BAS-210 0023

Santos

Darwin Pipeline Duplication (DPD) Project – Trenching and Spoil Disposal Management and Monitoring Plan (TSDMMP)

PROJECT / FACILITY	Barossa DPD Project
REVIEW INTERVAL (MONTHS)	No Review Required
SAFETY CRITICAL DOCUMENT	NO

Rev	Owner	Reviewer/s Managerial / Technical / Site	Approver
	Project Environmental Lead	Project HSE Manager	Project Director

Rev	Rev Date	Author / Editor	Amendment
A	2/09/2022	Sam Billingshurst / Kat Thorne (RPS)	Issued for review
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C	23/01/2023	Sam Billinghurst / Kat Thorne (RPS)	Issued for review
D	10/03/2023	Sam Billinghurst / Kat Thorne (RPS)	Issued for review

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Abbreviations and acronyms

Abbreviation/acronym	Definition
AAPA	Aboriginal Areas Protection Authority
ABWM	Australian Ballast Water Management
AFANT	Amateur Fishing Association for the Northern Territory
AFZ	Australian Fishing Zone
AIMS	Australian Institute of Marine Science
ALARP	As low as reasonably practicable
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines
ASS	Acid sulphate soils
ASSDMP	Acid Sulphate Soils and Dewatering Management Plan
ARMCANZ	Australian and Resource Management Council of Australia and New Zealand
AWR	Air Weapons Range
BHD	Backhoe dredge
BIA	Biologically Important Area
BOM	Bureau of Meteorology
BTEXN	Benzene, toluene, ethylbenzene, xylenes and naphthalene
CAMBA	China-Australia Migratory Bird Agreements
CCS	Carbon Capture Storage
CEMP	Construction Environmental Management Plan
CHI	Channel Island
CHP	Charles Point
CMID	Common Marine Inspection Document
CMT	Crisis Management Team
CPRFPA	Charles Point Reef Fish Protection Area
CPW	Charles Point Wide
CSD	Cutter suction dredge

Abbreviation/acronym	Definition
CSS	Cargo Stowage and Securing
CTD	Conductivity, temperature, and dissolved oxygen
DAWE	Department of Agriculture, Water and the Environment
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DEME	Dredging, Environmental and Marine Engineering
DEPWS	Northern Territory Department of Environment, Parks and Water Security
DGV	Default guideline value
DHAC	Darwin Harbour Advisory Committee
DIPL	Department of Infrastructure, Planning and Logistics
DITT	Northern Territory Department of Industry, Tourism and Trade
DLNG	Darwin Liquefied Natural Gas
DLRM	Department of Land Resource Management
DP	Dynamic positioning
DPD	Darwin Pipeline Duplication
DPIR	Department of Primary Industry and Resources
DPIRD	Department of Primary Industry and Regional Development
DSDMP	Dredging and Spoil Disposal Management Plan
EAAS	Environmental Assurance Activities Schedule
ECAP	Environmental Compliance Assurance Plan
ECNT	Environment Centre NT
EHS	Environment, Health, and Safety
EIS	Environmental Impact Statement
EMS	Environmental Management Strategy
ENVID	Environmental Impact Identification
EPA	Environmental Protection Agency
EP Act	Environmental Protection Act 2019
EPBC	Environment Protection and Biodiversity Conservation Act 1999
EPO	Environmental performance objective
EPS	Environmental performance standards
FCGT	Flood, clean, gauge and testing

Abbreviation/acronym	Definition
GEP	Gas export pipeline
GHG	Greenhouse gas
GIS	Geographic Information System
GOMO	Guide for Offshore Marine Operations
HAB	Habitat
HAT	Highest astronomical tide
HFO	Heavy Fuel Oil
HSE	Health, safety and environment
HSEQ	Health, safety, environment and quality
HSEQ-MS	Health, safety, environment and quality management system
IACS	International Association of Classification Societies
ILT	Inline tee
ITF	Indonesian Through Flow
IMS	Introduced marine species
KP	Kilometre point
LAT	Lowest astronomical tide
LTS	Listed threatened species
LoR	Limits of Reporting
MA	Management actions
MDO	Marine diesel oil
MGO	Marine gas oil
MMNMP	Marine Megafauna Noise Management Plan
MoC	Management of changes
NTU	Nephelometric turbidity units
NT	Northern Territory
Offshore CEMP	Offshore Construction Environment Management Plan
Onshore CEMP	Onshore Construction Environmental Management Plan
PAH	Polynuclear aromatic hydrocarbons
PAR	Photosynthetically active radiation
PASS	Potential acid sulphate soils
PLET	Pipeline end termination

Abbreviation/acronym	Definition
PLRS	Pig launcher/receiver
PPT	Parts per thousand
PSV	Platform supply vessel
PTS	Permanent threshold shift
Q1, Q2, Q3 and Q4	Quarter 1, 2, 3 and 4
TBT	Tributyltin
TSDA	Trench spoil disposal area
TSHD	Trailing suction hopper dredge
TSDMMP	Trenching and Spoil Disposal Management and Monitoring Plan
TPH	Total petroleum hydrocarbons
TRH	Total recoverable hydrocarbons
TTS	Temporary threshold shift
SER	Supplementary Environmental Report
SHB	Split hopper barge
SSC	Suspended sediment concentration
UXO	Unexploded ordnance

Glossary

Term	Definition
Biologically important area	Areas spatially defined and mapped by the Commonwealth Department of Environment (DoE) where aggregations of individuals of a species are known to display a biologically important behaviour such as breeding, foraging, resting or migration.
Consequence	Impact of an even or incident e.g., a loss, injury or concern. May be expressed qualitatively or quantitatively.
Environmental Performance Standard	A statement of performance required of a management action.
Environmental Performance Objective	Measurable level of performance required for the management of environmental aspects of an activity to ensure that environmental impacts and risks are of an acceptable level.
Impact	A positive or negative effect the DPD Project would have on the environment (including physical, ecological and socio-economic environments).
Measurement Criteria	A system of measurements that define whether a project is successful.

Term	Definition
Non-Indigenous	Refers to heritage artefacts or sites that are not deemed "sacred sites" per the Northern Territory Aboriginal Sacred Sites Act or deemed Aboriginal archaeological sites or artefacts per the *Heritage Act 2011* (NT).
Performance Criteria	he standards by which success of management actions is evaluated.
Project Area	Project Area is an area extending 500 m either side of the Pipeline, within which the Construction Activity will take place.
Residual risk	Risk remaining after implementation of mitigation measures
Risk	A combination of the potential consequence of an event occurring and the likelihood of the consequence occurring.
Sensitive receptor	A receptor that could be subject to adverse impacts from the DPD Project
Shore pull onshore termination point	The point (KP 122.484, approximately 2 m above highest astronomical tide) to which the pipeline will be pulled ashore to by the shore-pull activity
Target	Specific and measurable performance requirements to achieve Environmental Performance Objectives.

Units of measurement

Unit	Definition
°	degrees
µS	micro Siemens
MA	centimetre
dB	decibels
dB(A)	A-weighted sound pressure level in decibels
kHz	kilohertz
km	kilometre
km2	square kilometre
m	metre
m2	square metre
mg/L	milligrams per litre
nm	nautical mile (1.856 km)

1 Introduction

1.1 Project overview

Santos NA Darwin Pipeline Pty Ltd is the operator of the existing Bayu-Undan to Darwin Gas Export Pipeline (GEP) in the Timor Sea. The Bayu-Undan to Darwin GEP is a dry natural gas export pipeline transporting gas from the Bayu-Undan Field located in Timor-Leste waters to the Darwin liquefied natural gas (DLNG) Facility at Wickham Point peninsula near Darwin, Northern Territory (NT), Australia. The Bayu-Undan to Darwin GEP has been operational since 2005. In anticipation of the end of the Bayu-Undan Field's commercial production in 2022 – 2023, the Barossa Field is being developed to supply gas to the DLNG facility. The original approved base case for the supply of backfill gas to DLNG included the installation of a new 262 kilometres (km) Barossa GEP to a tie-in point on the existing Bayu-Undan to Darwin GEP.

