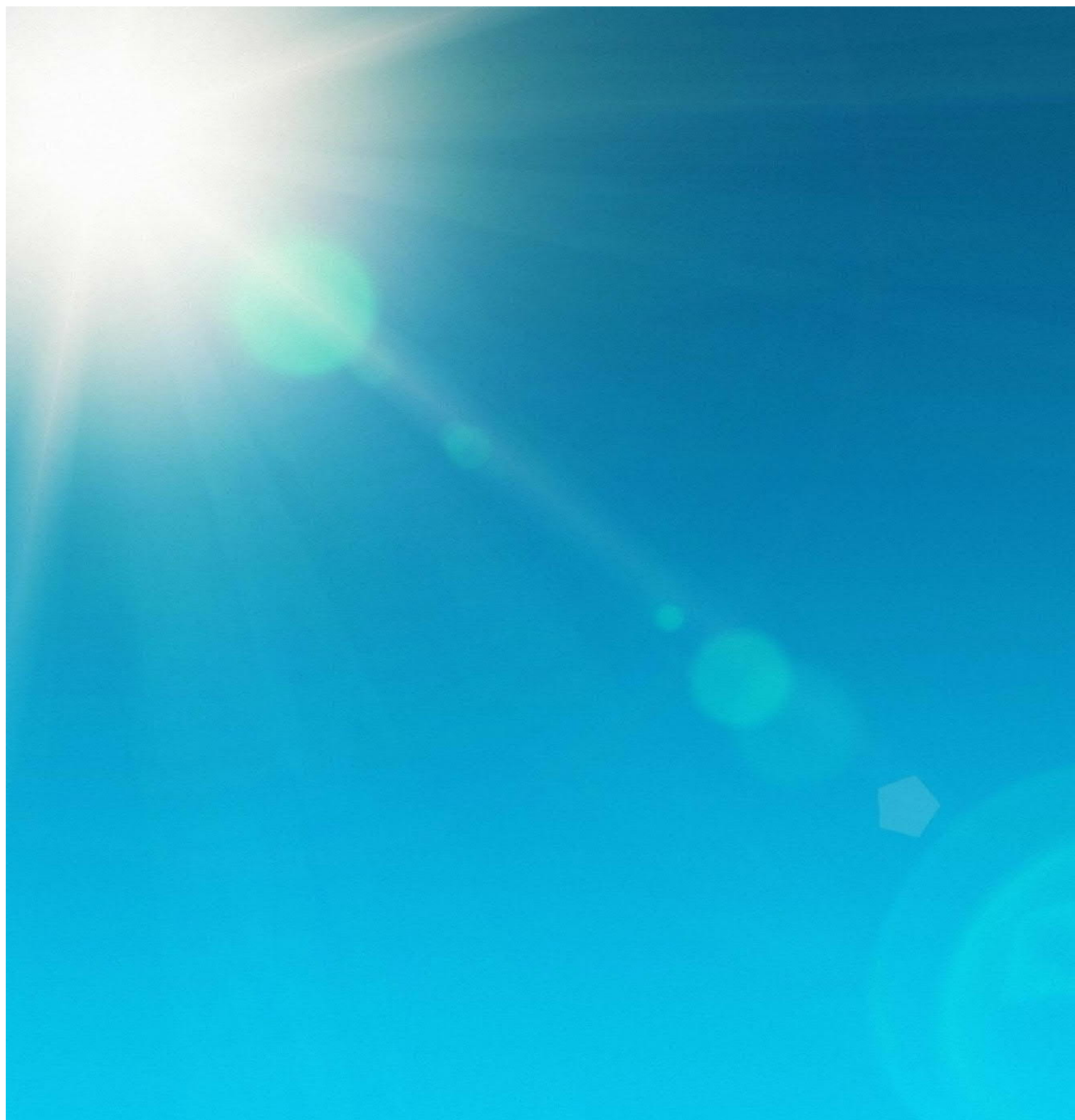


March 2022

Chapter 9 – Marine Environmental Quality

Australia-Asia PowerLink Environmental Impact Statement

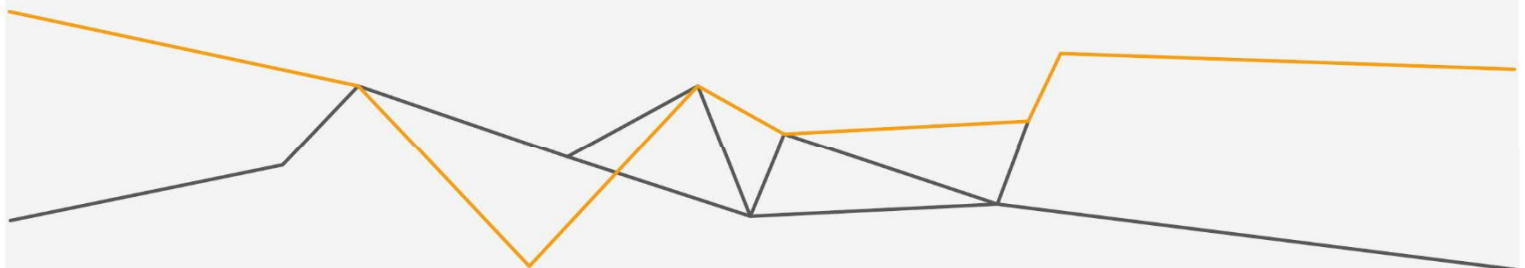


Chapter 9 - Marine Environmental Quality

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9 Marine Environmental Quality

The NT EPA's objective for the Marine environmental quality factor is to:

“Protect the quality and productivity of water, sediment and biota¹ so that environmental values are maintained.”

This chapter describes and assesses the significance of potential impacts to water, sediment, and biota in the marine environment (Marine environmental quality) associated with the Australia-Asia PowerLink (AAPowerLink) proposal.

The potential impacts water, sediment and biota considered in this chapter were identified with reference to the EIS Terms of Reference (TOR) issued by the NT Environment Protection Authority (NT EPA) (Appendix A), issues raised by stakeholders, and professional judgement of the EIS team (Appendix D) based on their knowledge and understanding of the AAPowerLink components and activities described in Chapter 2 Proposal Description. Potential impacts were then assessed using the Environmental Impact Assessment (EIA) methods described in Chapter 3 Impact Assessment. This chapter presents the findings of the EIA process undertaken for the Marine environmental quality factor.

The impacts considered in this chapter are associated with installation and maintenance of the Subsea Cable System within both NT coastal waters and Commonwealth waters. The boundary between the two jurisdictions is shown in Figure 9-1 and the extent is described below:

1. **Nearshore:** Northern Territory coastal waters, which consist of the waters from Lowest Astronomic Tide (LAT) outwards by 3 nautical miles (5.55 km) and includes the Beagle Gulf. Potential impacts in this area are assessed under the NT *Environment Protection Act 2019 (EP Act)*.
2. **Offshore:** Commonwealth marine area, which extends from the boundary of the NT coastal waters to the edge of the continental shelf and includes the Australian Exclusive Economic Zone (AEEZ). Potential impacts in this area are assessed under the Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act*).

The discussion of impacts in this chapter is limited to marine water quality and sediments. Impacts to marine habitats and biota are addressed in Chapter 10 Marine Ecosystems, drawing on the information contained in this chapter.

9.1 Information sources

The key information sources used to compile this chapter are summarised below:

- A targeted numerical sediment transport modelling study was undertaken to determine the likely area of influence of increased suspended sediment on the environment surrounding the AAPowerLink Subsea Cable System footprint (Metocean Solutions Pty Ltd, 2021a). The study methods and results are reported in Appendix R.
- The regional oceanographic conditions and baseline marine water quality in the region were described in a desktop review undertaken by Metocean Solutions Pty Ltd, (2021b) (Appendix S).
- A targeted geophysical and geotechnical survey described the seabed environment along part of the Subsea Cable corridor from 125 km west of the shoreline at Murrumujuk, to the edge of the AEEZ, including a buffer of 500 m to either side of the centreline (Guardian Geomatics 2021). The survey report provides detailed, high-resolution bathymetry, sediment geomorphology, seabed material depth, locations of other cables/pipes, and seabed material characterisation (see Appendix Z).

¹ The flora and fauna of a region.

The Guardian Geometrics (2021) survey did not include the section of the Subsea Cable Corridor within Shoal Bay (due to corridor variation following survey), nor the portion of the Subsea Cable Corridor within the Commonwealth marine area beyond the AEEZ boundary. This gap in survey data was addressed by review of available data and literature as follows:

- The offshore bathymetry and benthic environment in the continental shelf region are described based on review of available data and literature as documented in Appendix T Marine Ecosystems Report.
- The nearshore bathymetry and benthic environment are described based on the results of surveys undertaken in Darwin and Bynoe Harbours between 2015-2018 by Geoscience Australia, the Australian Institute of Marine Science, and the Department of Environment and Natural Resources within the Northern Territory Government (data reference Siwabessy et. al. 2020; technical report reference Galaiduk et. al. 2020).

Other data sources referenced in this chapter include:

- The Australian Oceans Data Network contains routine data collected from marine observing stations in Australian marine waters. Water quality profiles from one station were downloaded and plotted to assess the variability of temperature and turbidity in the water column (IMOS, 2020).
- Acid sulfate soils (ASS) mapping was used to identify areas where ASS may be intercepted in the proposal footprint (data reference DEPWS 2018; technical report reference Hill and Edmeades 2008).
- Available literature and previous survey reports for the nearshore and offshore marine environments have been referred to where available.

9.2 Relevant policies and guidelines

The EIA for marine environmental quality references the following legislation, policies, and guidelines relevant to the marine and coastal environment:

Darwin Harbour Water Quality Objectives

The *Darwin Harbour Water Quality Objectives* (Fortune 2010), provide guideline values for physical and chemical parameters relevant to Darwin Harbour and Shoal Bay. These guideline values have been adopted as the basis for assessment of impacts to water quality associated with the AAPowerLink cable laying and burial activities documented in this chapter.

The Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018)

ANZG guidelines for the Integrated Marine and Coastal Regionalisation zones identify three bioregions that the Subsea Cable transects: Anson-Beagle, Bonaparte Gulf and Oceanic Shoals. Specified guideline values for these bioregions were consulted online at <https://www.waterquality.gov.au/anz-guidelines/your-location/australia-marine-IMCRA>. However, guideline values for relevant parameters (e.g., turbidity and temperature) have been unavailable since mid-2021 because the guidelines are being updated. Correspondence with ANZECC indicates there is no timeline for when these guideline values will become available. In the absence of guideline values, the EIA adopted conservative guideline values based on review of available water quality data presented in Appendix S.

International Convention for the Prevention of Pollution from Ships (MARPOL)

MARPOL has been adopted by the Commonwealth and Northern Territory governments in multiple regulations and policies. These laws are in place to minimise environmental impacts associated with ballast water management, marine biosecurity, pollution and waste dumping, and oil spill response. Ship operators are legally responsible for those measures, which are regulated by the Northern Territory Government and Commonwealth Government of Australia. All ships and vessels used for construction and operation of the proposal will adhere to the relevant regulations that comply with MARPOL commitments, which inherently reduces the risks associated with activities such as discharge of ballast water and dumping of waste at sea.

North Marine Parks Network Management Plan

The *North Marine Parks Network Management Plan* (Director of National Parks 2018) provides for the management of the North Marine Parks Network, which includes the Commonwealth marine area traversed by the AAPowerLink Subsea Cable System corridor. The objectives of this plan are to provide for:

- The protection and conservation of biodiversity and other natural, cultural and heritage values of marine parks in the North Network; and
- Ecologically sustainable use and enjoyment of the natural resources within marine parks in the North Network, where this is consistent with the above objective.

The plan establishes the uses that are permitted in different zones of the Marine Parks Network. The AAPowerLink Subsea Cable System is a use permitted in the zones traversed by the corridor, subject to assessment and approval.

9.3 Environmental values

This section describes the physical characteristics and processes of the marine environment within the AAPowerLink proposal footprint and surrounding areas, as well as the beneficial uses and environmental values that are present. Information is presented for the nearshore (Shoal Bay and Beagle Gulf) and offshore parts of the AAPowerLink Subsea Cable System corridor.

9.3.1 Oceanic processes

Available tide, current, wind and wave data for the nearshore and offshore areas traversed by the AAPowerLink Subsea Cable System corridor are reviewed and analysed in Appendix S Section 3.6. The key oceanic processes are summarised below, with a focus on those processes that drive natural variation in turbidity, which is key water quality indicator relevant to assessing potential impacts to marine water and sediment quality from the AAPowerLink cable laying and burial activities.

9.3.1.1 Climate

The climate in Northern Australia is acutely related to the oceanic processes that occur on weekly, monthly, seasonal, and annual cycles. Northern Australia's marine climatology is associated with two major climate classifications: (1) tropical wet and dry, and (2) tropical monsoon. These classifications are broadly characterised by a wet season, dry season, and two transition seasons. Current, wind and wave conditions vary between the seasons and are key drivers of seasonal variations in water quality in the marine environment, which are described in Section 9.3.3 below.

The wet season occurs during the southern hemisphere summer months and is characterised by hot (average minimum 25 °C / average maximum 32.3 °C (BOM 2021)), humid weather, with bursts of active and inactive monsoons. Active monsoons consist of pulses of north-westerly wind, cloud cover, low pressure, and rainfall, resulting in troughs stretching across the Timor Sea. Strong monsoons can result in tropical cyclones. Darwin experiences between one and four active monsoons per year (Holland 1986), and a tropical cyclone comes to within 500 km of Darwin Harbour on average every 5 years. The wet season, and monsoonal and cyclonic

conditions, is associated with increased turbidity and water temperature, and in the near-shore environment wet season runoff can influence biological conditions through nutrient inputs.

The dry season occurs during the southern hemisphere winter months and is characterised by warm (average minimum 21 °C / average maximum 31.5 °C (BOM 2021)) and dry weather. Persistent east to south-easterly trade winds originates from higher latitudes and bring cool, dry air to the equatorial region. The dry season is associated with decreased water temperature and lower turbidity compared to the wet season.

Transitional seasons occur between the wet and dry season. The most commonly referred to transitional season is the 'build-up' and occurs after the dry and before the wet season from about October until December. Low pressure builds over northern Australia bringing hot and humid weather, with transitional winds and typically calm, glassy seas. The transitional season that occurs after the wet and before the dry – around April – is also characterised by transitional winds, calm glassy seas, but with occasional brief localised squalls.

9.3.1.2 Tides and currents

Tidal range increases in a landward direction from the edge of the Australian continental shelf towards Darwin Harbour and Shoal Bay. Sea level variations in Shoal Bay are large (up to 8 m) and comprise a semi-diurnal tidal pattern, meaning two high and two low tides occur each day. Spring tides comprise a relatively large range between low and high tide – 5 to 8 m. Neap tides comprise a relatively small range between low and high tide – less than 5m. According to Landbridge (2020) the average tidal range (LAT) in the Darwin Harbour area is:

- Mean spring tide: 6.9 m (high) and 1.3 m (low)
- Mean neap tide: 5.0 m (high) and 3.2 m (low).

Spring and neap tides alternate fortnightly. The lowest spring tides of the year occur during October, November, and December, while the highest spring tides take place in June and July.

Due to the macro-tidal regime of Beagle Gulf and surrounding waters, prevailing currents are of tidal origin (Williams et al., 2006; Siwabessy, 2015) i.e., tidal currents occur in conjunction with the rise and fall of the tide.

Tidal currents can also play an important role in the open sea, especially over the shelves, but they normally remain below 0.6 m/s (SKM, 2002; Rothlisberg, 2005; Makarynskyy and Makarynska, 2019). In general, tidal currents tend to the south-southeast during flooding and to the north-northwest during ebbing. These flows are augmented by wind- and wave-generated currents that have strong seasonality in strength and direction. Such currents, with speeds below 0.5 m/s (SKM, 2002), are expected to reflect seasonal wind patterns, flowing to the east or north-east during the wet season and to the west or south-west during the dry season.

There are no persistent, low-frequency currents, such as the East Australian Current found off the coast of Sydney. A low-frequency current exists in the Timor Trough; however, this is not proximate to the AAPowerLink footprint.

