitate: • Suspension of turbidity-generating construction activity in the event a persistent turbidity plume is observed beyond the silt curtain(s).	Rock fill (expected to be hard rock) will be screened and washed prior to use, resulting in minimal turbidity release. Any changes in turbidity as a result of the project will be short-term and are likely to affect an extremely small area. The magnitude of such changes are considered likely to be consistent with short-term increases in turbidity associated with natural processes such as large storms or the regular strong wind events experienced in the area. Implementation of management measures during construction will ensure that the quality of water, sediment and biota will be maintained and the EQOs will be met.
Temporary impacts to water quality during Bundle launch and tow due to chains on the seabed	Measures to avoid: • No more than three launches per year will occur. Measures to minimise: • NA Measures to rehabilitate: • NA	An average of two Bundle launches may occur per year with a maximum of three. Water quality impacts will be minor, local, and of short duration. The quality of water, sediment and biota will not be significantly impacted and the EQOs will be met. <u>Monitoring</u> Given the short-term nature of

Potential Impact	Mitigation Measures	Predicted Outcome
		the predicted turbidity, no formal monitoring is proposed, although a visual assessment (likely aerial) will be undertaken during the first Bundle launch).
Impacts to water and/or sediment quality in the event of a loss of control of the Bundle or support vessel (e.g. from a chemical spill)	Measures to avoid: • Bundle fully pressure tested and leak tested prior to launch. • Ongoing monitoring of Bundle pressures prior to and during launch. • Weather forecast/seasonal data reviewed to inform launch schedule. • Weather forecast monitored ahead of launch operations and launch window defined. • Weather conditions monitored during launch operations. • Defined limiting weather criteria. • High specification tow vessels for launch operations. • System confirmation check completed prior to departing Parking area. • Secondary system/redundancy design in bundle monitoring system. • Lead tow vessels to be equipped with 'Dynamic Positioning' (DP) systems, with a suitable level of system redundancy. • Full tow vessel position monitoring system verification prior to leaving Bundle Parking area. • Secondary tow vessel position keeping system in place for passage through Ningaloo Marine Park. • Vessel Assurance Suitability Surveys conducted prior to commencement of operations.	Given the control measures to be implemented to prevent a loss of control of the Bundle or support vessel, any such incident is extremely unlikely. Further, given the inherent strength of the carrier pipe (the outside casing of the Bundle), the lack of liquid chemicals within the carrier pipe, the release of a chemical, leading to an impact to marine environmental quality, is extremely unlikely. The quality of water, sediment and biota will not be significantly impacted and the EQOs will be met.

Potential Impact	Mitigation Measures	Predicted Outcome
	• Notice to mariners supporting information issued prior to tow to inform local vessels of operations. • Guard vessel to monitor/enforce exclusion zones. • Each vessel operating in adherence to International Regulations for Preventing Collisions at Sea (COLREGs) • Vessel intervention if required (as described in guard vessel procedure for engaging 3rd party vessels). • Community engagement and announcements locally. • Broadcasting on VHF as required. • Visual monitoring of bundle on surface (surface buoys and lights). • Timing of Surface tow through Ningaloo Marine Park chosen to coincide with benign sea, tidal and weather conditions. Measures to minimise: • Bundle carrier pipe does not contain any hydrocarbons (filled with inert nitrogen gas plus solid corrosion inhibitors). • Any chemical to be used within flow lines must have: o An OCNS Hazard Quotient rating of Gold, Silver, E or D have no substitution or product warning; or o Further assessment to ensure the environmental risk is ALARP. Measures to rehabilitate: • Each vessel equipped with a vessel specific Shipboard Oil Pollution Emergency Plan (SOPEP) or equivalent, and will follow response actions to incidental pollution in accordance with the vessel's emergency plan.	

Table 5-17: Proposed Mitigation Measures and Predicted Outcome for Marine Environmental Quality