In recognition of potential Carbon Capture and Storage opportunities at the Bayu-Undan Field, Santos NA Barossa Pty Ltd (Santos) has approved an alternative solution to transport backfill gas to the DLNG facility through the construction of an additional segment of pipeline to extend the Barossa GEP to the DLNG facility, instead of tying into the Bayu-Undan to Darwin GEP. Construction of this segment of pipeline is referred to as the Darwin Pipeline Duplication (DPD) Project, as it will be installed parallel to the existing Bayu-Undan to Darwin GEP. The effective 'duplication' of the existing Bayu-Undan to Darwin GEP is considered the optimal route to minimise potential environmental and social impacts.

The pipeline will run from the point where the Barossa GEP reaches the existing Bayu-Undan pipeline and continue through Darwin Harbour to the beach valve location at the DLNG facility at Wickham Point (**Figure 1-1**). Santos' DPD Project includes a ~23 km segment in Commonwealth waters and ~100 km segment in NT waters and lands adjacent to the existing Bayu-Undan to Darwin pipeline route. This Trenching and Spoil Disposal Monitoring and Management Plan (TSDMMP) will only cover activities in NT waters. The DPD Project pipeline will be located for the most part ~100 m from the existing Bayu-Undan to Darwin pipeline, to minimise potential environmental and social impacts. The Project Area for the DPD Project includes a 2 km buffer around the pipeline route in NT waters, the onshore construction area at the DLNG facility and an offshore spoil disposal ground for the trench spoil disposal (**Figure 1-1**).

Pre-lay trenching is required to meet a number of objectives, including providing pipeline protection and stability (in combination with rock installation), reducing pipeline spanning and ensuring compliance with shipping channel clear water requirements. Sections of the pipeline route within the harbour, with a combined length of up to ~16.5 km, will be trenched using various equipment with the remainder of the pipeline laid directly on the seabed. Rock sourced from a local quarry will be used to backfill in some areas where anchor protection or additional stabilisation is required.

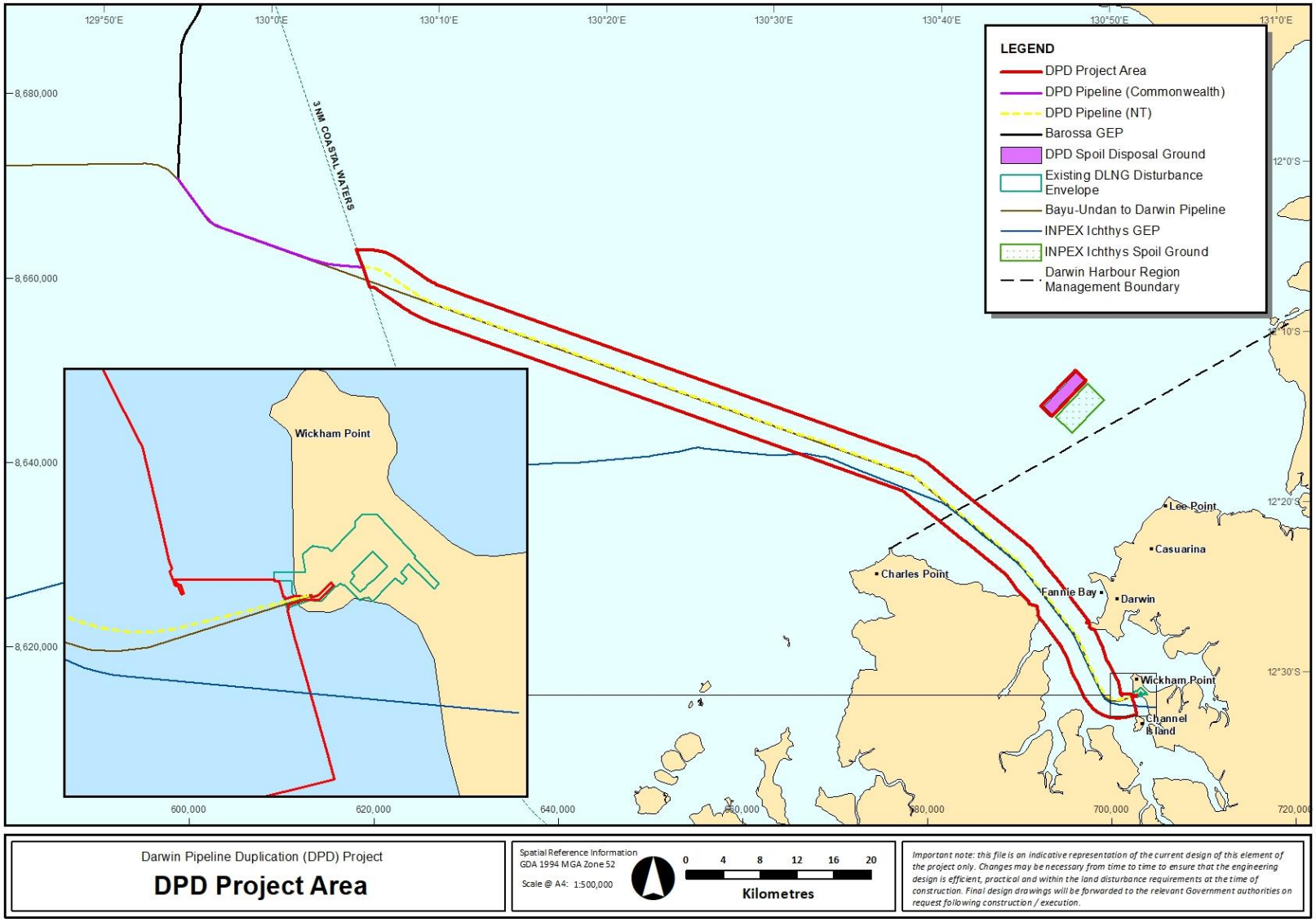


Figure 1-1: DPD Project Location

1.2 Purpose

This TSDMMP outlines the environmental impacts and risks arising from the trenching and spoil disposal activities associated with the DPD Project, within Darwin Harbour and offshore within NT waters and details how these impacts and risks will be monitored and managed.

The purpose of this TSDMMP is to:

+ Demonstrate that all measures deemed reasonable and practicable will be implemented to manage risks associated with, and potential environmental impacts arising from, the proposed trenching and spoil disposal activities
+ Prior to finalisation, demonstrate how the requirements of relevant conditions of approvals under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the NT *Environment Protection Act 2019* (EP Act) will be met.
+ Satisfy the Northern Territory Environmental Protection Authority (NT EPA) requirement for a TSDMMP for subsea trenching activities that includes:
  - baseline (pre-construction) condition of habitats within the zone of influence of the proposal and relevant parameters to be monitored to detect impacts
  - trigger levels for relevant parameters (and description of their derivation) corresponding to actions that must be taken should monitoring indicate trenching activities are likely to impact sensitive receptors
  - management actions to be applied if triggers are exceeded in accordance with the environmental decision-making hierarchy.
  - a communications strategy for engaging with government and other proponents undertaking or proposing dredging in the harbour;
  - a monitoring program for the assessment of cumulative impacts from concurrent or consecutive dredging programs not related to the proposal; and
  - a proposed approach to managing dredging in coordination with other proponents/dredging projects to avoid significant cumulative impacts to Darwin Harbour from dredging activities.

Note, as final decision is yet to be made as to the exact trenching methodology, the monitoring programme presented herein should be considered as a draft at this stage and may be adapted to reflect the final trenching methodology selected.