9.3.1.3 Wind and waves

Wind strength and direction in the region follows the climatic seasons described in Section 9.3.1.1. During the wet season, pulses of active monsoon result in persistent north-westerly winds for several weeks. During these periods, short-range north-westerly wind swell from the Timor Sea creates peak wave heights (~2 m) with relatively short-wave periods² (~4.5 to 6 seconds), resulting in choppy seas. As the wind swell reaches shallower waters (<30 m deep) between the Tiwi Islands and mainland, the underwater wave oscillations reach the seabed and re-suspend seabed sediment. From the Darwin Harbour coastline, this effect is visible as a turbid³ zone extending from the shoreline toward the sea. When the winds are strong and persistent, the waves are larger and the turbid zone from the shoreline extends further into the sea. The turbid zone along the shoreline can persist for months at very high turbidity levels, particularly during the wet season (for examples, see Table 9-3). This is the primary cause of high turbidity levels at the coastline during the wet season and explains why deeper water is generally less turbid than shallow water.

In the offshore areas in the Timor Sea, where the water is generally deeper than 55 m, it is unlikely that the waves generated by the short and choppy wind swell would affect the seabed, although this has not been measured. In this case, the turbidity near the seabed is driven predominantly by the tides and is likely to only impact the bottom few metres of the water column.

During the dry and transition seasons, water clarity (turbidity) is predominantly driven by the large tidal range. High turbidity levels generally occur multiple times per day during the fastest flows of the tides, except when the neap tidal range is smallest. There are fortnightly cycles of high turbidity during spring tides and low turbidity during neap tides. The variable tidal cycles cause turbidity fluctuations at the seabed level in deep water, and throughout the water column in shallow water. The uplift of bed sediment caused by tidal flow on the seabed is different to the orbital uplift of sediment caused by waves: less sediment is re-suspended into the water column by tidal movements than when there are large waves, even when the water is moving at the same velocity (Green and Coco 2014).

9.3.2 Seabed characteristics

The water depth, and nature and composition of the seabed structure greatly influences marine water quality and biodiversity. Bathymetry and sediment types are the two seabed features most relevant to assessing potential environmental impacts associated with the AAPowerLink cable laying and burial activities. These are described below for the nearshore and offshore parts of the AAPowerLink Subsea Cable System corridor.

9.3.2.1 Shoreline sediments

The shoreline crossing at Murrumujuk consists of coarse sandy beach. There is a high probability of Potential Acid Sulfate Soils in the intertidal zone (DEPWS 2008) – see Figure 9-4.

² The amount of time between successive wave crests at one location.

³ Turbidity, or 'water clarity' is a measure of how much light penetrates through the water column and is important for physical and biological processes in the water column and on the seabed. The grain-size of the seabed sediment plays a key role in how much turbidity there is in the water column. If the seabed is composed of large grains, such as pebbles or sand, then seabed disturbances are likely to have a localised and short-lived impact because the grains will quickly sink back to the seabed. If the seabed is composed of clay, silt, or mud, then seabed disturbance may result in longer-lasting sediment plumes (within which turbidity is elevated) because the smaller particles will not sink quickly and may be carried further away from the disturbance.

9.3.2.2 Bathymetry

The regional bathymetry along the Subsea Cable System corridor has been described using high resolution mapping (Geoscience Australia, 2018) and the bathymetric survey data recorded by Guardian Geomatics (2021). The bathymetry of the proposed Subsea Cable System is shown on Figure 9-1.

The intertidal zone adjacent to the Cable Transition Facilities slopes at approximately 1:50 in the intertidal zone and 1:700 from the low water mark toward Beagle Gulf (Water Technology 2017). The bathymetry gradually slopes down, through the Beagle Gulf and towards the continental shelf. The downward slope is interrupted by the Van Diemen Rise, which rises to approximately ~60 m below Lowest Astronomical Tide (LAT)⁴ after the Beagle Gulf, then dips into the Bonaparte Basin, which is a valley or depression of ~125 m depth. The Bonaparte Basin is dotted with pinnacles which can rise rapidly from the seabed (~230 m) to 13 m depth. The seabed rises out of the Bonaparte Basin and up to the western part of the Sahul Shelf to ~90 m depth where it continues to the continental slope and drops to more than 700 m.

The bathymetric survey undertaken by Guardian Geomatics (2021) shows that overall bathymetry slopes downward at an average of 3 degrees. In some areas, slopes as high as 10 degrees occur in association with outcropping rocks, seabed depressions, mega-ripples, and pockmark clusters. The maximum recorded depth along the Subsea Cable System corridor was 127.9 m, which was recorded close to the EEZ, and the minimum depth occurs at the coastline in Shoal Bay where the Subsea Cable System crosses the intertidal zone.

⁴ All depths reported in this chapter are below lowest astronomical tide (LAT)

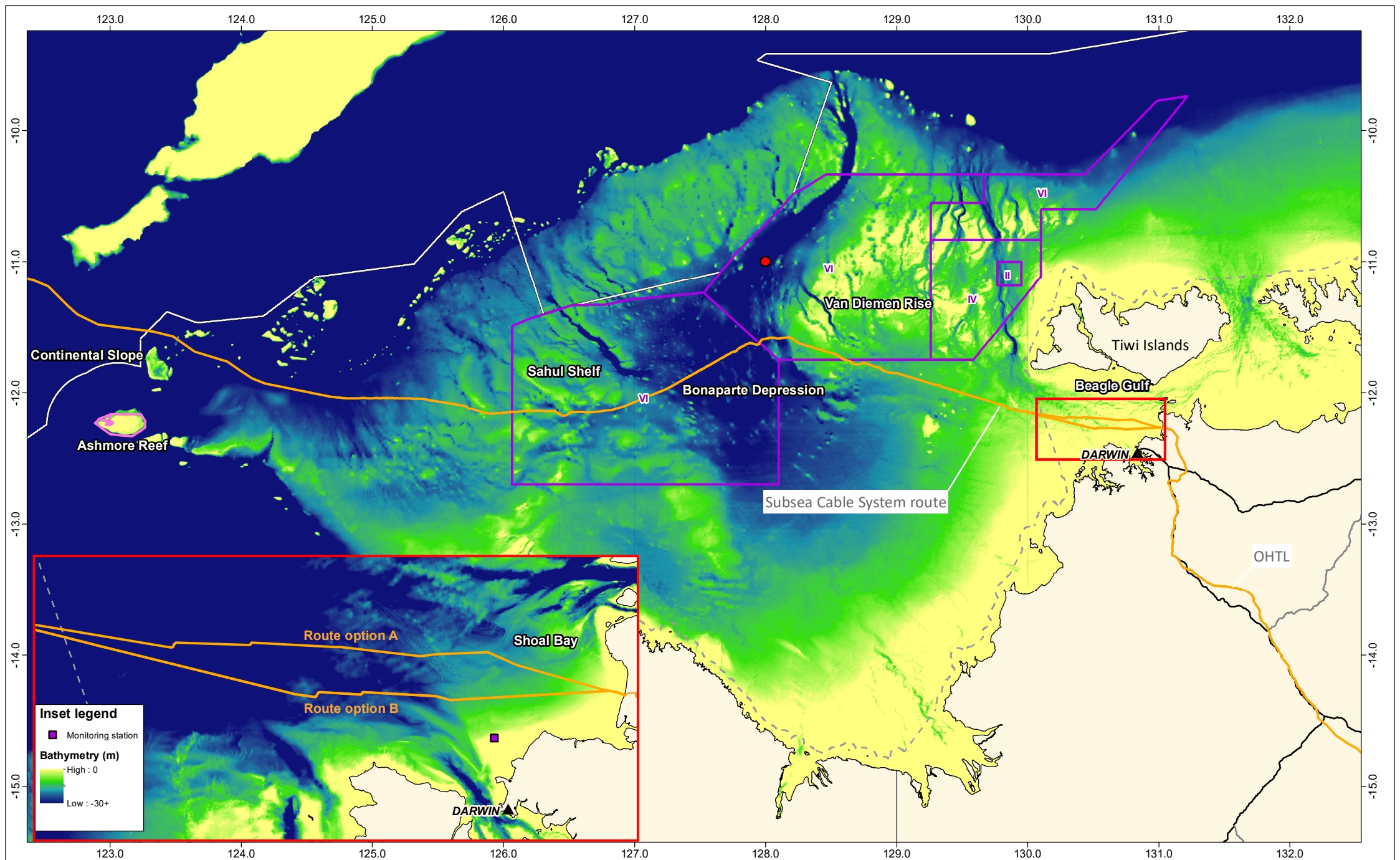


Figure 9-1: Map of bathymetry along the the Subsea Cable System Corridor

Project: **Australia-Asia PowerLink**

Reference: M-Files ID 200235

Revision: 0

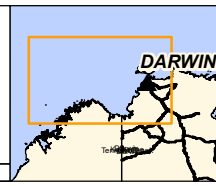
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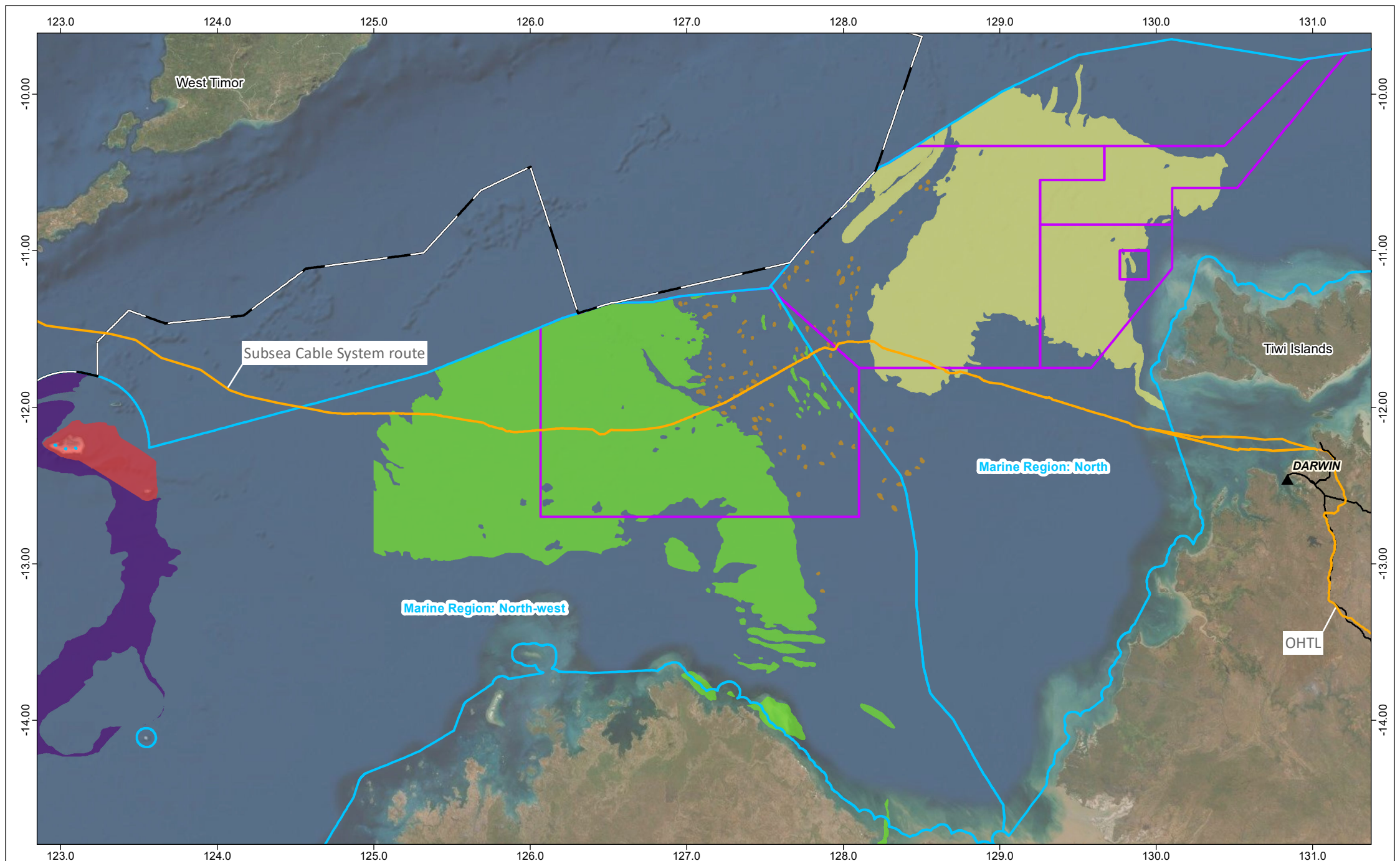


9.3.2.3 Geomorphology and sedimentology

Figure 9-2 shows the regional geomorphology of the North and North-west Marine Regions using Geoscience Australia data. Table 9-1 documents the types and extent of geomorphic features intersected by the Subsea Cable System corridor. Away from the coast, the marine landscape becomes a mostly featureless shelf. The offshore landscape is then dominated by the shoals of the Van Diemen Rise and Sahul Shelf, separated by the Bonaparte Basin that is punctuated throughout by tall pinnacles as described in Section 9.3.2.2 above.

Table 9-1. Geomorphic features intersected by the Subsea Cable

Feature	Proportion of corridor
Shelf	50.0%
Terrace	17.4%
Basin	11.5%
Bank/shoal	10.4%
Slope	5.0%
Plateau	2.1%
Deep hole/Valley	1.7%
Canyon	1.2%
Pinnacle	0.4%
Tidal-sand wave/sandbank	0.3%
Reef	0.1%



Legend

AAPowerLink Infrastructure

Commonwealth Marine Area

Marine regions

Oceanic Shoals Marine Park

National key ecological features

Ashmore Reef and Cartier Island and surrounding Commonwealth waters

Carbonate bank and terrace system of the Sahul Shelf

Carbonate bank and terrace system of the Van Diemen Rise

Continental Slope Demersal Fish Communities

Pinnacles of the Bonaparte Basin

DARWIN

Project: **Australia-Asia PowerLink**

Reference: M-Files ID 200235

Revision: 1

Coordinate System: GDA2020

Date: 10/03/2022

0 30 60 90 120

Kilometers

Scale: 1:3,350,000

A4

SUN CABLE

Figure 9-2: Map of regional geomorphology along the Subsea Cable System corridor

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9.3.2.4 Seabed sediment characteristics

The seabed sediments of the Outer Darwin Harbour, including the nearshore parts of the Subsea Cable System corridor in Shoal Bay, were documented based on extensive survey data as part of the Darwin Harbour Mapping Project (Nicholas et al., 2019; Siwabessy et al., 2019). The sediments are generally muddy sands with varying amounts of gravel, although moderate to large proportions of mud were identified in shallow water on the eastern side of Shoal Bay and at various locations in deeper parts of the Harbour. High sand percentages were also located over shallower parts of the nearshore region between Darwin and Gunn Point. The nearshore sediments in Shoal Bay are well sorted, potentially due to wave energy in the nearshore environment (Siwabessy et al., 2019).

Marine sediments along the Subsea Cable System corridor were characterised by Metocean (2021a) from geotechnical test results documented in Guardian Geomatics (2021). Figure 9-3 based on particle size distribution (PSD) of samples collected during the survey shows that the seabed sediments along the corridor vary and include clay, silt, sand, and gravel. The PSD data were averaged for each site based on samples collected at different depths. The analysis suggests that muddy sands with varying amounts of gravel dominate the seabed along the offshore part of the Subsea Cable System corridor.

Table 9-2 summarises the seabed sediment characteristics for the seascape features beyond Shoal Bay. Generally, coarse material such as sand and gravel are found on shallower banks and terraces, and fine material such as silt and clay in depressions and valleys (Heap et al. 2011).