1.3 Scope

This TSDMMP has been prepared to allow for a maximum volume of 750,000 m^3 to be trenched within a 15-month construction period. This includes over-trenching and contingency trenching, therefore the actual volume to be trenched based on trench designs is expected to be much less at ~325,000 m^3.

This TSDMMP addresses trenching activities that will be undertaken within the proposed trench and pre-sweep areas between the pipeline shore pull onshore termination point to the Commonwealth/NT waters boundary and the disposal of trenched material at the proposed spoil disposal ground within NT waters.

This TSDMMP forms part of a suite of environmental management plans under an overarching Santos DPD Project Offshore Construction Environmental Management Plan (Offshore CEMP; BAS-210 0024)

which covers all construction activities from the Commonwealth/NT waters boundary to the shore pull onshore termination point. The construction of the remaining section of pipeline between the onshore termination point and the upstream weld of the beach valve will be subject to the DPD Project Onshore CEMP (BAS-210 0025; Onshore CEMP) (**Figure 1-2**).

In addition to this TSDMMP, there are two further EMPs under the Offshore CEMP that address specific activities during construction (**Figure 1-2**). These are the:

+ Acid Sulphate Soil and Dewatering Management Plan (ASSDMP) (BAS-210 0049) that addresses all activities associated with acid sulphate soils (ASS) from lowest astronomical tide (LAT) to the upstream weld of the beach valve
+ Marine Megafauna Noise Management Plan (MMNMP) (BAS-210 0022) that addresses all activities associated with noise impacts to marine megafauna from the Commonwealth/NT waters boundary to the onshore termination point.

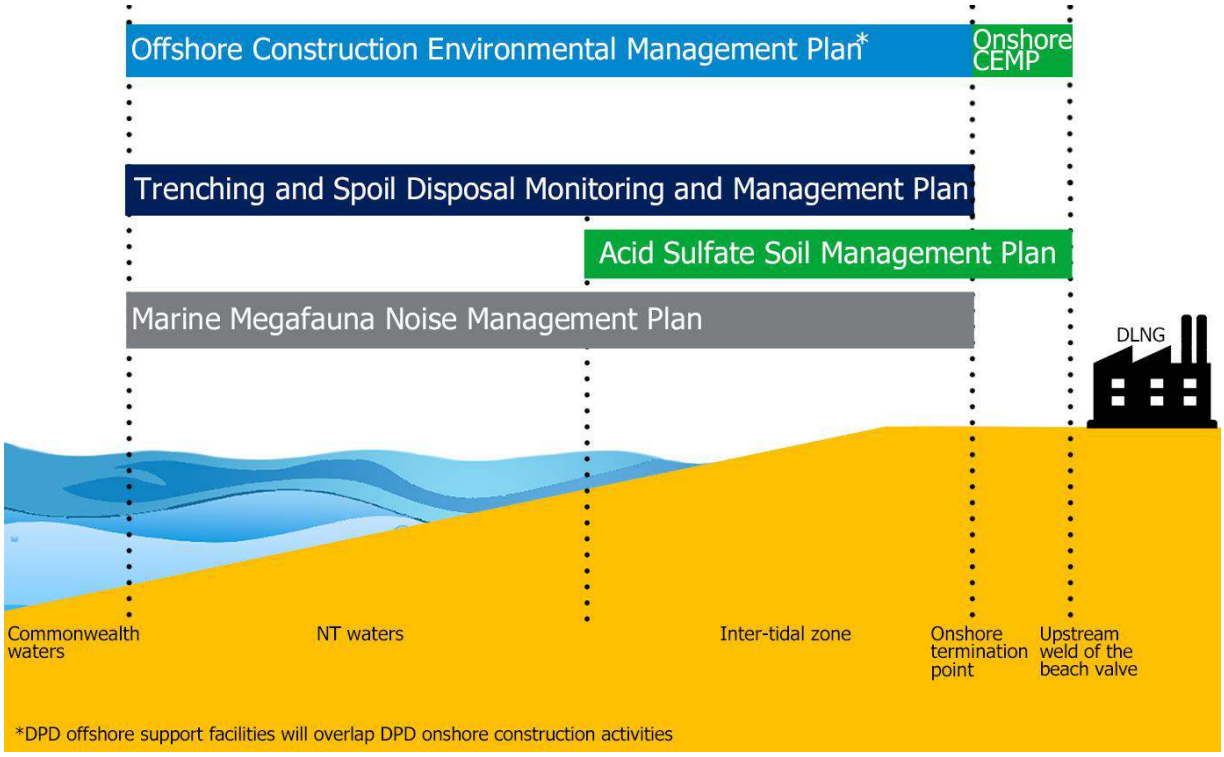


Figure 1-2: Conceptual model of management plan geographical scopes

1.4 Plan structure

This TSDMMP has been prepared and structured in accordance with the NT EPA:Draft Guideline for the Preparation of an Environmental Management Plan (NT EPA, 2015) and the NT EPA: Draft Guidelines for the Environmental Assessment of Marine Dredging in the Northern Territory (NT EPA, 2013) as indicated in **Table 1-1**.

Table 1-1: Trenching and Spoil Disposal Monitoring and Management Plan structure

Regulatory requirement		Relevant TSDMMP Section
NT EPA: Draft Guideline for the Preparation of an Environmental Management Plan 2015	**NT EPA: Draft Guideline for the Environmental Assessment of Marine Dredging in the Northern Territory**	
Project Overview Proponent details Key contacts	-	**Section 1**: Introduction
Clear and comprehensive project description	-	**Section 2**: Detailed Activity Description
Legal and other obligations	Legislation	**Section 3**: Legal and Other Obligations
Environmental management framework		**Section 4:** Environmental Management Framework
Existing environment	Describing benthic habitats Background environmental data Critical windows of environmental sensitivity	**Section 5**: Existing Environment
Conceptual Site Model Environmental risk assessment	Environmental Impact Assessment	**Section 6:** Sediment Dispersion Modelling and Water Quality /Benthic Habitat Impact Predictions **Section 7**: Risk Assessment The requirement for a conceptual site model is addressed within the risk assessment.
Environmental Management Strategies	Environmental Management Plan Risk-based environmental management framework	**Section 8**: Environmental Management Strategies
Monitoring	Environmental Management Plan Risk-based environmental monitoring	**Section 9**: Environmental Monitoring

Regulatory requirement		Relevant TSDMMP Section
NT EPA: Draft Guideline for the Preparation of an Environmental Management Plan 2015	**NT EPA: Draft Guideline for the Environmental Assessment of Marine Dredging in the Northern Territory**	
Corrective actions and contingencies Auditing Reporting and Review Training and awareness	-	**Section 10**: Implementation Strategy
Communication	Public notification and engagement	**Section 11:** Stakeholder Engagement and Communications

1.5 Proponent

1.5.1 Details of the proponent

Santos, as the operator of the Barossa Joint Venture, has applied to the NT Department of Industry Tourism and Trade (DITT) for two pipeline licences for the DPD pipeline (NT):

+ Coastal and Territorial Waters Licence for the section of the pipeline under the jurisdiction of the *Petroleum (Submerged Lands) Act 1981* (NT) (i.e., between the NT Coastal Waters Limit and the Territorial Sea Baseline)
+ Inland Waters Licence for the section of Pipeline under the jurisdiction of the *Energy Pipelines Act 1981* (NT) (i.e., between the Territorial Sea Baseline and the onshore beach valve).

Both licences are applicable to the section of pipeline within the scope of the Barossa CEMP although the trenching activities covered under this TSDMMP will only be required for the section of pipeline covered by the licence under the *Energy Pipelines Act 1981*. The proposed proponent details are provided in **Table 1-2**, with the nominated operator shown in bold.