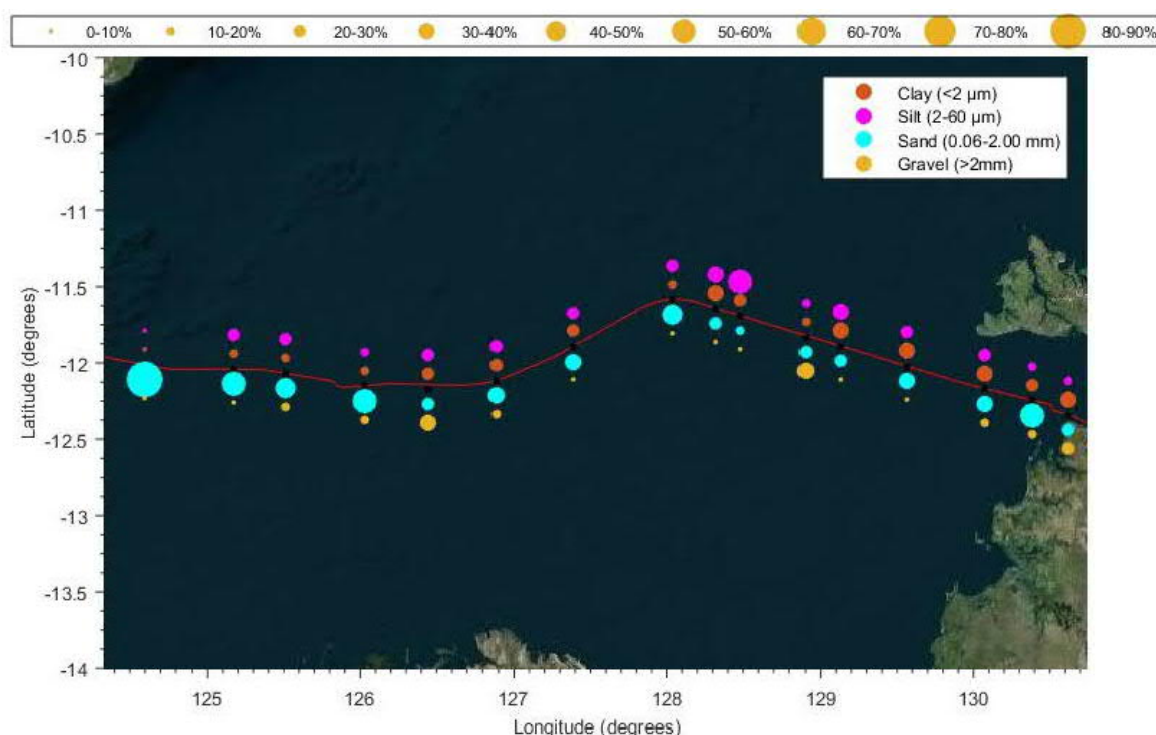


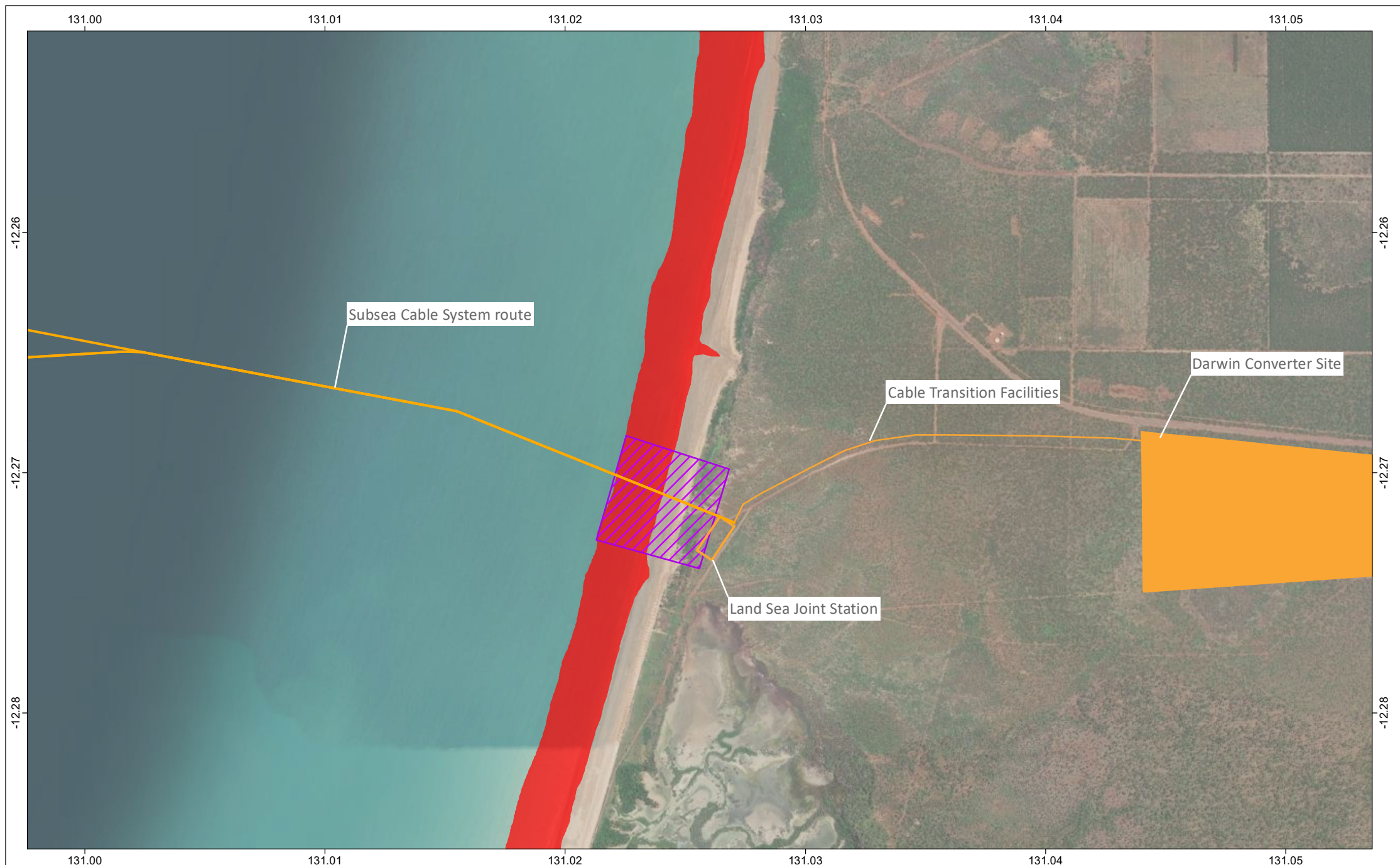
Figure 9-3. Sediment characteristics recorded along Subsea Cable System corridor (Source: Metocean 2021b)

Table 9-2. Seabed sediment characterisation along the Subsea Cable System corridor

Location	Sediment characteristics
Shoal Bay	<i>Unsurveyed.</i> Thought to be sandy with scattered rocks and mud.
Beagle Gulf	Sandy with patches of sandy silt, sandy clay, and areas of large sand waves
Van Dieman Rise	Sand and clay, with patches of silty sand, gravel
Bonaparte Depression (basin)	Sand and clay, with patches of silt and some rocky outcrops and associated gravel
Sahul Shelf (west)	Sand, clay and silt, patches of gravel and occasional sand waves
Continental slope	<i>Unsurveyed</i>

9.3.2.5 Potential acid sulfate soils

ASS is common along much of Australia's coastline, including around the Darwin region. ASS risk mapping undertaken by Hill and Edmeades (2008) covers the AAPowerLink Shore Crossing Site footprint. The mapping identifies Potential ASS (PASS) in the nearshore region, directly adjacent to the shoreline, that the shore crossing and subsea cables will pass through (see Figure 9-4). Potential impacts associated with disturbance of PASS material are discussed in Section 9.4.2.3.



9.3.3 Water quality

Available water quality data for the nearshore and offshore areas traversed by the AAPowerLink Subsea Cable System corridor are reviewed and analysed in Appendix S Section 4. Water quality in the Shoal Bay area has been assessed in the Darwin Harbour Report Cards from 2009 to 2019 for the following indicators: nutrients, water clarity (turbidity), dissolved oxygen and algae. Outer Shoal Bay has been graded A or ‘excellent’ eight times and B or ‘very good’ three times over this period, indicating that the water quality complies with the Darwin Harbour Water Quality Objectives indicators at least 85% of the time. These positive water quality outcomes are likely linked to the limited population and industry that feeds into this zone (DEPWS 2020a). The offshore portion of the AAPowerLink footprint in Beagle Gulf has not been routinely assessed but is assumed to be in near-pristine condition given its expanse, sparse development, low-density shipping, and highly regulated commercial fisheries. The sections below describe the physical, chemical, and biological characteristics of the marine waters within and surrounding the AAPowerLink footprint.

9.3.3.1 Physical characteristics

Turbidity and water temperature are the key physical water quality characteristics relevant to assessing the potential impacts associated with the AAPowerLink Subsea Cable System. Appendix S Section 4.4 reviews and analyses of available data for these parameters. Both vary naturally throughout the nearshore and offshore regions as described below.

Turbidity

Turbidity, or ‘water clarity’, is a measure of light penetration in water and is influenced by several factors, including suspended sediment loads; highly turbid waters generally have high sediment loads and lower levels of light penetration. High levels of turbidity correspond with dirtier looking water with low water clarity. Turbidity is a key consideration for assessment of impacts associated with development activities in the marine environment, as light penetration affects the growth and survival of biota, and high turbidity (i.e., high sediment loads) can impact fish and other marine species. Turbidity⁵ is naturally highly-variable across the region surrounding the AAPowerLink Subsea Cable System corridor, and especially in the shallow waters near the coast, where it can be affected by the tides, weather, stormwater runoff and algae in the water column.

Shoal Bay has not been extensively monitored for turbidity or suspended sediment concentration; however, available data suggest high turbidity values in shallow (<10 m) areas (Figure 9-5). Suspended Sediment Concentrations (SSC) observations from Casuarina Beach are presented in Yang et. al. (2020), which noted fluctuating SSC concentrations, with a peak of ~500 mg/L recorded in January 2015. Casuarina Beach is comparable to Gunn Point Beach in that it is on the outer harbour, facing north-west, and is influenced by wave action (more so than the protected inner harbour of Darwin Harbour). Turbidity and SSC measurements from previous projects in the vicinity of the proposal footprint are summarised in Table 9-3.

Cardno presented monitoring data for numerous sites in and around Darwin Harbour between 2012 and 2014, to assess impacts from dredging as part of the Inpex Ichthys Nearshore Environmental Monitoring Program (Cardno 2015). Data from Lee Point, just west of Gunn Point (and likely similar conditions in terms of exposure to aspects such as winds, tides, and waves), is presented in Figure 9-6. Clear seasonal trends are observed, with dry season turbidity fluctuations ranging between 0 and 25 NTU. Wet season turbidity peaked at ~210 NTU (turbidity) and >200 mg/L (SSC) and remained above 90 NTU for over two weeks in 2013 – 2014 (see Table 9-3 and Figure 9-6).

⁵ Turbidity suspended sediment concentrations (SSC) and total suspended solids (TSS) are referred to throughout this chapter. Turbidity (a measure of light penetration) is commonly used as a measure of water quality due to the relative ease of measurement. TSS represents all suspended matter (sediment plus algae, particulate matter etc.), while SSC represents only the sediment matter in suspension in water. SSC is used for modelling impacts from activities such as trenching, while baseline data (e.g., for Darwin Harbour) often measures turbidity. The nearshore turbidity and suspended sediment concentration (SSC) can be roughly related linearly on a 1:1 ratio when the SSC is less than 50 mg/L (Cardno 2013).

Table 9-3. Turbidity measurements in the vicinity of the proposed Subsea Cable System footprint

Location	Dry season turbidity range (NTU)	Peak season turbidity	wet	Peak season SSC	wet	Duration and year of observation
Lee Point (coastal Shoal Bay) ^{6,7}	0-25 NTU (bed)	>210 (bed)	NTU	-		- Extended period of 3 weeks of avg daily turbidity > 20 NTU (January 2013)⁶ 2 x extended periods per year (>3 weeks) of turbidity > 30 NTU over (2013-2014)⁵ 2 x extended periods per year (>2
Casuarina Beach (coastal near Shoal Bay) ⁸	-	-		>200mg/L (bed)		2 x extended period weeks) of turbidity > 90 NTU (2013-2014)⁵per year (>2 weeks) of SSC > 40 mg/L (2012-2013)⁷ 1 x extended period per year⁷
Lee Point (12 km offshore) ⁵	0-25 NTU (bed)	>190 (bed)	NTU	-		2 x extended periods per year (>2 weeks) of turbidity > 120 NTU (2013-2014)⁵
IMOS wave buoy ⁹	3.5 – 6 NTU (surface)	3.5 – 6 (surface) >350 (bed)	NTU	-		2015 - 2017⁸

⁶ Cardno (2015). These measurements were taken during dredge works; however, quantitative analysis was unable to determine any differences in observations between dredging and non-dredging time periods.

⁷ Cardno (2013)

⁸ Andutta et al. (2019)

⁹ MetOcean Marine Environmental Quality Report (Appendix S)

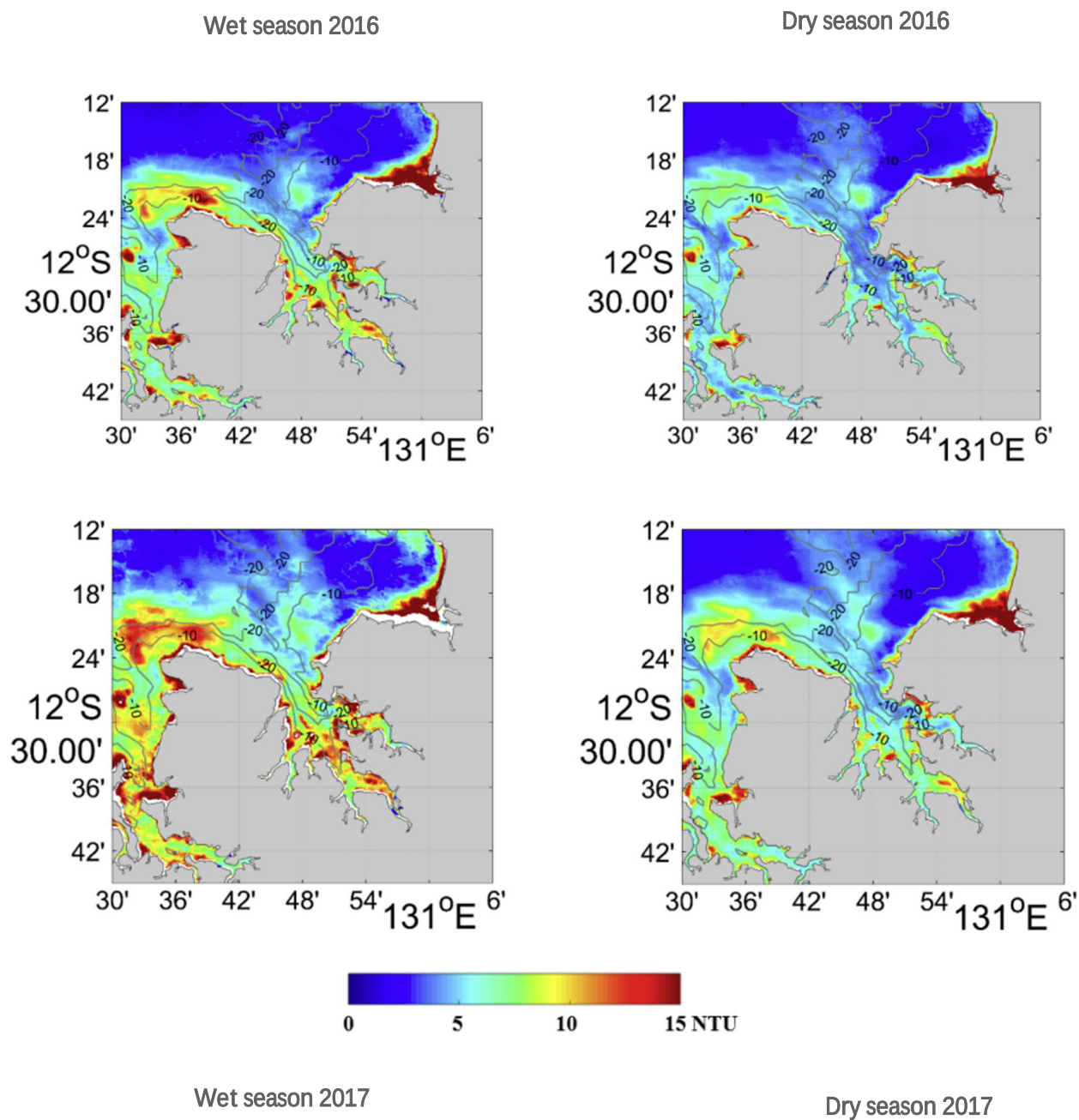
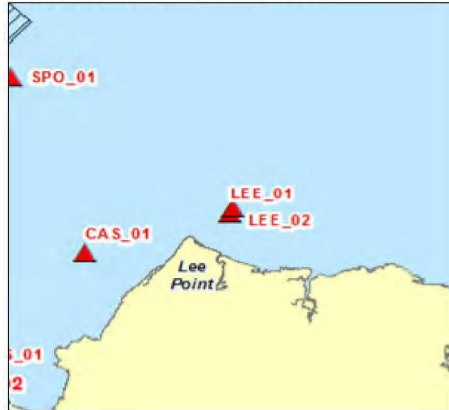


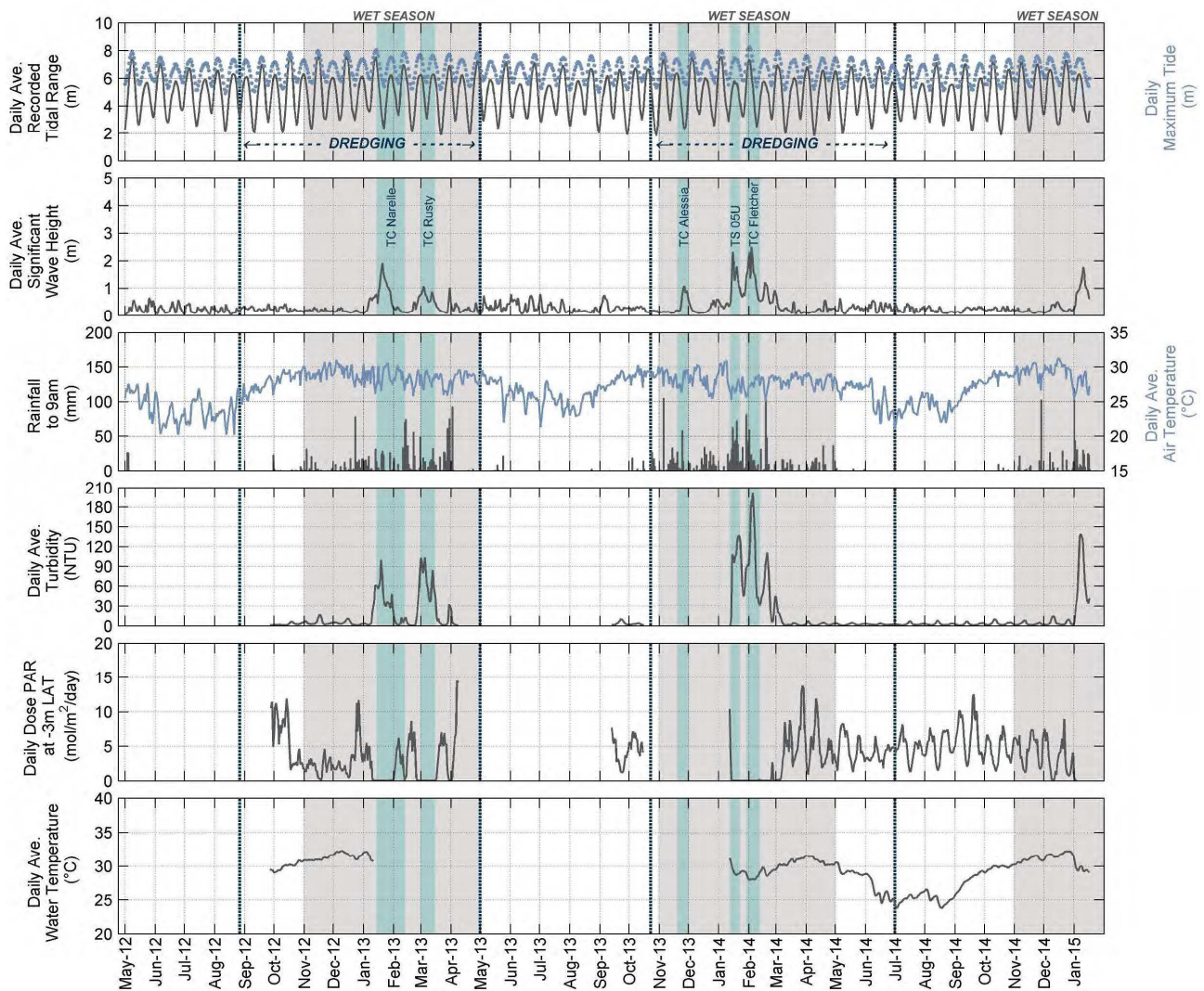
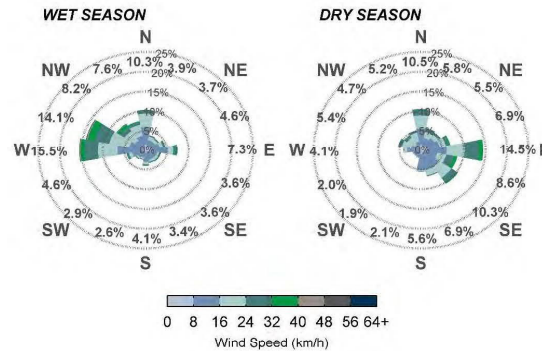
Figure 9-5. MODIS retrieved seasonally averaged turbidity for the low water spring tide in Darwin Harbour (Source: Yang et al. 2018)



Lee Point Site 02



Site ID : LEE_02
 Primary Habitat : SEAGRASS
 Site Location : DARWIN OUTER
 Deployment Period : 27 Sep 2012 to 17 Jan 2015
 Site Depth : 7.67m



C:\Users\Public\INPEX\IS050_Water_Quality\06_Analysis\Logged_Data_Processing\PostConstructionReport\plot_PCR_SiteAppendixSheet.m

Figure 9-6. Water quality data for Lee Point recorded over three years (Source: Cardno 2015)

In the offshore region, the literature generally agrees that the seabed environment is high in turbidity (Przeslawski et al. 2014) and this is largely driven by tidal (Porter-Smith et al. 2004) and seasonal (Nichol et al. 2013) physical drivers (see Section 9.3.1.3). There are no known reports detailing specific levels of turbidity for the offshore region. The water surrounding the seabed is reported to be more turbid than the rest of the water column, indicating that the tidal currents drive the re-suspension of bed sediment (Heap et al. 2011). This pattern has been confirmed by a limited number of water quality profiles collected at a monitoring station close to the proposal footprint (Margaret Harries Banks in Figure 9-1), which was exported from the Australian Oceans Data Network (IMOS 2020) (see Figure 9-7). It is documented that the western part of the Oceanic Shoals Marine Park is more turbid than the eastern part (NERP MBH 2015).

Water temperature

Water temperature is an important water quality variable for regulating the biota ecosystem functions (growth, reproduction, metabolism, and mobility), and the toxins and dissolved metals they are exposed to in the water column and at the seabed. Review of data available for water temperature in the nearshore and offshore environments traversed by the AAPowerLink Subsea Cable System is presented in Appendix S Section 4.4.1.

In Shoal Bay, which is shallow and vertically well-mixed, water temperature is very similar at the surface as at the bed level. Annual water temperature ranges from 21.6°C to 34.5°C and a median of 25°C. Cooler water temperatures are generally observed during the dry season and may occur during extended monsoons due to increased cloud cover. In the deeper Beagle Gulf, surface, and seabed (28m depth) temperatures are slightly, but not significantly different with surface temperatures slightly warmer and oscillating several degrees throughout the day and night cycle.

In the offshore area, water column profiles measuring salinity, temperature and turbidity were extracted from the Australian Ocean Data Network Portal spanning 7 years of wet season and 8 years of dry season data (IMOS 2022) – see Figure 9-7. Fourteen water column profiles were available for both wet and dry seasons and were taken at the Margaret Harries Banks (see Figure 9-1). There are weak thermal stratifications during the wet and dry seasons: surface water temperature ranges from about 29 to 32 °C in the wet season, and 26 to 28°C in the dry season. Seabed temperature ranges from about 22 to 27°C in the wet season and 23 to 28°C in the dry season at approximately 145 m depth.

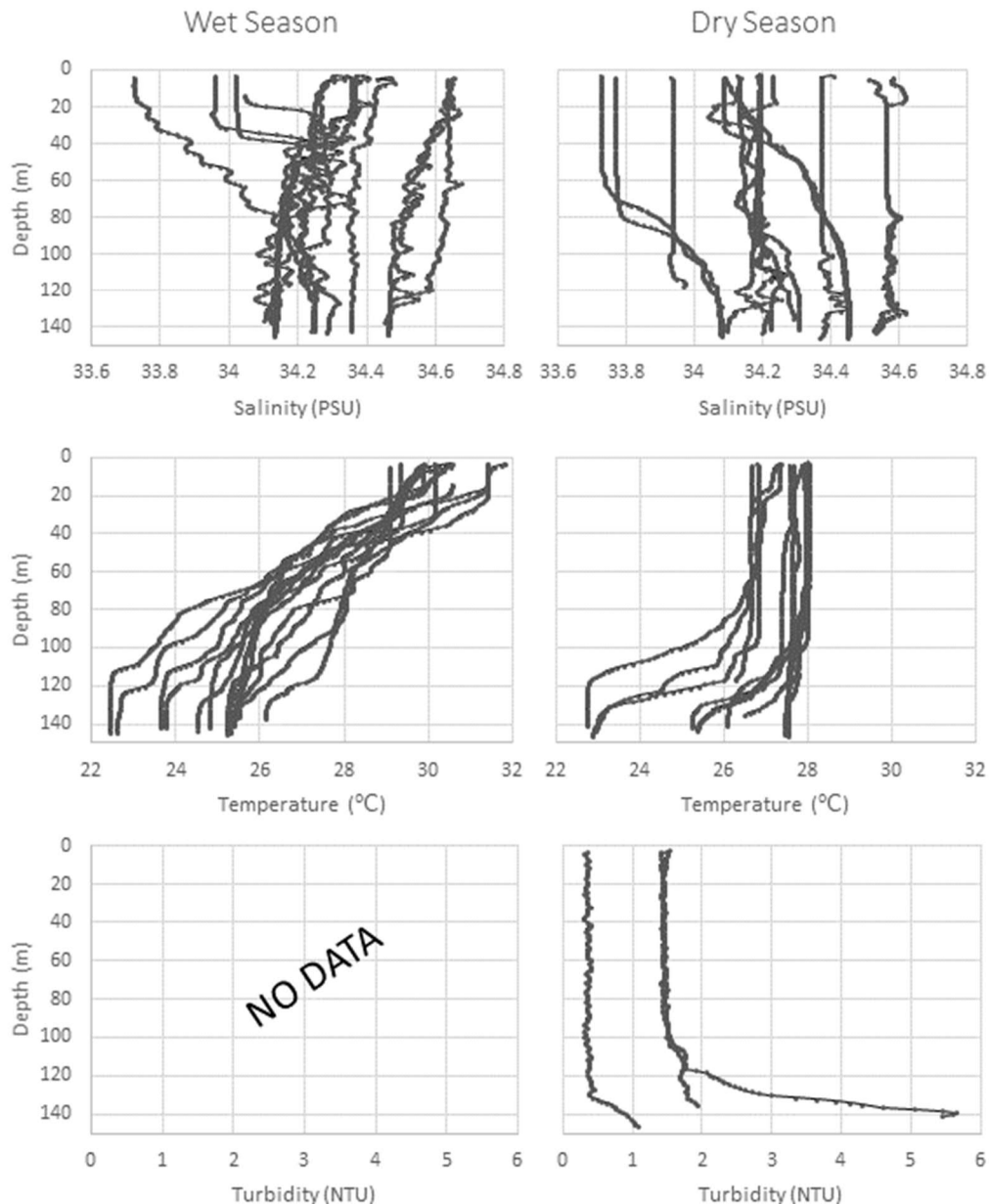


Figure 9-7. Offshore water quality profiles during the wet ($n=14$ spanning 7 years) and dry ($n = 14$ spanning 8 years) seasons (Source: Australian Ocean Data Network Portal)

9.3.3.2 Chemical characteristics

Salinity and dissolved oxygen are important chemical properties for the growth and health of biota living in the water column and at the seabed. Appendix S Section 4.5 reviews and analyses available water quality data for these parameters. Background water chemistry of the nearshore and offshore regions is summarised below.

The natural salinity range in Shoal Bay is approximately 34 to 37 PSU in the dry season, which can decrease to 28 PSU during the wet season and lower levels near the shore during rain and flood events. The surface PSU fluctuates with rainfall but is quickly mixed due to the strong tidal flows. Offshore salinity is approximately 33 to 36 PSU, and surface salinity is also likely to vary with localised rainfall but quickly return to ambient levels due to tides and wind mixing.

Dissolved oxygen (DO) levels in Shoal Bay indicate that it is a well-oxygenated water body, with levels ranging between approximately 70 % (25th percentile) and 107 % (75th percentile) saturation throughout the year

(Appendix S). Higher variability of DO throughout the wet season is observed in the outer harbour, close to Shoal Bay, and is likely the effect of abrupt changes in water temperature, salinity, turbidity, productivity, and biological oxygen demand. Some instances of saturation above 100 % may be due to intense photosynthesis or a rapid change in temperature. Offshore, DO at the surface is generally in equilibrium with atmospheric levels (around 65 %, or 4.7-5.0 mg/L), and reduces with depth.

9.3.3.3 Biological

Appendix S Section 4.6 reviews and analyses available water quality data for nutrients and chlorophyll-a, which are key indicators of marine water quality. Background water quality of the nearshore and offshore regions is summarised below.

Nutrients

Nutrients, such as nitrogen (N) and phosphorus (P), are substances that are required for growth and reproduction of aquatic plants and algae. However, significant increases in nutrient concentrations can result in problematic growths of algae, and in turn may have undesirable effects on the marine ecosystem (Padovan, 2003). Nutrients can be present in soluble, particulate, organic and inorganic forms. The bioavailability of different forms varies; transformation of one form to another depends on the physical and chemical condition of waters and sediments and is often mediated by biological processes.

In general, the data review found that nutrients appear to be weakly variable with seasons in the nearshore environments traversed by the Subsea Cable System corridor. Variability of nutrients is complex and can be influenced by combination of tidal dynamics with biological activity (changes in primary production) and re-suspension of organic material from the seafloor, freshwater discharge and nutrient loads, and flushing rates. The majority of nutrients that enter the nearshore areas are imported from the ocean and are typically in the particulate or organic form (Burford et al., 2008). These nutrients are not considered to be bioavailable, that is, able to be used by biological organisms. Nutrients also enter the area from the surrounding catchment and are derived from both diffuse sources, such as urban and rural runoff, as well as point sources such as treated sewage effluent.

The waters of the offshore area are primarily oligotrophic (i.e., nutrient poor and oxygen rich) with low levels of nitrates in surface waters (Condie et al., 2003). However, nutrients may be transported into the Bonaparte Basin through storm and cyclone events.

Chlorophyll-a

Chlorophyll-a is a key indicator for primary productivity in marine water quality and varies depending on available nutrients, flow, and water clarity. High chlorophyll-a values may indicate high nutrient levels in the water column, while low levels may indicate there is not enough sunlight in the water column for sufficient algal growth.

The data review found that chlorophyll-a concentrations in Shoal Bay are stable throughout the year and range from 0.3 to 0.9 µg/L. In Beagle Gulf, chlorophyll-a concentrations are similar but reach up to 2 µg/L. Near the seabed, chlorophyll-a concentrations reach up to 12 µg/L. Higher concentrations of chlorophyll-a are sometimes associated with wet season run-off and associated nutrient elevations close to the coast.

Offshore, surface chlorophyll-a is estimated using satellite colour data, with a range of 0.15 to 0.75 mg/m³ in the wet season, and similar but slightly higher (max >0.5 mg/m³) in the dry season.

9.3.4 Water quality guidelines

The Darwin Harbour Water Quality Objectives (WQOs) were designed for detecting long-term (decadal) changes in marine environmental quality, and therefore, a standardised sampling regime during neap high tides was used to determine the water quality guideline values, which demonstrate the water quality expected at neap, high tides. Although natural tidal and seasonal changes are not reflected in this guideline value (Fortune, 2010), they have been used as a conservative reference throughout this document.