Table 1-2: Proponent details for Barossa DPD Project's Pipeline licences

Title	Proponent (nominated operator in bold)	ABN	Interest	Titles
+ Coastal and Territorial Waters Licence	Santos NA Barossa Pty Ltd	44 109 974 932	25.0%	Business Address: Level 7, 100 St Georges Terrace, Perth, Western Australia, 6000 Telephone number: (08) 6218 7100 Fax number: (08) 6218 7200
	Santos Offshore Pty Ltd	38 005 475 589	25.0%	

Title	Proponent (nominated operator in bold)	ABN	Interest	Titles
+ Inland Waters Licence				Email address: barossa.regulatory@santos.com
	SK E&S Australia Pty Ltd	55 158 702 071	37.5%	Business Address: Level 6, 60 Martin Place, Sydney NSW 2000, Australia Telephone number: (02) 21213304 Fax number: None Email address: hyunjoon-kim@sk.com
	JERA Barossa Pty Ltd	18 654 004 387	12.5%	Business Address: Level 9 Brookfield Place, 125 St Georges Tce, PERTH, WA, 6000

1.5.2 Details of nominated liaison person

Name: Dr Lachlan MacArthur

Title: Environmental Approvals Adviser

Business address: Level 7, 100 St Georges Terrace, Perth, WA 6000

Telephone number: (08) 6218 7100

Email: Barossa.regulatory@santos.com

1.5.3 Notification procedure in the event of changed details

If there is a change in the nominated operator, or a change in the contact details for the operator or liaison person, Santos will notify the NT DITT and provide the updated details.

1.6 Plan availability, review, and revision

Santos is responsible for submitting this TSDMMP alongside its Supplementary Environmental Report (SER) for the DPD Project to the NT EPA and DITT for comment and final approval. This plan will also be provided to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) in support of Santos' Preliminary Documentation (EPBC 2022-9372) submission for assessment under the EPBC Act. Santos will review and update the document as required based on regulatory feedback and any regulatory conditions on DPD Project approval as applicable. The final TSDMMP will be made publicly available on an Australian website.

2 Trenching and Spoil Disposal Methodology

The following sections provide an overview of the proposed trenching and spoil disposal activity, including work sites and methods.

2.1 Overview

This TSDMMP has been prepared to allow for a maximum of 750,000 m^3 of material to be trenched. This maximum volume is considered a worst-case scenario that incorporates over-trenching and contingency trenching and a volume of ~325,000 m^3 of material is expected to be dredged. This figure includes volume for pre-sweep areas and for maintenance trenching. The trenching campaign is expected to commence in Q1 2024 and is expected to continue for 2 – 3 months, with any contingency trenching taking place at a later date for a period of ~2 weeks. The potential for natural events such as cyclones, tropical storms and flooding to cause deposits of large amounts of sediment within the Project Area means maintenance or contingency trenching may be required to ensure the trench is in specification for the pipelay.

2.2 Project area

2.2.1 Trenching areas

The trenching areas are located along the DPD Project pipeline route, parallel to, and approximately 50 – 100 m from, the existing Bayu-Undan to Darwin pipeline. Trench design width is expected to occur within a 50 m disturbance corridor along the DPD Project pipeline route. Trenching will only occur in NT waters. Trenching will occur along pipeline route sections between a point approximately 34 km offshore (KP 92.2) to the shore pull onshore termination point (KP 122.5). Specific locations of proposed trenching along the project pipeline route are shown in **Figure 2-1**.

2.2.2 Spoil disposal ground

The spoil disposal ground is located north of the Darwin Harbour Region Management Boundary, within Beagle Gulf, adjacent to the spoil ground used by INPEX for the Ichthys Gas Field Development Project (**Section 2.2.2**). Water depths at the site are between 15 m and 20 m below lowest astronomical tide (LAT). The site was selected with consideration of technical, environmental, cost and safety aspects. The site is 6.25 km^2 and is to be filled progressively so that the full volume of dredged material can be accommodated. The site is located within NT waters.

Material excavated via land-based plant (refer to **Section 2.4**) will be placed as close to LAT as possible adjacent to the trench to be subsequently removed by a dredge vessel and disposed to the offshore spoil disposal ground.

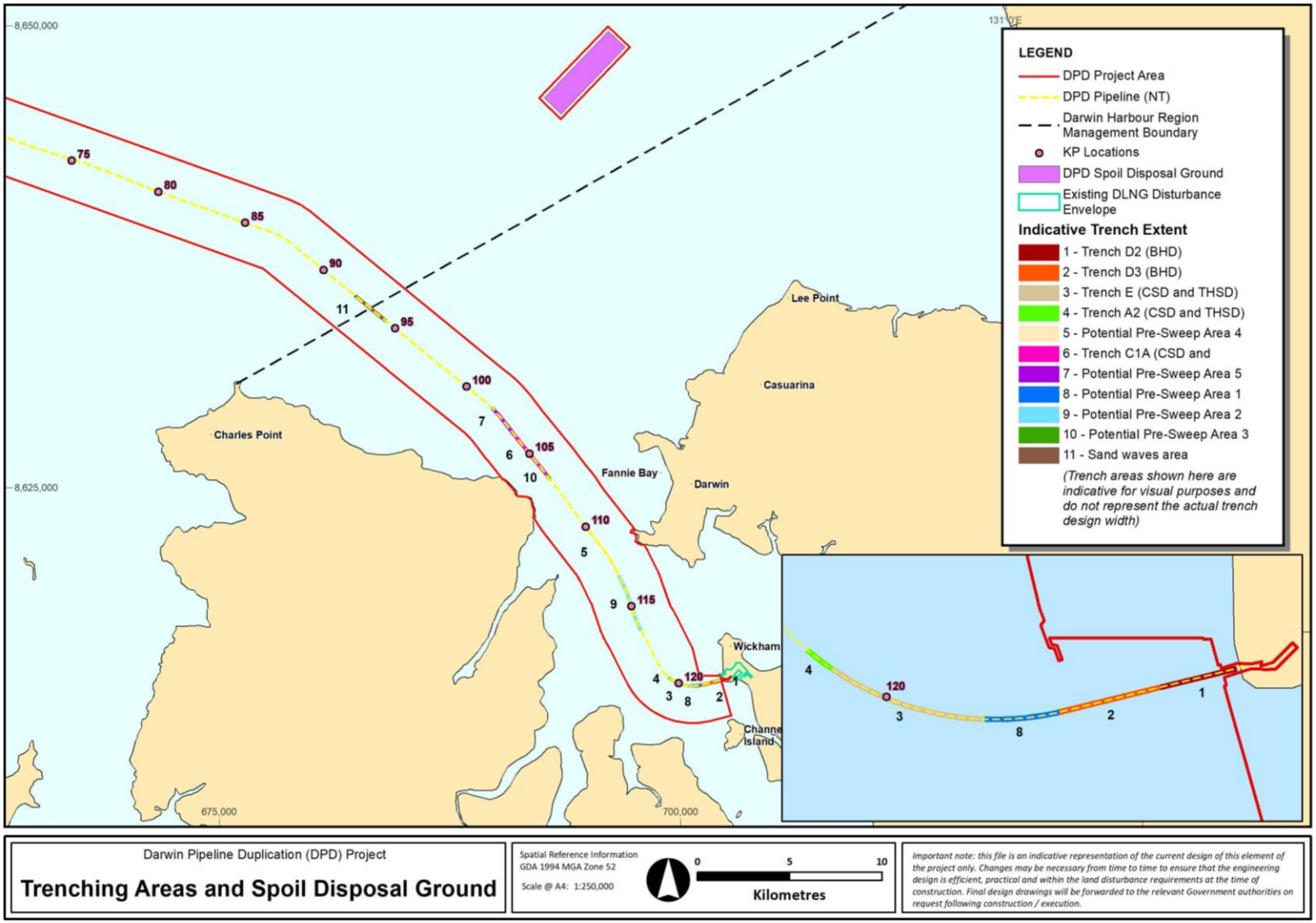
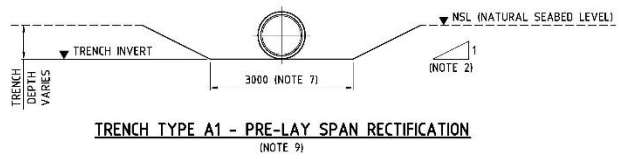


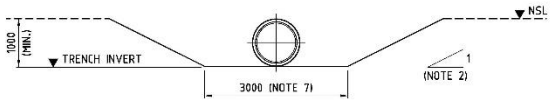
Figure 2-1: Proposed trenching and spoil disposal locations

2.3 Trench designs

Trench design, including trench depth and presence/type of rockfill will vary between trenching locations depending on the specific trench objectives. Indicative trench designs are shown in **Figure 2-2**, with corresponding locations shown in **Figure 2-8,** however specifications of trench design may alter slightly as they are finalised.