The Darwin Harbour WQOs provide locally derived guideline values for water quality indicators in Darwin Harbour to protect and sustain the identified environmental values and beneficial uses (Fortune 2010). These include:

- To maintain and protect the ecological condition of marine, estuarine and freshwater ecosystems of the Darwin Harbour Region
- To maintain marine, estuarine, and freshwater quality so that it is suitable for activities such as swimming and other direct water contact sports
- To maintain water quality for the production and consumption of aquatic foods derived from aquaculture, recreational, commercial, or indigenous food gathering.

The WQOs for turbidity and suspended solids in Shoal Bay were calculated based on percentiles (80th or 20th) of ambient guideline values measured before 2010 – see Table 9-4 (Fortune 2016). The ambient guidelines are based on dry season neap tide conditions (i.e., when turbidity and suspended solids are naturally low). These guideline values were adopted in the assessment of impacts to water quality associated with AAPowerLink cable laying and burial activities presented in Section 9.4.2.1. However, it is noted that turbidity and suspended solids concentrations naturally exceed these guideline values, particularly during spring tides and the wet season.

Table 9-4. Outer estuary Water Quality Objectives for turbidity and total suspended solids (Source: Fortune 2016)

Indicators	Sub-indicators	Water quality guideline value
Water clarity	Turbidity (NTU) or	<4
	Suspended solids (mg/L)	<10

Offshore guidelines for water quality limits are provided in the Australia and New Zealand guidelines for fresh and marine water quality (IMCRA 4.0). These guidelines provide guidance for the mesoscale biodiversity areas of the Bonaparte Gulf and Oceanic Shoals. At the time the AAPowerLink sediment transport modelling was undertaken, there were no guideline values available for turbidity. The modelling assessed SSC above 2 mg/L (in contrast to the 10 mg/L adopted for the nearshore areas) because turbidity and SSC is naturally lower (i.e., water clarity is higher) in the offshore environment due to substrate, dilution, and water depth (i.e., less impact from wind and waves).

9.3.5 Declared beneficial uses and other environmental values

9.3.5.1 Nearshore

Declared beneficial uses for waterways are an effective way of identifying community values and uses of waterway resources. Ten categories are used to describe values for groundwater and surface water in Fortune (2010). There are declared beneficial uses for the Shoal Bay and the Vernon Islands region, and Darwin Harbour and its marine reaches, which are proximate to the AAPowerLink Subsea Cable System corridor. These are:

- Environment: habitat for plants and animals
- Cultural: recreation (e.g., swimming or fishing)
- Cultural: aesthetics (visual amenity).

These declared beneficial uses are listed in the Darwin Harbour WQO's and are based on data collected before 2010 (Fortune 2010). The proposed Sea Dragon aquaculture project is likely to result in a fourth beneficial use being added in Shoal Bay:

- Aquaculture: aquaculture (in water or on land)

Shoal Bay is a Site of Conservation Significance (SOCS) identified by the NT Government due to its internationally significant wildlife aggregations and nationally significant tidal mudflats which support migratory birds, as well as rainforest patches on the margins of the tidal mudflats. Benthic habitat likely to occur within Shoal Bay (based on modelling) includes seagrass, seaweed, and hard corals, all of which support a range of fish and marine fauna, including iconic and culturally important species such as dugong and dolphins. Further detail on environmental values in the nearshore environment are provided in Chapter 10 Marine Ecosystems Section 10.3.

The Darwin Harbour region and surrounds are culturally important to Aboriginal people. Gunn Point Beach and Shoal Bay are the traditional country of the Larrakia people, and Tiwi people also maintain customary ties to country at Murrumujuk. Further detail on cultural values and potential impact can be found in Chapter 14 Culture and Heritage.

The Darwin Harbour region and surrounds are highly valued for recreational fishing and tourism. Shoal Bay is an important recreational fishing area (most of the area is closed to commercial fishing), and also an important barramundi nursery (Marsden Jacob Associates 2012). Further detail on social and recreational values and potential impact can be found in Chapter 15 Community and Economy.

9.3.5.2 Offshore

The Subsea Cable System corridor runs through the Oceanic Shoals Marine Park (OSMP) which is located approximately 250 km offshore, west of the Tiwi Islands (see Figure 9-8). The OSMP is zoned to manage which activities can occur throughout the marine park area; see the *North Marine Parks Network Management Plan* (Director of National Parks 2018). The Subsea Cable System traverses two zones; Multiple Use Zone (IUCN VI) and Special Purpose Zone (Trawl) (IUCN VI).

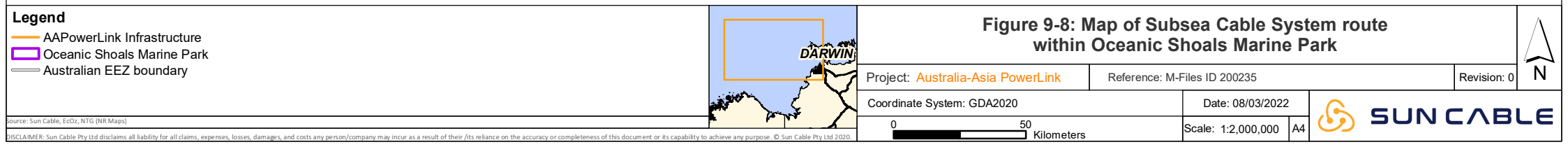
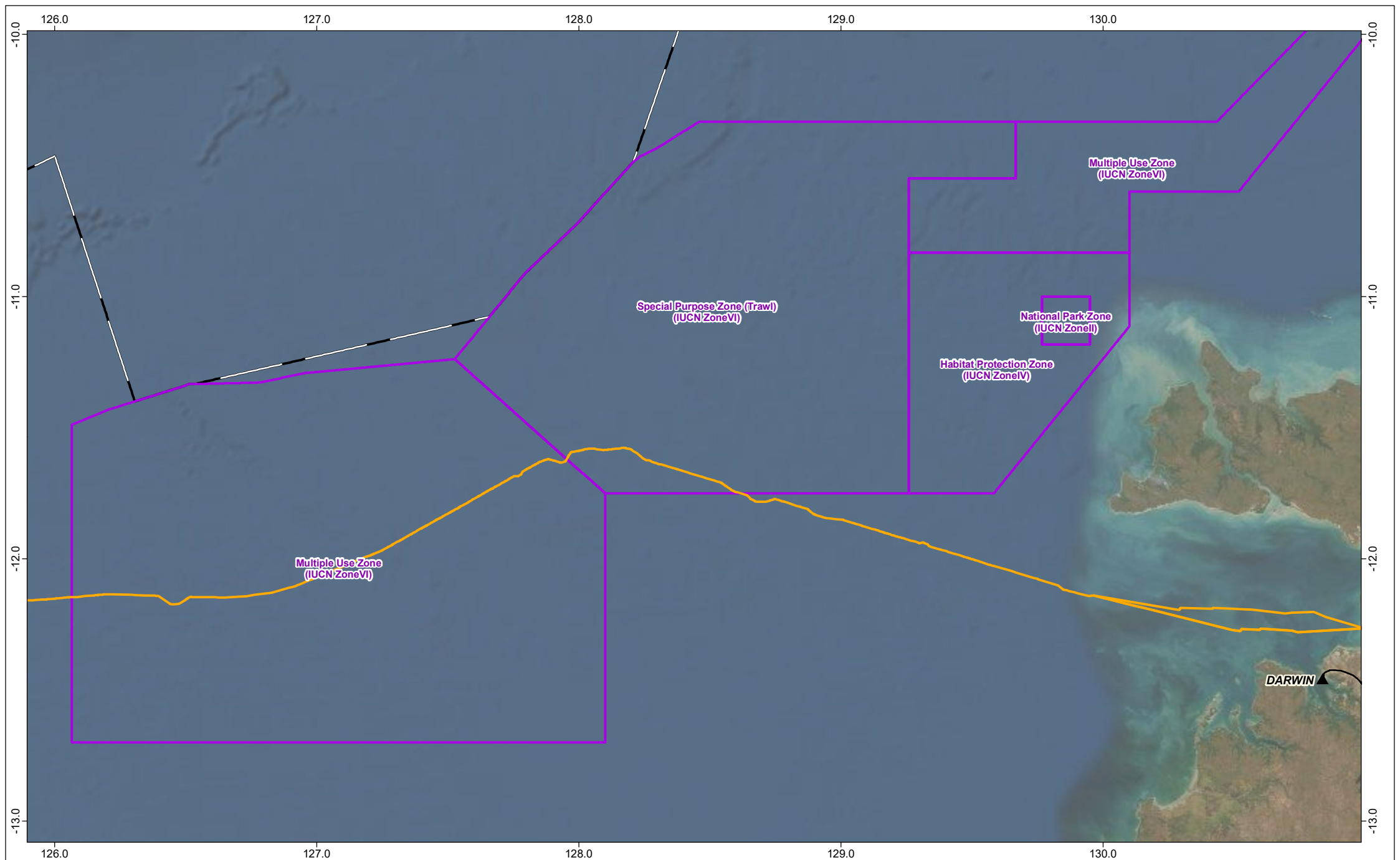
Within the Multiple Use Zone (IUCN VI) and Special Purpose Zone (Trawl) (IUCN VI) most activities are allowed, or allowable subject to obtaining authorisation from Parks Australia, within the two zones traversed by the Subsea Cable System (summarised in Table 9-5; information from Parks Australia 2018). Note this list is not exhaustive, but relevant to activities which may be undertaken regularly in the area or may be undertaken as part of the proposal. In addition to obtaining approval under the EPBC Act, Sun Cable will obtain the necessary authorisations for activities within the OSMP.

The most environmental sensitive areas of the OSMP zoned National Park (IUCN II) and Habitat Protection (IUCN IV) are located to the east of the Subsea Cable System corridor and are outside of the zone of influence of the proposal (at its closest point, the Subsea Cable System is located ~ 25 km from these zones; see Figure 9-8). In these areas activities are restricted to ballast water discharge, disposal of waste (in accordance with MARPOL), vessel transiting, recreational use (including fishing) and traditional use.

There are three key ecological features (KEF) intersected by the Subsea Cable System corridor – the carbonate bank and terrace system of the Van Diemen Rise, the carbonate bank and terrace system of the Sahul Shelf, and the Pinnacles of the Bonaparte Basin (shown on Figure 9-1). Further detail on these features and discussion of potential impacts can be found in Chapter 10 Section 10.3.2.2.

Table 9-5. Rules for activities within relevant zones of the Oceanic Shoals Marine Park

Activity	Special Purpose Zone (Trawl) (IUCN VI)	Multiple Use Zone (IUCN VI)
Ballast water discharge and exchange	Allowed	Allowed
Disposal of waste from normal operations (in accordance with MARPOL)	Allowed	Allowed
Recreational use (including fishing and spearfishing)	Allowed	Allowed
Traditional use (non-commercial fishing, hunting and food gathering, ceremonial and cultural use)	Allowed	Allowed
Anchoring and vessel transiting	Allowed	Allowed
Commercial fishing	Allowable with authorisation, including trawling. Longline (demersal, auto-longline) not allowed.	Allowable with authorisation. Trawling, net fishing and longline (demersal, auto-longline) not allowed.
Construction and operation of pipelines	Allowable with authorisation	Allowable with authorisation
Structures and works	Excavation, erection of structures (including submarine cables) and dredging, disposal of dredge spoil, creation of artificial reefs allowable with authorisation.	Excavation, erection of structures (including submarine cables) and dredging, disposal of dredge spoil, creation of artificial reefs allowable with authorisation.



9.4 Potential impacts

The potential impacts to marine environmental quality associated with the AAPowerLink construction and operation have been assessed using the EIA methodology described in Chapter 3 – Impact Assessment. The EIA identified and assessed the following impacts associated with the construction phase:

- Sediment re-suspension in the water column caused by cable burial
- Sediment runoff and water quality impacts from shore crossing trenching
- Disturbance of PASS, impacting water quality
- Spills of hazardous substances, impacting water quality.

The EIA identified and assessed the following impacts associated with the operations phase:

- Seabed disturbance from cable repairs
- Localised temperature increase in the vicinity of the Subsea Cable System.

The EIA considered the impact avoidance and mitigation measures detailed in Section 9.5 and assessed the residual impacts to marine environmental quality assuming these measures are effectively implemented. A residual impact rating was then assigned taking into consideration the scale, magnitude and duration of the impacts, the presence/absence of environmental values and/or sensitive receptors and the level of certainty with respect to the intensity of the impact and the effectiveness of the mitigation measures. The residual impact ratings adopted in the assessment are provided in Table 9-6.

The outcomes of the EIA are summarised in Table 9-7 and Table 9-8 below from the Impact Assessment Register provided at Appendix E and discussed in the subsequent sections.

Table 9-6. Residual impact ratings adopted for the AAPowerLink EIA

Ratings and Description
Minor: A minor residual impact is unlikely to be significant. A minor impact generally has two or more of the following characteristics: Scale: Limited/Localised Magnitude: Negligible/Minor Duration: Short-term/ Medium-term/Reversible. OR There are no sensitive receptors or land uses present, and the environment does not contain any aspects that are valuable or otherwise important or unique (i.e., Very Low/Low rating), and there is moderate to high degree of certainty about the likelihood and intensity of the impact, and the effectiveness of proposed mitigation measures.
Moderate: A moderate residual impact has potential to be significant. The significance depends on the acceptability of the impacts and the effectiveness of mitigation measures. A moderate impact generally has two or more of the following characteristics: Scale: Localised/Regional Magnitude: Moderate Duration: Medium-term/Long-term AND/OR There are sensitive receptors or land uses present, or environmental aspects that are valuable or otherwise important or unique (i.e., Medium-High value rating), and there is a low degree of certainty about the impact, and the effectiveness of proposed mitigation measures.
Major: A major residual impact is likely to be significant. The level of acceptability will depend on offsets or benefits compensating for the impact. Impact generally has two or more of the following characteristics: Scale: Regional/ Widespread Magnitude: Moderate/Major Duration: Long-term/Permanent AND There are sensitive receptors or land uses present, or environmental aspects that are valuable or otherwise important or unique (i.e., Medium-High value rating).

Table 9-7. Summary of EIA results – Marine environmental quality factor - Construction

Impact	Location	Likelihood	Scale	Duration	Magnitude	Value rating	Certainty	Residual impact
Increased turbidity in marine waters caused by cable burial activities	Subsea Cable System - nearshore	Likely Cable burial will result in disturbance of sediments and increased suspended sediment concentrations (SSC) in the water column.	Widespread Sediment transport modelling indicates elevated SSC could occur over a wide area of shallow waters (up to 26 km x 11 km).	Short-term Elevated SSC will be experienced for periods of days to weeks as the cable burial activities occur in the shallow waters of Shoal Bay.	Moderate Water quality objective exceeded for short periods but unlikely to affect marine habitats or biota adapted to high turbidity conditions.	Medium Water quality supports marine ecosystems, including seagrass, seaweed and hard coral, and beneficial uses.	High Marine modelling undertaken (see Appendix R). Model assumptions are conservative.	Moderate
	Subsea Cable System - offshore	Possible Cable burial will occur in offshore environment	Limited Modelling indicates elevated SSC concentrations around cable and bottom layer of the water only.	Short-term Elevated SSC will occur for hours to days following trenching.	Negligible Maximum modelled SSC <4 mg/L near seabed; no increase near surface.	Medium Water quality supports marine ecosystems and beneficial uses.	High Marine modelling undertaken (see Appendix R). Model assumptions are conservative	Minor
Sediment mobilisation from Shore Crossing Site impacting water quality	Shore Crossing Site	Likely Shore crossing will include trenching and disturbance of sediments in intertidal area.	Localised SSC may be elevated in intertidal area and may spread along the coastline for several hundred metres.	Short-term Mobilisation of sediment may occur intermittently over short construction phase (one month).	Moderate Water quality objective exceeded for short periods but unlikely to affect marine habitats or biota adapted to high turbidity conditions.	Medium Water quality supports marine ecosystems, including seagrass, seaweed and hard coral, and beneficial uses.	High Footprint is small and will be reinstated post construction. Disturbance will occur for a short period of time.	Minor

Impact	Location	Likelihood	Scale	Duration	Magnitude	Value rating	Certainty	Residual impact
Disturbance of PASS at Shore Crossing Site impacting water quality	Shore Crossing Site	Possible Ground disturbance for the shore crossing may disturb PASS.	Limited Footprint is small and period of exposure for PASS would be limited to weeks. Significant acid generation unlikely in that time, and impacts limited to immediate vicinity.	Short-term Construction will occur over one month with water quality returning to baseline post construction.	Minor Any acidity impacts to water would be minor and rapidly diluted.	Medium Water quality supports marine ecosystems, including seagrass, seaweed and hard coral, and beneficial uses.	High Testing and management of PASS in accordance with guidelines is proven effective in mitigating risk of water quality impacts.	Minor
Spills of hazardous substances impacting water quality	Subsea Cable System	Possible Ships and barges will be used in the marine environment which are powered by marine fuel oil. No other hazardous materials will be used for cable installation.	Limited Spill would be small in volume and would weather, disperse, and dilute.	Short-term Spills will be detected and remediated immediately.	Minor No detectable change in water quality beyond the direct spill location.	Medium Water quality supports marine ecosystems, including seagrass, seaweed and hard coral, and beneficial uses.	High Adherence to regulations and MARPOL are proven effective in mitigating risk to marine environment.	Minor
	Land Sea Joint Station	Possible Temporary storages of fuel and other substances will be located at the Land Sea Joint Station.	Limited Spills may occur but storage and handling procedures mean a spill will be limited to ground around spill and will not enter marine water.	Short-term Spills to ground will occur intermittently. Spills will be detected and remediated immediately.	Negligible No impact to marine water quality.	Low Land Sea Joint Station is >300 m from beach and no marine environments within the footprint.	High Australian Standards for storage and handling are established and proven effective for mitigating risk.	Minor

Table 9-8. Summary of EIA results - Marine environmental quality factor - Operations

Impact	Location	Likelihood	Scale	Duration	Magnitude	Value rating	Certainty	Residual impact
Increased turbidity in marine waters caused by cable maintenance activities	Subsea Cable System	Possible Repairs may require cables to be uncovered or additional cable to be laid. Potential for water quality impacts due to increased suspended sediment concentrations.	Limited Repairs would only be required due to damage, in a small section of the Subsea Cable System.	Short-term Water quality impacts could occur over days during repairs.	Minor Spatially restricted and over a short time frame.	Medium Water quality supports marine ecosystems, including seagrass, seaweed and hard coral, and beneficial uses.	High Repairs would only be required if damage occurred, in a small footprint, and over a short period of time.	Minor
Localised temperature increase	Subsea Cable System	Likely Operation of the HVDC cables will generate heat.	Limited Heat emissions will be restricted to the immediate vicinity of the cable, including sediment within ~ 1 m of cable.	Long-term Heating will occur for duration of operations.	Minor Heating within immediate vicinity of cable only. Unlikely to impact habitat value.	Medium Water and sediment quality support marine ecosystems and beneficial uses.	High Peer reviewed studies of other similar cables have informed impact assessment.	Minor

9.4.1 Areas of potential impact

9.4.1.1 Proposal footprint (direct disturbance)

The proposal footprint where there will be direct disturbance of the marine environment encompasses the Shore Crossing Site located at Murrumujuk, Gunn Point Beach and the Subsea Cable System corridor, which extends over 4,200 km to Singapore. Only the 895 km section located in NT Coastal Water and the Commonwealth Marine Area is assessed in this EIS, with the remaining section subject to assessment and approval under the laws of Indonesia and Singapore as discussed in Chapter 1 Introduction.

The direct disturbance footprint for the Shore Crossing Site is a 500 m by 500 m footprint (see Figure 9-4), within which open trenches approximately 2 m deep and 2 m wide will be excavated for each cable. The footprint has been sized to accommodate up to six cables to accommodate future system capacity; however, initially it is proposed that three cables will be laid. Following cable laying the trenches will be backfilled and the area reinstated, with the intent that there will be no permanent infrastructure or disturbance visible on the surface.

The Subsea Cable System corridor required to accommodate six cables is 1 km wide, plus a 100 m buffer each side. The direct disturbance footprint within this corridor is up to 12 m wide per cable where cable laying and burial activities, and maintenance activities if required, will directly disturb the seafloor. This direct disturbance footprint will extend from the Shore Crossing Site to the edge of the Commonwealth marine area (see Figure 9-1).

9.4.1.2 Area of influence (indirect disturbance)

Cable laying and burial activities are likely to indirectly impact water quality due to sediment re-suspension and decreased water clarity. The area of influence to water quality has been determined by hydrodynamic and sediment transport modelling (Appendix R), the results of which are summarised in Section 9.4.2.1. The possible area of influence and is predicted to be widespread throughout nearshore shallow (<20 m depth) waters where short periods of elevated turbidity could occur at some distance from the Subsea Cable Corridor, before returning to background concentrations once the cable is in place. The modelled area of influence is shown on Figure 9-9 and the meaning of the different suspended sediment concentration contours shown in the Figure are explained in Section 9.4.2.1 below.

For the Shore Crossing Site, the area of influence for water quality impacts due to sediment transport or acidic runoff from disturbance of PASS is limited to areas proximate to the direct disturbance footprint described above. Sediment may spread along the coastline for several hundred metres in either direction of the Shore Crossing Site subject to currents, tide, and wind direction. Any impacts from acidity would be isolated, as PASS will be identified and managed in accordance with Australian guidelines (see Section 9.4.2.3).

In the offshore environment, modelling predicts very little change in water quality and sediments surrounding the cables during trenching (due to a number of factors described in Section 9.4.2.1). The area of influence to marine water quality in this environment is restricted to areas proximate to the direct disturbance footprint.

9.4.2 Construction

The potential for impacts to marine water quality and sediments will be greatest during the construction phase when cable laying and burial activities will disturb the seabed and mobilised sediments into the water column. The sections below discuss the potential impacts of construction activities at the Shore Crossing Site at Murrumujuk, Gunn Point Beach, and cable laying and burial activities through the nearshore and offshore environments.

9.4.2.1 Increased turbidity in marine waters caused by cable burial

As detailed in Chapter 2 Section 2.8.3, the Subsea Cable System will be installed predominantly using jet-trenching methods, with up to six cables laid (three for the initial installation and a further three in future). Whilst the direct disturbance footprint associated with these is narrow (up to 12 m wide), the cable burial process will increase suspended sediment concentration (SSC) in the water column, which can then be further distributed by tides, waves, and wind. Elevated SSC in the water column can increase turbidity (i.e., decrease light penetration) which if elevated concentrations persist for periods of time may limit light for primary producers, and can also clog gills and impact fauna (e.g., fish) feeding.

Hydrodynamic and sediment transport modelling undertaken by Metocean (2021a) (Appendix R) indicates it is likely that elevated SSC from jet-trenching will temporarily increase turbidity in the marine waters of Shoal Bay (the nearshore environment) during the nearshore cable burial activities. The modelled SSC concentrations are within the natural range recorded in Shoal Bay where the receiving environment is naturally turbid for periods of time, particularly during the wet season (see Section 9.3.3.1). However, as the cable burial activities could occur during the dry season or wet season, the activity may result in unseasonal periods of elevated SSC when it occurs at times during the dry season when background SSC concentrations are typically low.

Sediment transport modelling

The sediment transport modelling was based on a cable installation scenario that involves jet-trenching along three simultaneously jetted cable sections, 50 km in length, with three passes along each undertaken seven days apart. Two locations were modelled – the nearshore area of Shoal Bay, and an offshore area of the OSMF. These two areas were selected to enable assessment of potential impacts under different conditions¹⁰, and also because they represent two ecologically sensitive areas based on location of marine habitats which could be susceptible to elevated SSC (see Chapter 10 Marine Ecosystems). The model methodologies and outputs are detailed in Appendix R.

The model is considered to provide a conservative assessment of potential water quality (i.e., likely an overestimate of extent of elevated SSC concentrations) because it is based on the following key assumptions:

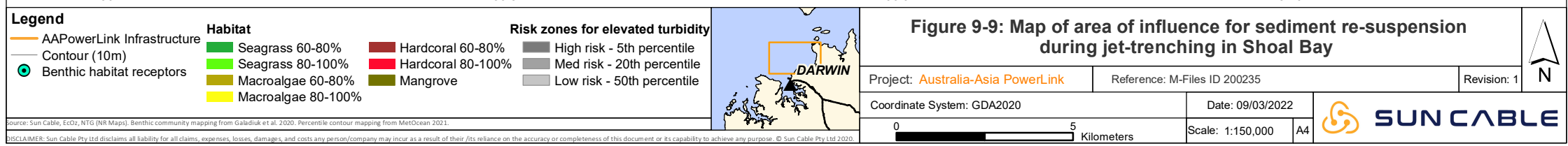
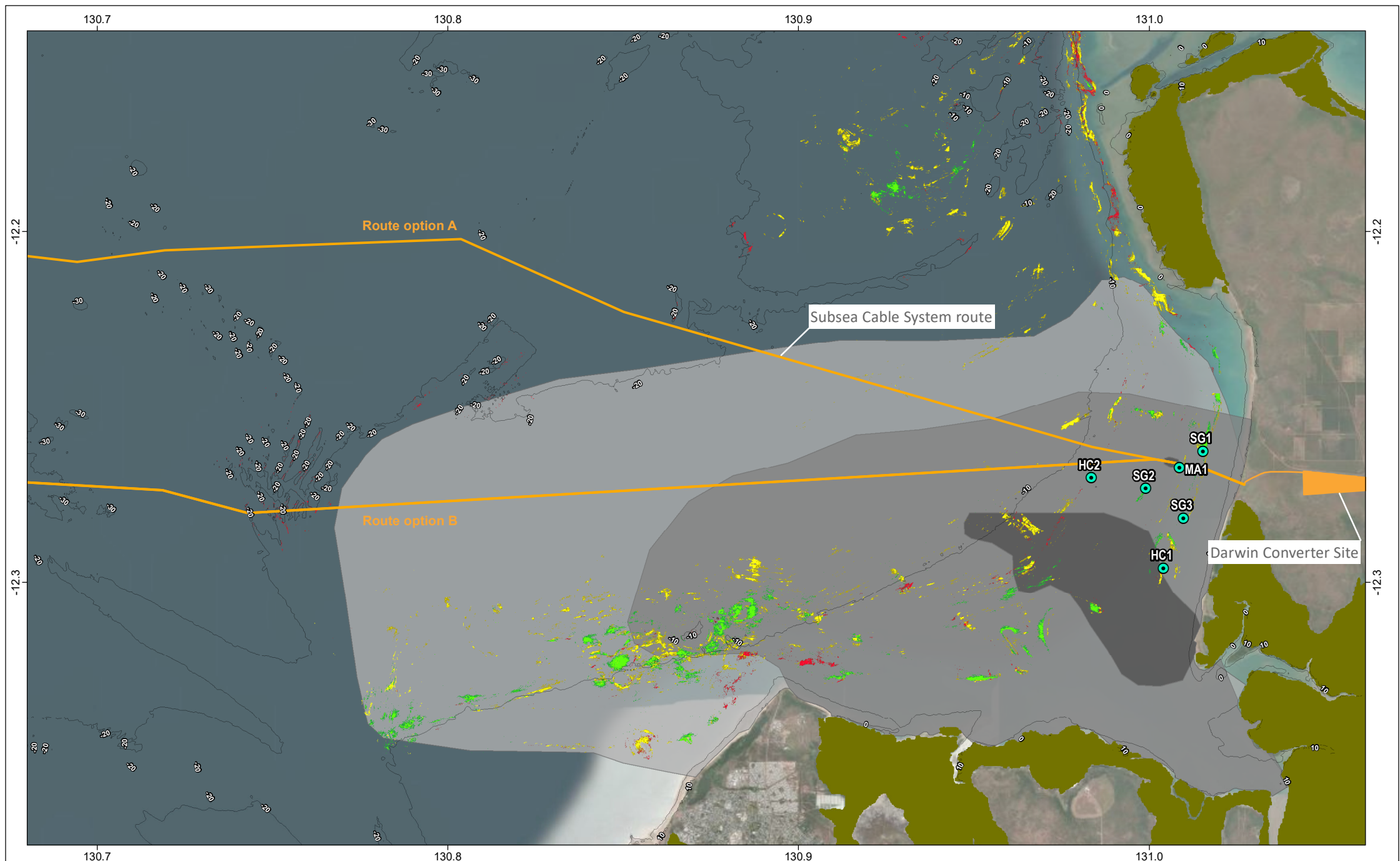
1. A high (30%) re-suspension of sediment from the seabed into the water column for the cable burial process. The amount of resuspension will vary depending on sediment characteristics and burial methods. The modelled scenario assumes high clay and silt content and jet trenching along the entire corridor, which is considered worst-case for SSC.
3. High clay (36 %) and silt (17.5 %) content for the seabed material. This was based on geotechnical survey data in Darwin Harbour, as there were no in-situ geotechnical surveys undertaken in Shoal Bay; however, there is likely to be less clay and silt in the seabed material in some sections of the corridor. Clay and silt remain in suspension for a longer period of time, and so if less clay and silt is present in the corridor than that modelled the extent and duration of sediment re-suspension will be less.
4. The model output is based on the percentiles of SSC concentrations falling below the Darwin Harbour WQO of 10 mg/L. There are no baseline SSC concentrations in Shoal Bay; however, 10 mg/L is a conservative guideline based on dry season neap tides. The SSC concentrations in Shoal Bay frequently exceed 10 mg/L naturally (see Table 9-3 and Figure 9-6). Therefore, while SSC is expected to exceed 10 mg/L for a short period of time following cable burial, the exceedance above the natural baseline is currently unknown.

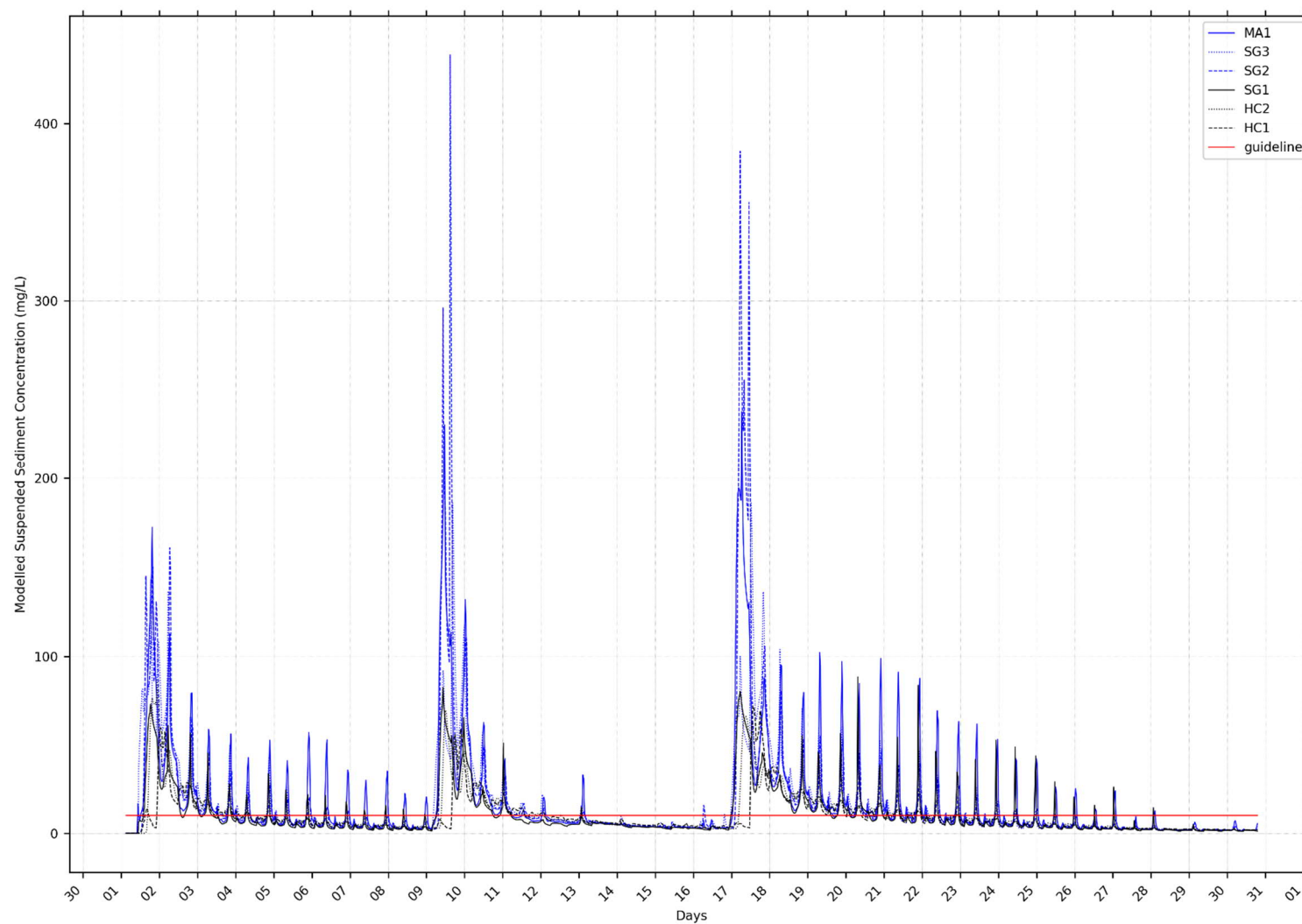
¹⁰ The inshore area has shallow water, higher silt and clay content, and sediment re-suspension is more likely due to the influence of factors such as wind, waves, and tides. The offshore area has a deeper water column, is less susceptible to sediment re-suspension, and is sandier (sand stays in suspension for a shorter period of time than silt). See Section 9.3.2.4.