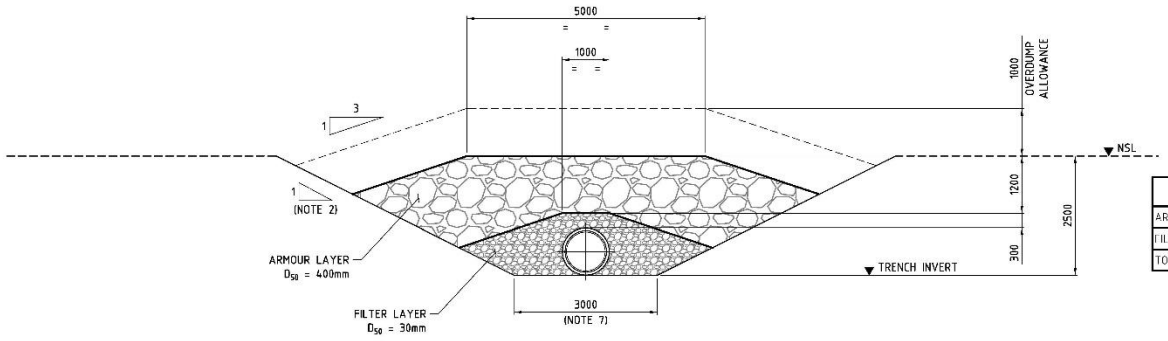
TRENCH TYPE A1 - PRE-LAY SPAN RECTIFICATION
(NOTE 9)



TRENCH TYPE A2 - CLEARWATER
(NOTE 8)

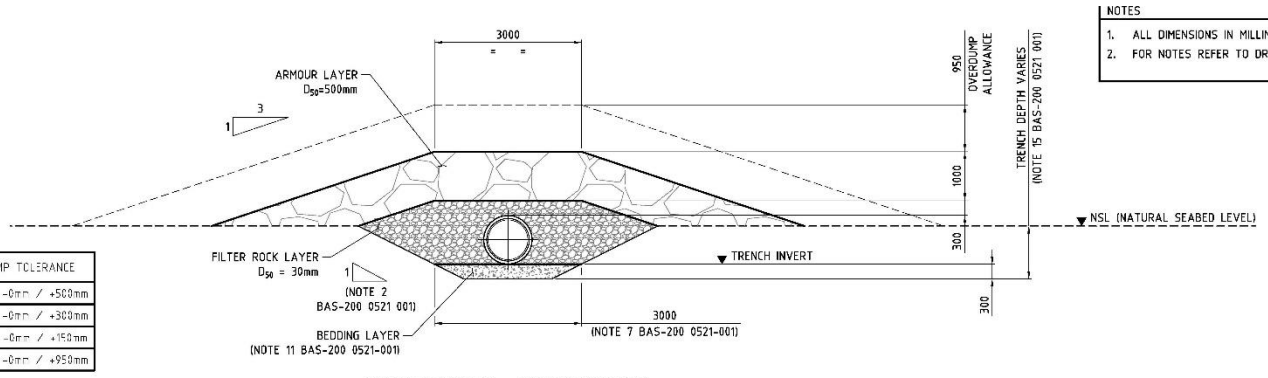
NOTES

1. ALL DIMENSIONS IN MILLIMETRES (mm) U.N.O.
2. TRENCH SLOPE TO BE ADEQUATE FOR SITE SPECIFIC SOIL AND ENVIRONMENTAL CONDITIONS TO PREVENT SLUMP.
3. TRENCH EXCAVATION WORKS SHALL BE PERFORMED IN COMPLIANCE WITH SPECIFICATION FOR PRE-TRENCHING DOCUMENT BAS-200 0552.
4. ROCK DUMP SHALL BE PERFORMED IN COMPLIANCE WITH SPECIFICATION FOR ROCK DUMPING DOCUMENT NUMBER BAS-200 0551.
5. ROCK GRADING SHALL COMPLY WITH SPECIFICATION FOR ROCK SUPPLY DOCUMENT NUMBER BAS-200 0550.
6. REFER TO DRAWINGS BAS-200 0523 001 TO BAS-200 0523 012 NEARSHORE PIPELINE TRENCH & TRENCH BACKFILL ALIGNMENT DETAILS FOR TRENCH INVERTS.
7. DIMENSIONS FOR TRENCH DEPTH, TRENCH WIDTH, ROCK BERM DEPTH OF COVER ABOVE PIPELINE AND ROCK BERM CREST WIDTH ARE MINIMUM TO MEET DESIGN REQUIREMENTS. CONTRACTOR MAY PROPOSE ALTERNATIVE DIMENSIONS FOR COMPANY APPROVAL WHEREVER INSTALLATION/CONSTRUCTION REQUIREMENTS DICTATE.
8. FOR TRENCH TYPE A2, TRENCHING IS ONLY REQUIRED IN AREAS WHERE THE PIPELINE BREACHES THE CLEARWATER REQUIREMENT. SEE TRENCH AND TRENCH BACKFILL ALIGNMENT SHEETS FOR MORE DETAIL.
9. LOCALISED PRE-TRENCHING MAY BE REQUIRED FOR FREE SPAN RECTIFICATION ALONG OTHER SECTIONS OF THE PIPELINE ROUTE WITHIN DARWIN HARBOUR.
10. REFER TO DRAWING BAS-200 0651 001 FOR CONTINGENCY TRENCH TYPE C3A DETAILS. TRENCH TYPE C3A MAY BE USED IN PLACE OF TRENCH TYPE C1A, SUBJECT TO COMPANY APPROVAL, IN AREAS WHERE TRENCH DEPTH CANNOT BE ACHIEVED.
11. BEDDING LAYER WILL BE REQUIRED IN TRENCH PROFILES WHERE THE PIPELINE WIL BE PULLED ON-BOTTOM.
12. PIPE OVERALL OD DRAWN AS 1.0m. THIS IS CONSIDERING A 50mm CONCRETE COATING.
13. FOR TRENCH TYPE E, MINIMUM CLEARANCE BETWEEN TOP OF BERM AND NSL IS 2200mm.
14. FOR TRENCH TYPE E, TRENCH DEPTH WILL INCREASE TO ENSURE 16m LAT CLEARWATER REQUIREMENT IS MET. NOMINAL BOTTOM OF TRENCH ELEVATION SHALL BE THE LOWER OF (LAT - 16m - 3.5m) OR (NSL - 3.5m).
15. THE TRENCH DEPTH FOR TRENCH TYPE D1 WILL VARY DEPENDING ON THE SEABED AND TERRAIN ELEVATION ALONG THE PIPELINE ROUTE. REFER TO DRAWING BAS-200 0527 001 FOR TRENCH INVERT.



VERTICAL ROCK DUMP TOLERANCE	
ARMOUR LAYER	-0mm / +700mm
FILTER LAYER	-0mm / +300mm
TOTAL ROCK DUMP	-0mm / +1000mm

TRENCH TYPE C1a - 20Te ANCHOR PROTECTION
(NOTE 13)

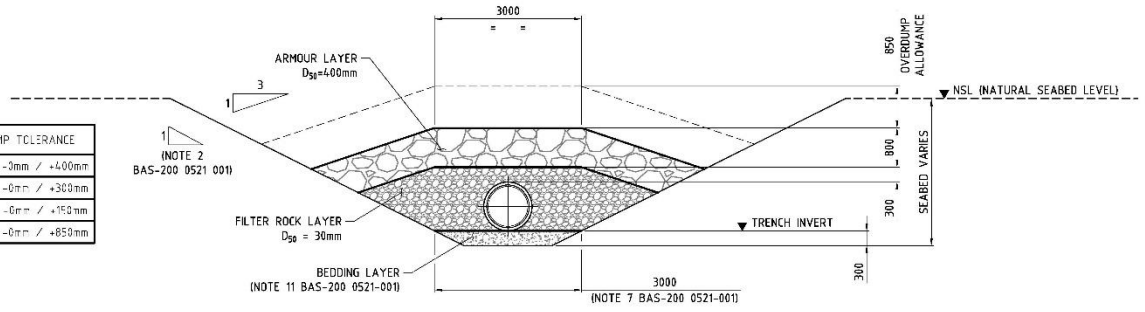


VERTICAL ROCK DUMP TOLERANCE	
ARMOUR LAYER	-0mm / +500mm
FILTER LAYER	-0mm / +300mm
BEDDING LAYER	-0mm / +150mm
TOTAL ROCK DUMP	-0mm / +950mm

TRENCH TYPE D1 - SHORE CROSSING

NOTES

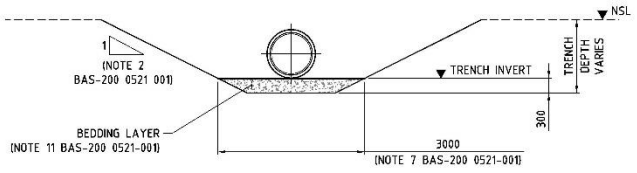
1. ALL DIMENSIONS IN MILLIMETRES (mm) U.N.O.
2. FOR NOTES REFER TO DRAWING No. BAS-200 0521 001.



VERTICAL ROCK DUMP TOLERANCE	
ARMOUR LAYER	-0mm / +400mm
FILTER LAYER	-0mm / +300mm
BEDDING LAYER	-0mm / +150mm
TOTAL ROCK DUMP	-0mm / +850mm

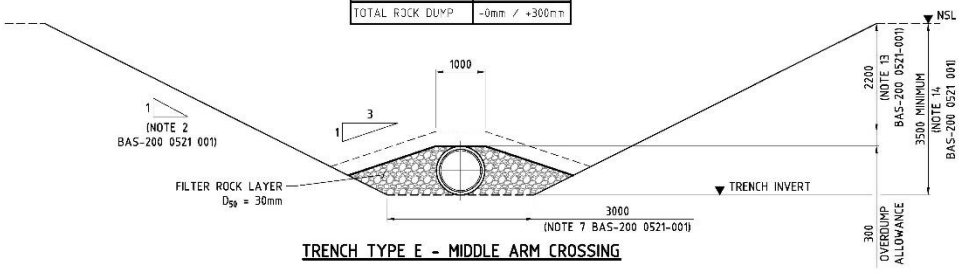
TRENCH TYPE D2 - SHORE CROSSING

VERTICAL ROCK DUMP TOLERANCE	
BEDDING LAYER	-0mm / +150mm
TOTAL ROCK DUMP	-0mm / +150mm



TRENCH TYPE D3 - SHORE CROSSING

VERTICAL ROCK DUMP TOLERANCE	
FILTER LAYER	-0mm / +300mm
TOTAL ROCK DUMP	-0mm / +300mm



TRENCH TYPE E - MIDDLE ARM CROSSING

Figure 2-2: Indicative trenching designs – Note these are not actual project specifications but included for descriptive purposes only

2.4 Equipment

Trenching and spoil disposal for the DPD Project will require the use of specialised equipment and vessels. Equipment and vessels used for the trenching and spoil disposal activities are list below:

+ Backhoe Dredge (BHD): Type "Nulla Nulla /Razende Bol", or similar; with mounted hydraulic tools if required (**Section 2.4.1**).
+ Trailing Suction Hopper Dredge (TSHD): Type "Bonny River/Vox Amalia", or similar (**Section 2.4.2**)
+ Cutter Suction Dredge (CSD): Type "Ambiorix/Athena", or similar (**Section 2.4.3**)
+ Split Hopper Barges (SHB): Type "Johannes de Rijke", or similar (**Section 2.4.4**).
+ Excavator (refer to **Section 2.4.5**)

2.4.1 Backhoe dredger

A BHD is a type of mechanical dredging equipment (**Figure 2-3**), consisting of a hydraulic arm and bucket system mounted on a turntable at the front of the pontoon with attached spud legs. Spud legs are driven into the seabed preventing movement due to wind, waves, and currents. BHDs can achieve a precise finished level and therefore are especially suitable for working in confined spaces in the presence of obstacles such as jetties or pipelines and are mainly utilised in shallow or confined waters.

A BHD will be used to trench shallower sections of the DPD pipeline route near the shore crossing. The BHD will be towed to location and will begin operations once positioned and stationary. Trenched material will be lifted by the BHD bucket to an SHB for transport to the spoil disposal ground.

Figure 2-3: Typical Backhoe Dredgers (Dredging, Environmental and Marine Engineering (DEME) Offshore & Van Oord JV, 2022)

The use of hydraulic tools is required for hard material that the BHD cannot cut through. Hydraulic tools may include an Xcentric Ripper or a hydraulic hammer which will be used to fracture rock as required. Once fractured the bucket is reattached to the BHD and the broken of fractured strata is dredged by the BHD and loaded into the SHB for transport to and discharge at the spoil disposal ground. This method will only be used when required at specific locations and is a discontinuous process.

2.4.2 Trailing suction hopper dredge

A TSHD is a type of hydraulic dredger that is a self-propelled sea-going vessel equipped with a hopper that can be loaded or emptied via a dredging arm. Dredging via TSHD is a cyclical process of loading

(dredging), transporting, and discharging. TSHD hoppers vary in volume from a few hundred m^3 up to 33,000 m^3. TSHDs are the only non-stationary dredger and are not anchored by spud poles or anchors.

At the trenching location the TSHD vessel slows to approximately 2 to 3 knots, then one or more suction tubes with dragheads (suction mouths) are lowered to the seabed. Whilst on the seabed swell compensators control the contact between the draghead and the seabed. Pumps then dredge the material (a mixture of soil and water) from the seabed into the hopper located within the TSHD.

TSHD overflow devices discharge water from the hopper when it has reached a certain level within the hopper. If the slurry dredged is a settling slurry, then water is discharged via the overflow while sediment settles in the hopper. However, if the dredged slurry contains fine sediment and is a non-settling slurry, then water and fine sediment is discharged. This can increase turbidity in the near- and far-field of the dredging operations.

After the hopper is filled with dredged material, the pumps are stopped, the suction pipes and draghead lifted on deck and the TSHD will sail to the spoil disposal ground. At the spoil disposal ground the dredged material will be discharged by opening the bottom doors of the hopper.