5. Jet-trenching was the assumed burial method in the modelling across the entire nearshore Subsea Cable System corridor. Jet-trenching is thought to be an overall higher impact than ploughing (Muneez et al. 2018) and is likely to make up 60-70 % of the cable burial method. Sections of the cable may be laid directly on the seabed, and in some cases mechanical ploughing will be used along short sections of the corridor.
6. It was assumed that three cables will be laid simultaneously (i.e., three jet-trenchers operating at the same time), and each section of cable was passed by the jet trencher three times. If one jet-trencher operates at any given time and/or less than three passes are required to achieve burial depth, then sediment re-suspension is likely to be less than that modelled.

The modelling predicted the extent of water quality impacts (i.e., above background SSC) based on three percentile levels, 5th, 20th and 50th, referred to herein as 'percentile contours'. The percentile contours are used to provide an indication of the variation in water quality impacts that could occur. The 5th, 20th and 50th percentile contours can be thought of as high, medium, and low risk zones respectively; there is a higher risk of SSC exceeding the Darwin Harbour WQO, and for a longer period of time, within the 5th percentile contour zone, and a lower risk in the 20th and 50th percentile contour zones respectively.

Model outputs for each of the nearshore and offshore sections of the Subsea Cable System corridor are provided below. The percentile contours for Shoal Bay are shown on Figure 9-9, representing the area of influence within which water quality impacts may occur. As the extent to which elevated SSC impacts marine habitats and biota depends on the duration of the impact, time series sediment concentrations were modelled for several benthic habitat locations within Shoal Bay close to the proposed Subsea Cable System corridor. A subset of the time series results is shown on Figure 9-10 and predict that SSC will return to background levels within days following completion of cable burial activities. The implications of this short-term water quality impact for marine habits and biota are discussed further in Chapter 10 Marine Ecosystems.





HC = hard coral, SG = seagrass, MA = macroalgae.
Locations of each receptor are shown on Figure 9-9.

Figure 9-10. Time series plot of Suspended Sediment Concentrations at nearshore receptors; highest modelled values (worst-case scenario)

Shoal Bay (Nearshore)

The modelled zone of influence to marine water quality is shown in Figure 9-9. The 5th percentile contour indicates the zone of highest risk to water quality associated with the cable burial activities. The contour represents the area where 95 % of the model SSC results exceeded the Darwin Harbour WQO (guideline value) for SSC (10 mg/L). The 20th percentile and 80th percentile contours represent areas of Medium to Low risk where lower portions of the modelled SSC results exceeded the guideline value of 10 mg/L.

The extent of the High-risk zone (5th percentile contour) is slightly offset (south) from the cable corridor, toward the Shoal Bay coastline. This offset indicates that the net sediment movement direction is shoreward. This is likely due to the effect of surface winds on the movement of the sediment and could also indicate the process of shoreward tidal pumping due to flood tide dominance, where stronger shoreward currents incrementally move sediment upstream.

To further assess the potential impact of elevated SSC on the marine environment, time series modelling was used to determine the duration of elevated SSC that is likely to be experienced on the marine waters of Shoal Bay. This is because, in the Shoal Bay environment where conditions are naturally turbid for periods of time, elevated SSC and turbidity are only likely to impact marine habitats and biota when experienced for extended periods. Time series were prepared for sensitive receptor locations, which included areas predicted to support seagrass, macroalgae (seaweed), hard coral and/ artificial reef habitats as described and mapped in Chapter 10 Marine Ecosystems. The modelling results are discussed in detail in Chapter 10 where they are used to assess the potential impact to marine habitats and biota associated with the short-term increase in turbidity that is predicted to occur.

The time series plots indicate that SSC concentrations at locations in Shoal Bay will peak with each pass of the jet trencher, then rapidly dissipate with a few days. To illustrate this Figure 9-10 presents the time series plots for six locations with the highest (i.e., worst-case) SSC. The three peaks in SSC on Figure 9-10 represent the modelled passes of the jet trenchers, each of which is predicted to result high concentrations (up to ~400 mg/L) for short periods of time (hours) in very shallow (e.g. <10 m AHD) locations, followed by sustained elevated SSC over three days, before returning to below the WQO. During the time between each pass of the jet trencher, there is modelled to be spikes in SSC associated with the daily tidal cycles as sediments are mobilised and re-suspend. Note that the SSC concentrations on the time series plots are independent from background SSC, and so the magnitude of increase from baseline would depend on the tides and weather conditions at the time of cable burial.

For each of the modelled risk zones (High, Medium, and Low) Table 9-9 shows the area potentially impacted, and the cumulative number of days when SSC is predicted to exceed the Darwin Harbour WQO of 10 mg/L (as determined from time series plots). For the High-risk zone, it is predicted that the WQO will be exceeded for a total of 11 days during the cable burial program. However, as indicated above, sustained exceedance of the WQO is only predicted to occur for three days during and following each pass of the jet trencher. Following the final pass of the jet trencher, the SSC are predicted to dissipate to below the WQO within 11 days. If three passes of the jet trencher are required along each cable¹¹, then measurable water quality impacts could occur over a month.

¹¹ The number of passes required will depend on the sediment characteristics and effectiveness of cable burial. The depth of burial is assessed after each pass to determine if further passes are required.

Table 9-9. Sediment transport modelling quantitative characteristics for Shoal Bay area of influence

Risk zone (defined by percentile contours)	Area (km ²) of zone	Approximate dimensions of zone (km)	Maximum cumulative days of SSC >10mg/L
High (5 th percentile)	20.4	5 x 2	11.6
Medium (20 th percentile)	164.6	15 x 11	18.4
Low (50 th percentile)	332.6	26 x 11	1.1

Available water quality data are summarised in Section 9.3.3, and from these it is known that shallow locations have a naturally higher turbidity than deeper locations, particularly in Shoal Bay which is an open, north-westerly facing coastline which experiences higher stress from wind and waves (Figure 9-5). Turbidity and sediment concentrations naturally fluctuate to high concentrations in the wet season for periods of days to weeks but are often low (between 0 and 25 NTU) in the dry season. Construction of the Subsea Cable System is likely to result in periods of unseasonably high SSC and turbidity (i.e., if trenching occurred in the dry season). Existing data from other studies in comparable areas (i.e., Yang et. al. 2018 and 2020) indicates these short periods of elevated SSC concentrations in shallow waters are unlikely to affect marine habitats or biota as the ecosystem is adapted to periods of highly turbid water with high sediment loads. Chapter 10 Section 10.4.2 provides information about the marine habitats and biota that occur proximate to the Subsea Cable System footprint and discusses their level of sensitivity to the predicted water quality impacts associated with the cable laying and burial activities.

Oceanic Shoals Marine Park (Offshore)

The OSMP was the only offshore area modelled, as it was determined to be the most sensitive marine environment relevant to the Subsea Cable System corridor in the offshore area. As discussed in Section 9.3.1, turbidity and SSC is naturally lower (i.e., water clarity is higher) in the offshore environment due to substrate, dilution, and water depth (i.e., less impact from wind and waves). As such, modelling in the offshore zone assessed SSC above 2 mg/L rather than 10 mg/L. The modelling predicts no SSC above 1 mg/L in the top layer of the water column (i.e., no impact) and minimal elevation of SSC concentrations in the bottom layer of the water column. SSC did not exceed 1 mg/L in the 5th, 20th or 50th percentile model runs, and the maximum SSC concentration was <4 mg/L. This is a very low concentration and is unlikely to affect marine habitats or biota in an area where turbidity can be naturally elevated at the seabed, up to ~6 mg/L (Figure 9-7). The modelling indicates very little risk of any impact to water quality in the OSMP and offshore environment in general.

9.4.2.2 Sediment mobilisation from Shore Crossing Site impacting marine water quality

Works at the Shore Crossing Site will involve the excavation of open trenches from the Land Sea Joint Station across the beach and intertidal zone that will disturb soils, exposing them to an increased risk of sediment run-off during rain events, or when exposed to tidal movements. A trench will be excavated for each of three cables (for the initial system), and will be approximately 500 m long, 2 m deep and 2 m wide. A tracked excavator (either on the shore or mounted on a shallow barge) will dig a V-shaped trench, or alternatively, temporary trench support may be installed, usually in the form of steel sheet piling, particularly on the sandy beach. The trenches will be excavated progressively over one to two weeks to account for tidal differences, and cables will take two to three days to pull in, following which the trenches will be backfilled with the excavated material. The volume of sediment movement associated with works at the Shore Crossing Site is predicted to be limited as there is a high portion of sand present and construction will be completed over a relatively short period of time (i.e., two to three weeks).

Excavation of the trenches is likely to increase turbidity or SSC in the marine waters proximate to the Shore Crossing Site as the excavations are inundated each tidal cycle. Sediment may travel along the coastline either side of the construction footprint depending on factors such as currents, tides, and wave and wind action. As indicated by the sediment transport modelling for nearshore components of the cable installation discussed above, sediments are predicted to disperse rapidly (i.e., within days) following completion of the works.

9.4.2.3 Disturbance of potential acid sulfate soils (PASS) impacting marine water quality

Available mapping indicates that PASS could be encountered at the Shore Crossing Site as shown in Figure 9-4. Testing and assessment of PASS will be undertaken for the trench excavation footprints prior to works to determine the presence/absence of PASS material and associated management requirements. Assuming the worst-case and PASS are present in the trench footprints, the risk posed to the marine environment associated with oxidation and acid generation is low. This is because the volumes that will be disturbed and exposed at any given time are limited to the material present in the three trench footprints (each 500 m long x 2 m wide x 2m deep), and the period of exposure is short (i.e., two to three weeks).

If testing identifies ASS, an ASS Management Plan will be developed that stipulates handling methodologies in accordance with applicable standards and guidelines, including *National Acid Sulfate Soils Guidance* (Sullivan et al 2018) and the *Queensland Acid Sulfate Soil Technical Manual* (Dear et al. 2014). These guidelines are proven to be effective for managing PASS risks and adherence to these guidelines is expected to mitigate risks to water quality associated with cable installation where PASS is present.

9.4.2.4 Spills of hazardous substances impacting marine water quality

The construction equipment and vessels utilised at the Land Sea Joint Station, Shore Crossing Site and along the Subsea Cable System will contain fuels and oils that would not be released to the environment under normal operating conditions; however, there is potential for minor spills and leaks to occur.

In the nearshore environment worst-case spill volumes are small as there are no bulk fuel or hazardous chemicals storages, and therefore spills and leaks would be from individual pieces of equipment operating in the construction footprint due to burst hydraulic hoses or minor spills during refuelling. An Environmental Emergency and Spill Response Plan will be in place and equipment provided at the Land Sea Joint Station to respond to small spill events. With these measures in place minor spill incidents are unlikely to cause impacts to marine water quality.

In the offshore environment, it is possible that minor spills of marine fuel oils could occur from the cable laying vessels during installation of the Subsea Cable System. A large spill would only result from a major incident such as a collision or refuelling incident – both of which are very unlikely in modern seafaring. All vessels will comply with the *International Convention for the Prevention of Pollution from Ships* (MARPOL; see IMO 1983), which is proven effective at minimising the likelihood and impact of marine oil spills.

No other HAZMAT or chemicals will be used on ships during construction. Sewage and other potential contaminants such as ballast water will be managed in accordance with MARPOL and the NT *Marine Pollution Act*. The *International Convention on the Control of Harmful Anti-fouling Systems on Ships* (IMO 2008) prohibits the use of harmful biocides and anti-fouling paints on ships. Compliance with these international conventions minimises the risk of contamination or pollution from marine vessel operations.

9.4.3 Operation

During routine operations, there is limited potential for impacts to the marine environment. In the unlikely event of cable damage, then repair would necessitate some disturbance of the seabed and short-term water quality impacts associated with burial of the new cable section. The EIS TOR also required consideration of potential impacts associated with heat generated by the cables during operations.

9.4.3.1 Seabed disturbance from cable repairs

The most common reason for repair of a cable is damage caused by external interaction, typically by trawlers and commercial ship anchors. Such damage is usually localised. When a cable fault is detected, the damaged section will be located and retrieved to the surface for repair – as outlined in Chapter 2 Section 2.11.3.

The seabed disturbance caused by cable repairs is expected to be minimal, as these impacts will be localised to a small section of the Subsea Cable System and should occur infrequently over the life of the proposal. The main impact will be sediment re-suspension and direct disturbance of a small (hundreds of metres) portion of the seafloor. Impacts will be similar to those described in the Section 9.4.2.1; however, these impacts will be significantly lessened as only a small section of cable will be disturbed at any one time. Due to this, potential impacts to water quality from suspended sediment are expected to be spatially isolated and occur over days, after which water quality will return to background levels.

9.4.3.2 Localised temperature increases in the vicinity of the subsea cable

When the cables are in operation they generate thermal radiation, with a maximum operating temperature of 70 °C at the cable surface (Emeana et. al. 2016). There will be localised heating of the environment surrounding the cables (i.e., sediment for buried cable or water in the spaces between rock armouring). The rate of heat dissipation and magnitude of environmental heating will be determined by a number of factors; most notably: the amount of power passing through the cables, the design of the cables and the thermal properties of the surrounding media. Studies have found that heating generally stays within close proximity to the cable, with the area of impact varying depending on sediment type (and associated thermal conductivity). Generally, temperatures return to ambient within 40 cm of the buried cable in silts and clays, while temperatures remain above ambient up to 1 m from the cable in sands (see Emeana et. al. 2016). In most instances, when a cable is buried at a depth of 1 m, the sediment temperature returns to ambient within 20 cm of the surface of the seabed.

As the Subsea Cable System will be buried to a depth of between 0.5 – 1 m, any heating effect at the seabed would be very localised, only occurring in the sediment immediately surrounding the buried cables, with adjacent seawater remaining at background temperatures very close to the seabed surface. This heating could deter certain marine species from recolonising the seabed above the cables or could attract certain species. Further discussion of this aspect is provided in Chapter 10 Marine Ecosystems Section 10.4.3.2 where it is concluded that such localised impacts are unlikely to impact marine habitats or biodiversity.

9.5 Avoidance, mitigation, and monitoring

Sun Cable is committed to applying the environmental decision-making hierarchy. Consistent with Section 26 of the *EP Act*, this involves applying the following approaches in order of priority:

7. Avoid – Ensure that actions are designed to avoid adverse impacts on the environment.
8. Mitigate – Identify management options to mitigate adverse impacts on the environment to the greatest extent practicable.
9. Offset – If appropriate, provide for environmental offsets for residual adverse impacts on the environment that cannot be avoided or mitigated.