Figure 2-4: Trailer Suction Dredger's Bonny River (left) and Vox Amalia (right) (Allseas, 2022)

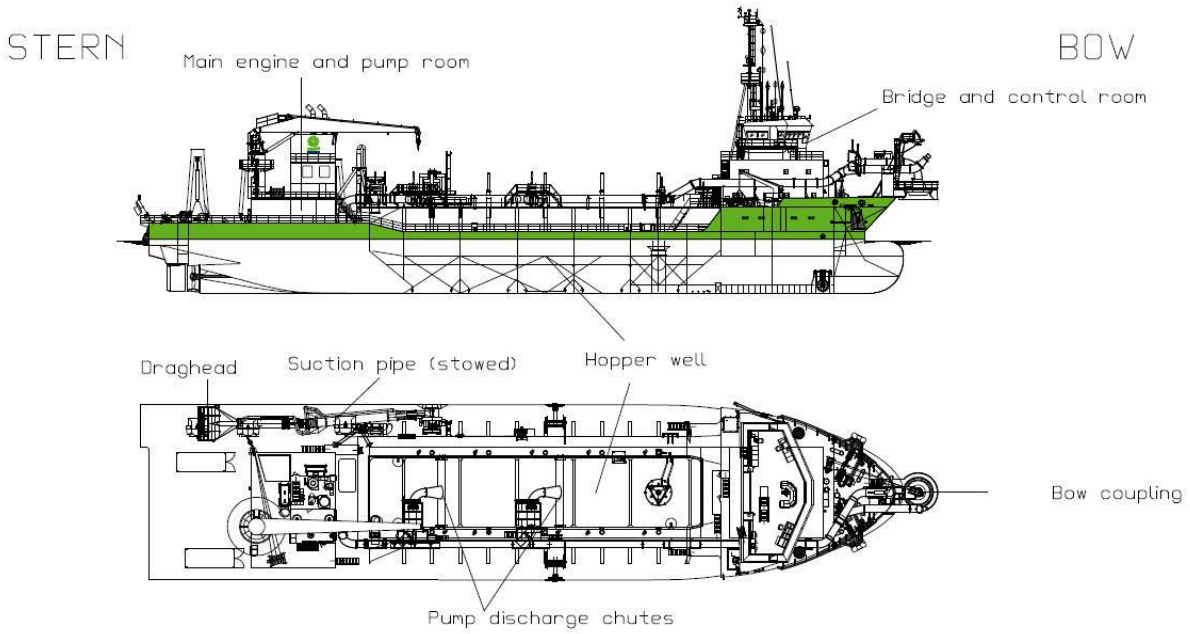


Figure 2-5: Main features of a Trailing Suction Hopper Dredger (TSHD) (Allseas, 2022)

2.4.3 Cutter suction dredger

CSDs are stationary hydraulic dredgers that are equipped with a cutter head (**Figure 2-6** and **Figure 2-7**). The cutter head rotates excavating the seabed which can then be sucked up by dredge pumps as a mixture of water and sediment (slurry). CSDs can also be used to break up harder material which is left in-situ for subsequent removal by a TSHD; this will be the mode of operation used for the DPD Project. Whilst operating the dredger moves around the spud pole via the pulling and slacking of two fore sideline wires. CSDs can excavate and then dredge all types of material, with accuracy due to the precise movement around the spud leg.

The CSDs utilised for this project will have self-propulsion, which will only be used during mobilisation between trench locations. Maximum dredge depth ranges between 31 m (Anthena) and 35 m (Ambiorix).

Figure 2-6: Cutter Suction Dredger's Ambiorix (left) and Anthena (right) (Allseas, 2022)

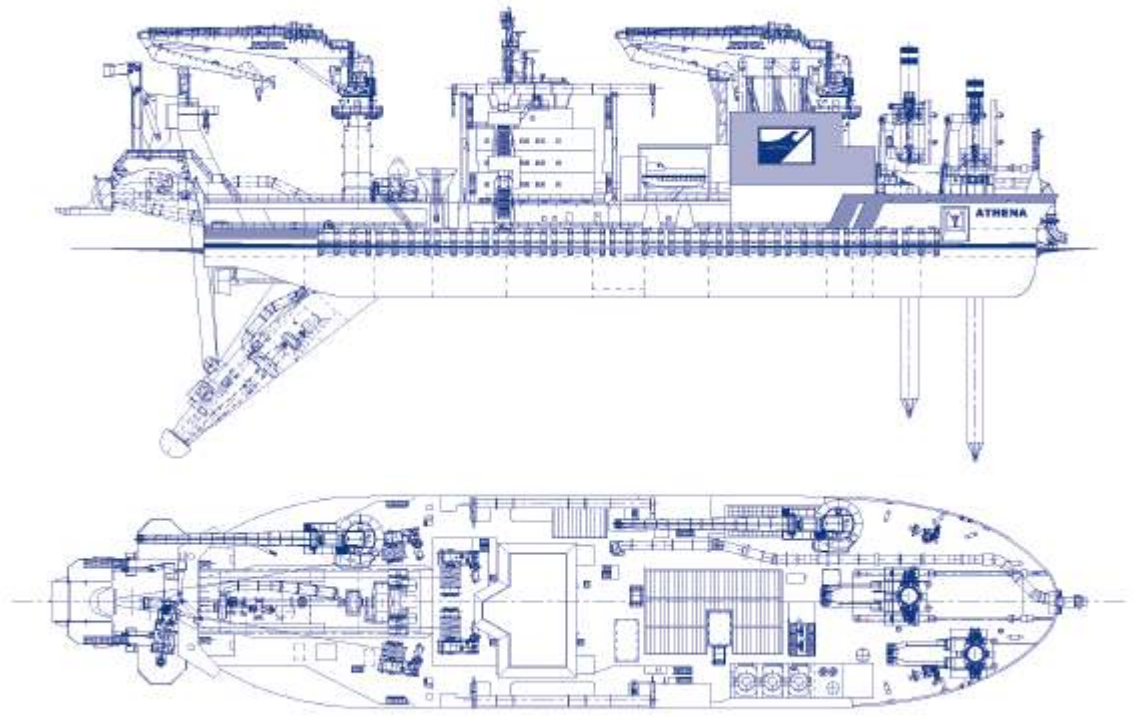


Figure 2-7: Schematic diagram of CSD Anthena (Van Oord, 2017)

2.4.4 Split hopper barge

SHBs are utilised for transporting and discharging of material dredged by the BHD. For this project, it is expected that two SHBs will be used to maximise efficiency and will be either self-propelled, towed or pushed by barges. A third barge may be used to further increase efficiency. SHBs are positioned and secured parallel to the BHD for loading. SHBs are loaded equally across the hopper area and once filled SHBs will sail to the disposal area. Once at the disposal area the load is discharged, by either opening the bottom doors or splitting the hopper well, depending on the type of barge.

2.4.5 Excavator

An excavator/s will be utilised to excavate material within the intertidal area and up to the shore pull onshore termination point. Excavators and the BHD will both work in the intertidal zone with operations dictated by tidal state. Material excavated will be deposited adjacent to the trench as close to LAT as possible where it will be collected by the BHD, if not already dispersed by tidal action.

2.5 Work method

2.5.1 Trenching method

The DPD trenching work can be divided into the following sections:

+ Intertidal zone
+ Near shore trenching zones
+ Trenching zones
+ Pre-sweep areas (5 areas)
+ Sand wave area

The trenching operations for the pipeline route have been divided into eleven sections made up of five trenching zones, five pre-sweep area and a sand wave area outlined in **Table 2-1** and **Figure 2-8**. The pre-sweep areas and single sand waves area only require sediments to be removed, while the trenching zones require the removal of both sediment and rock material. Pre-sweep areas are only potential trench areas and will only be trenched in targeted areas if pre-lay span rectification is required.

Trenching equipment will excavate a trench that is, at its maximum, approximately 3 m wide at the base and up to 9 m in depth, resulting in an approximate width of 40m along the pipeline route at distinct sections shown in **Figure 2-8** with the corresponding trench designs and kilometre points defined in **Section 2.2.2**.