The environmental management framework that will be adopted for the construction and operation of the AAPowerLink is detailed in Chapter 17 Environmental Management. The framework comprises a Construction Environmental Management Plan (CEMP) and Operations Environmental Management Plan (OEMP) that sit within an overarching Environmental Management System (EMS).

For each of the impacts to Marine environmental quality discussed in this chapter, Table 9-10 summarises the actions that will be taken to avoid environmental impacts (through site selection and design) and actions proposed to minimise impacts during construction, operation and decommissioning of the proposal. Relevant measures have been referred to in the above discussion of the likelihood and severity of potential impacts associated with each component of the AAPowerLink. The proposed controls are routine for marine developments and industrial operations and, assuming proper implementation and adaptive management, are expected to be effective in ensuring no unacceptable impacts to marine environmental quality. The measures provided in this chapter, along with any additional measures required to address conditions of approvals, permits and licences, will be integrated into the CEMP and OEMP prepared for the AAPowerLink.

Table 9-10. Marine environmental quality - Commitments

Impact	Avoidance	Mitigation	Monitoring	Reporting
Increased turbidity in marine waters caused by cable burial activities	Corridor selection avoids areas of significant marine habitat as much as possible. Cable burial methods will be selected to suit the local seabed conditions.	Nil	Turbidity monitoring in impact zone and baseline/reference site during cable installation in high-risk area (shallow waters <20m depth).	External reporting in accordance with environmental approval conditions
Sediment mobilisation from Shore Crossing Site impacting marine water quality	Construction of the Shore Crossing Site will avoid periods of monsoonal conditions, to minimise erosion risk.	Erosion and sediment controls will be installed and maintained in accordance with a site-specific Erosion and Sediment Control Plans (ESCP) that aligns with the <i>Best Practice Erosion and Sediment Control Guidelines</i> (IECA, 2008). Develop and implement a Reinstatement Plan for post-construction reinstatement of works areas to promote recolonisation of shore and benthic habitats.	During construction and post construction, visual inspections will be undertaken of the works area and surrounding marine waters until all areas are reinstated.	Internal records of inspections.
Disturbance of PASS impacting marine water quality	Sampling and assessment prior to construction to delineate PASS area.	Development and implementation of an Acid Sulfate Soils Management Plan (if required). Management of PASS in accordance with <i>National Acid Sulfate Soils Guidance</i> .	Visual inspections during excavation to assess for PASS in disturbed soils. Sampling and assessment of treated ASS in accordance with <i>National Acid Sulfate Soils Guidance</i> .	Internal records of PASS testing and management actions.

Impact	Avoidance	Mitigation	Monitoring	Reporting
Spills of fuels or hazardous chemicals impacting marine water quality	Besides marine fuel oil, no HAZMAT materials will be used on vessels during construction. Any HAZMAT stored at Land Sea Joint Station will be >300 m from beach and on bunded storages.	Compliance with MARPOL requirements regarding refuelling and spill prevention. Fuels and hazardous chemicals will be stored and handled in accordance with Australian standards and guidelines An Environmental Emergency and Spill Response Plan will be in place and equipment provided at all storage and handling locations. Construction and operations staff will be trained in spill response.	Visual inspections of land-based storages and during refuelling activities for early spill detection. In the event of a significant spill, water quality monitoring.	Internal records of volumes used and stored in accordance with Workplace Health and Safety Regulations. Internal inspection records Internal incident reporting. Incidents of off-site pollution or nuisance reported to the NT EPA within 24 hours.
Seabed disturbance from cable repairs	Minimise disturbance footprint by undertaking targeted repairs as required.	Nil	Nil	Nil
Localised temperature increase in the vicinity of the subsea cable	Use of HVDC cables which emit less heat than other cables (e.g., AC). Cable design (e.g., insulation) minimises heat loss.	Nil	Nil	Nil

Impact	Avoidance	Mitigation	Monitoring	Reporting
Increased turbidity in marine waters caused by cable burial activities	Corridor selection avoids areas of significant marine habitat as much as possible. Cable burial methods will be selected to suit the local seabed conditions.	Nil	Turbidity monitoring in impact zone and baseline/reference site during cable installation in high-risk area (shallow waters <20m depth).	External reporting in accordance with environmental approval conditions
Sediment mobilisation from Shore Crossing Site impacting marine water quality	Construction of the Shore Crossing Site will avoid periods of monsoonal conditions, to minimise erosion risk.	Erosion and sediment controls will be installed and maintained in accordance with a site-specific Erosion and Sediment Control Plans (ESCP) that aligns with the <i>Best Practice Erosion and Sediment Control Guidelines</i> (IECA, 2008). Develop and implement a Reinstatement Plan for post-construction reinstatement of works areas to promote recolonisation of shore and benthic habitats.	During construction and post construction, visual inspections will be undertaken of the works area and surrounding marine waters until all areas are reinstated.	Internal records of inspections.
Disturbance of PASS impacting marine water quality	Sampling and assessment prior to construction to delineate PASS area.	Development and implementation of an Acid Sulfate Soils Management Plan (if required). Management of PASS in accordance with <i>National Acid Sulfate Soils Guidance</i> .	Visual inspections during excavation to assess for PASS in disturbed soils. Sampling and assessment of treated ASS in accordance with <i>National Acid Sulfate Soils Guidance</i> .	Internal records of PASS testing and management actions.

Impact	Avoidance	Mitigation	Monitoring	Reporting
Spills of fuels or hazardous chemicals impacting marine water quality	Besides marine fuel oil, no HAZMAT materials will be used on vessels during construction. Any HAZMAT stored at Land Sea Joint Station will be >300 m from beach and on bunded storages.	Compliance with MARPOL requirements regarding refuelling and spill prevention. Fuels and hazardous chemicals will be stored and handled in accordance with Australian standards and guidelines An Environmental Emergency and Spill Response Plan will be in place and equipment provided at all storage and handling locations. Construction and operations staff will be trained in spill response.	Visual inspections of land-based storages and during refuelling activities for early spill detection. In the event of a significant spill, water quality monitoring.	Internal records of volumes used and stored in accordance with Workplace Health and Safety Regulations. Internal inspection records Internal incident reporting. Incidents of off-site pollution or nuisance reported to the NT EPA within 24 hours.
Seabed disturbance from cable repairs	Minimise disturbance footprint by undertaking targeted repairs as required.	Nil	Nil	Nil
Localised temperature increase in the vicinity of the subsea cable	Use of HVDC cables which emit less heat than other cables (e.g., AC). Cable design (e.g., insulation) minimises heat loss.	Nil	Nil	Nil

9.6 Residual Impact

As stated at the start of this chapter, the NT EPA's objective for the Marine environmental quality factor is to:

'Protect the quality and productivity of water, sediment and biota so that environmental values are maintained'.

The residual impact of the AAPowerLink is summarised below, assuming the adoption of impact avoidance, mitigation and monitoring measures described in this chapter.

Each impact to marine environmental quality was assigned a residual impact rating taking into consideration the scale, magnitude and duration of the impacts, the presence/absence of environmental values and/or sensitive receptors and the level of certainty with respect to the intensity of the impact and the effectiveness of the mitigation measures. The residual impact ratings adopted in the assessment were provided earlier in Table 9-6. The combined residual impact to marine environmental quality from AAPowerLink construction and operations of the Subsea Cable System, and Cable Transition Facilities, is summarised in Table 9-11.

Table 9-11. Residual impact ratings for impacts to Marine environmental quality

Impacts	Residual Impact Rating
Construction	
Increased turbidity in marine waters caused by cable laying activities	Moderate
Sediment mobilisation from Shore Crossing Site impacting water quality	Minor
Disturbance of PASS at Shore Crossing Site impacting water quality	Minor
Spills of hazardous substances impacting water quality	Minor
Operations	
Increased turbidity in marine waters caused by cable repair activities	Minor
Localised temperature increase around operating cables	Minor

The results of the EIA undertaken for the Marine environmental quality factor indicate that the proposal is likely to have a Minor to Moderate residual impact to marine water quality. The Moderate residual impact rating applies only to the water quality impacts that are predicted to occur in the nearshore areas of Shoal Bay when sediments are mobilised during the cable burial activities. This impact may be measurable during and immediately post cable burial (i.e., a period of approximately one month) after which turbidity is modelled to return to pre-construction background levels. Impacts to water quality in the offshore region are modelled to be negligible and assigned a Minor residual impact rating, meaning it is unlikely there will be any measurable impact to water quality in the Oceanic Shoals Marine Park.

It is important to note that the short-term impact to water quality associated with increased turbidity, is not predicted to adversely affect any marine habitats or biota. The Shoal Bay area does experience natural periods of elevated sediment and turbidity, and supported environmental values are adapted to short-term elevated sediment and changes to water quality and therefore are expected to be resilient to short-term water quality impacts associated with the AAPowerLink cable burial activities. The precautionary principle has been applied in assigning a Moderate residual impact rating due to the risk of unseasonably high turbidity when construction occurs in the dry season, when benthic communities are likely to be recovering from turbidity and sediment impacts which naturally occur in the wet season (see Chapter 10). These impacts are discussed in Chapter 10 Terrestrial Ecosystems.

For all other impacts to marine water quality assessed in this chapter, the residual impact is assessed as Minor. Construction in the intertidal zone may result in localised and short-term impacts to water quality due to sediment runoff, disturbance of PASS and/or minor spills, but impacts will be spatially limited and short-term, as the Shore Crossing Site footprint, which will be reinstated following construction. The mitigation measures proposed for these impacts (refer Section 9.5) are based on accepted standards and guidelines that are proven effective for mitigation of risks to water quality from these aspects.

For all operational activities, the residual impact is assessed as Minor. During operations, works will only be undertaken if repairs are required due to damage, and any impacts to water quality or the seabed would be spatially limited and short-term. Heating from cable operations may occur but would only impact sediment in the direct vicinity of the cables.

9.7 Cumulative impacts

The framework to assess cumulative impacts from the AAPowerLink and other existing and future developments is described in Chapter 3 – Impact Assessment. The process involves considering the cumulative or combined impacts to marine environmental quality associated with the residual impacts from the AAPowerLink, residual impacts from existing activities, and impacts associated with reasonably foreseeable developments described in Chapter 3.

The EIA undertaken for the Marine environmental quality factor did not predict any long-term residual impacts to marine waters from the AAPowerLink activities and therefore there is limited potential for cumulative impacts to occur. The background water quality in the inshore and offshore parts of the Subsea Cable System corridor is near pristine. There are some reasonably foreseeable future activities in Darwin Harbour that could cause cumulative impacts to the marine environment. Through the EIA process, the following areas of potential cumulative impacts were identified:

- Water quality impacts from the AAPowerLink are associated with the construction phase of the proposal, with impacts associated with elevated turbidity predicted to occur in shallow waters (<20 m deep) for approximately one month. The proposed Subsea Cable System corridors pass ~1.5 km north (Option A) and ~1 km south (Option B) of the INPEX maintenance dredge spoil disposal area. Cumulative impacts could occur if INPEX dredging and dredge spoil disposal occurred at the same time as the AAPowerLink Subsea Cable laying and trenching was undertaken; however, this is unlikely.
- Combined development of the AAPowerLink and proposed Sea Dragon Hatchery will disturb the shoreline and intertidal areas along a short section of Gunn Point Beach. There is potential for cumulative impacts to water quality to occur from the combined effects of discharges to the marine environment from the hatchery facilities and mobilisation of sediments associated with the AAPowerLink construction activities. It is not known if the hatchery will be in operation before the AAPowerLink is constructed; however, if it is the cumulative impacts would be limited to the period of cable burial activities (i.e., approximately one month).
- Santos proposes to duplicate the existing Bayu-Undan pipeline (i.e., construct another pipeline) as part of the Darwin Pipeline Duplication (DPD) Project. The pipeline corridor will commence in Darwin Harbour, with approximately 100 km in NT coastal waters, and 23 km in Commonwealth waters. The AAPowerLink Subsea Cable System corridor crosses the DPD corridor, and if the construction activities were to coincide there could be cumulative impacts to marine water quality. As the AAPowerLink is assessed as having a Minor residual impact to water quality that lasts for a short period (i.e., approximately one month), the potential for cumulative impacts is considered low.

Sun Cable will liaise with relevant proponents/operators, and authorities, regarding timing and location of works to minimise the risk of cumulative impacts on the environment. Sun Cable has already engaged with Sea Farms and will continue to liaise with them in relation to construction scheduling and potential conflicts.

9.8 Offsets

The EIA did not identify any significant residual impacts to marine environmental quality that require offsets.

9.9 References

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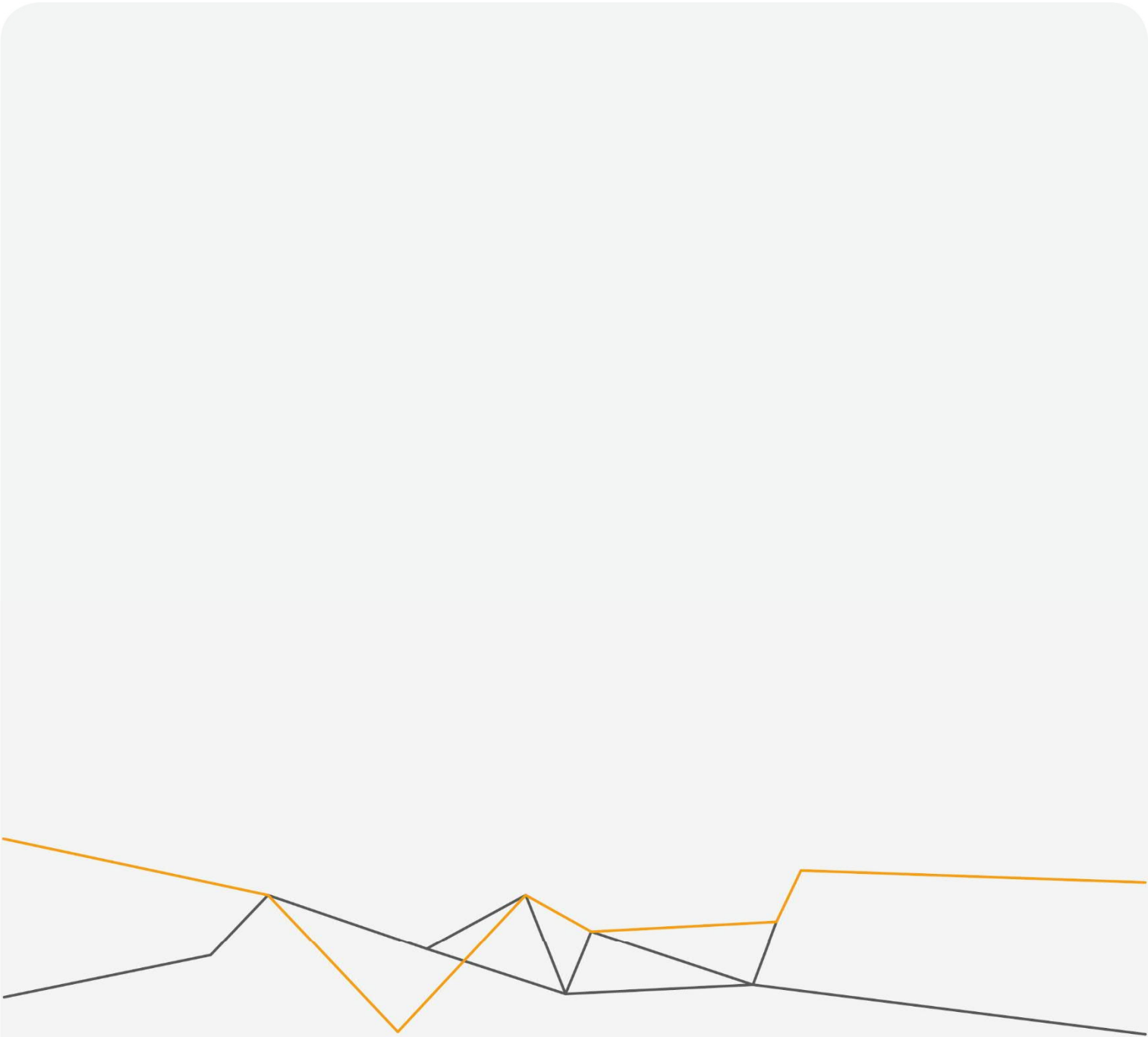
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