Trenching in the intertidal area will be completed via land-based excavators at low tide with material placed adjacent to the trench as close to LAT as possible but below mean sea level (MSL). This will minimise potential for soil oxidation and reduce acid sulfate soil risk (ASSDMP [BAS-210 0049]) and facilitate natural dispersion with tidal action. To assist with the pre-lay trenching at the shore crossing, Santos will require the use of temporary rock causeway/s. These structures will be located at the shore crossing. No blasting or rock fragmentation is proposed for the activity, however there may be some requirement for mechanical rock breaking using a BHD mounted hammer or Xcentric ripper at localised rock outcrops.

During periods above low tide, the BHD will excavate the trench with material placed into the SHBs for transport to the spoil disposal ground, the BHD will also remove any remaining material placed below MSL by the onshore excavator where accessible. Trenching in the nearshore trench zones will also be completed via BHD with material transported to the spoil disposal ground via the SHB/s.

Trenching in the pre-sweep areas and the sand wave area will be completed by TSHD. Material dredged via TSHD will be transported within the internal hopper to the spoil disposal ground where it will be discharged.

The remainder of the trench zones will be trenched using a three-step process:

1. The TSHD will pre sweep the zone removing sand and small material until rock is reached
2. The rock will be crushed using the CSD with material left in place
3. The TSHD will return to pick up the material for disposal at the spoil ground.

Estimated volumes of material to be removed through trenching are presented in **Table 2-1**.

Any maintenance dredging required prior to pipelay activities will be completed via TSHD as the material is anticipated to be soft and unconsolidated.

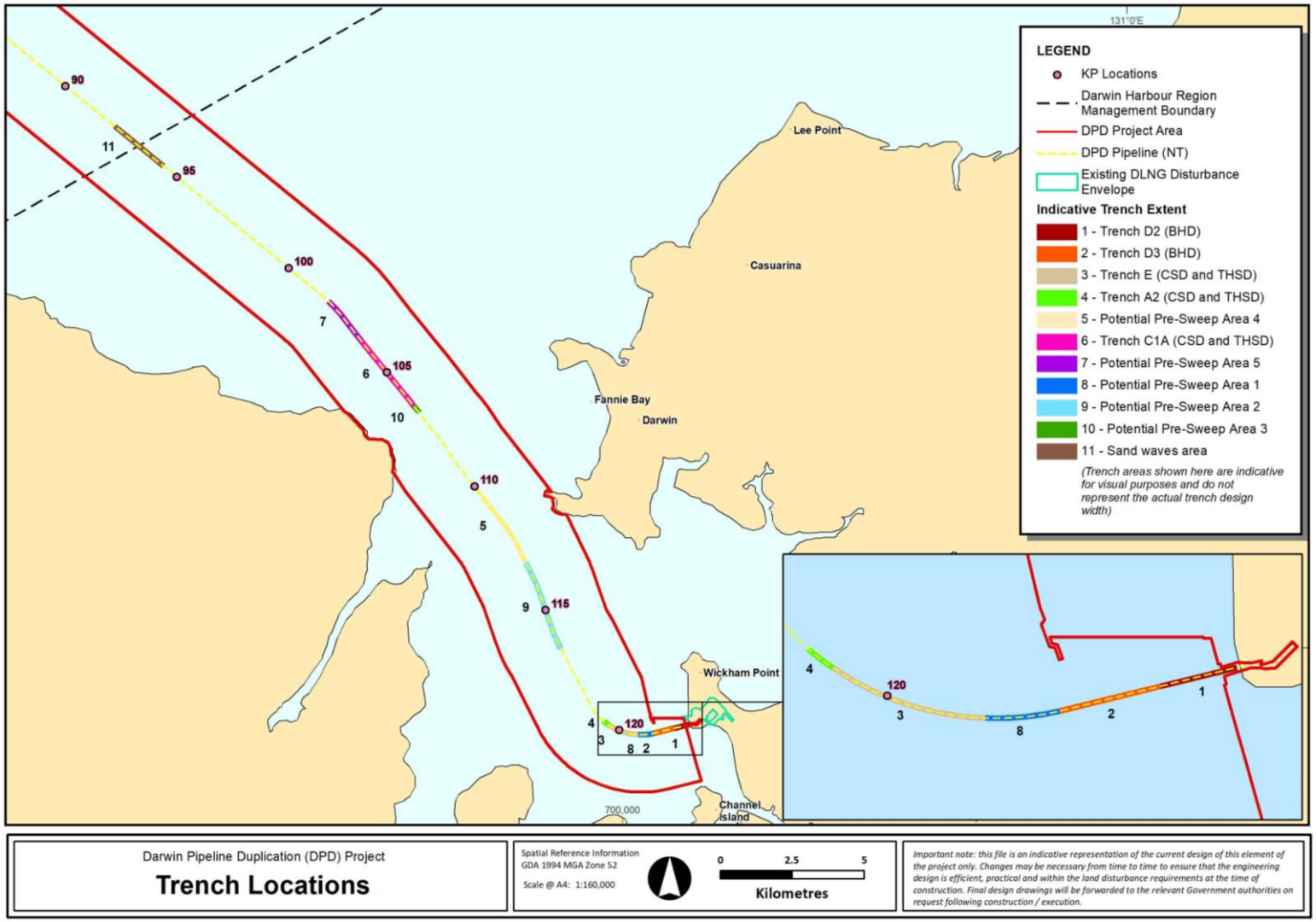


Figure 2-8: Proposed trenching locations

Table 2-1: Trench sections, locations, equipment proposed, and estimated volume of dredged material.

Trenching section	Pipeline location start KP	Pipeline location end KP	Trench length	Equipment	Task description	Base Case (Trench Zones and Sand Waves) Trench Volume m^3	[1]Potential (Pre-Sweep Areas) Trench Volume m^3	Disposal location
1. Trench D2 (Nearshore)[2]	~122.5	~121.9	~0.6 km	BHD / Hydraulic tools & SHB Land based excavator (onshore and intertidal zone)	Excavation of material by BHD, with rock breaking by hydraulic tools when necessary Excavation of material	~17,000		Spoil disposal ground As close to LAT as practicable
2. Trench D3 (Nearshore)	~121.9	~121.2	~0.7 km	BHD / Hydraulic tools & SHB	Excavation of material by BHD, with rock breaking by hydraulic tools when necessary	~6,000		Spoil disposal ground
8. Potential Pre-Sweep Area 1	~121.2	~120.6	~0.6 km	TSHD	Excavation of unconsolidated material by TSHD		~4,000	Spoil disposal ground
3. Trench E	~120.7	~119.5	~1.2 km	TSHD pre sweep & CSD	Excavation of unconsolidated material by TSHD Break hard consolidated rock by CSD Second excavation of unconsolidated material by TSHD	~40,000		Spoil disposal ground
4. Trench A2	~119.5	~119.3	~0.2 km	TSHD pre sweep & CSD	Excavation of unconsolidated material by TSHD Break hard consolidated rock by CSD Second excavation of unconsolidated material by TSHD	~8,000		Spoil disposal ground
9. Potential Pre-Sweep Area 2	~116.4	~113.2	~3.2 km	TSHD	Excavation of unconsolidated material by TSHD		~35,000	Spoil disposal ground
5. Potential Pre-Sweep Area 4	~113.2	~110.2	~3 km	TSHD pre sweep & CSD	Excavation of unconsolidated material by TSHD		~50,000	Spoil disposal ground
10. Potential Pre-sweep area 3	~106.5	~106.8	~0.3 km	TSHD	Excavation of unconsolidated material by TSHD		~3,000	Spoil disposal ground
6. Trench C1A	~106.6	~103.6	~3 km	TSHD pre sweep & CSD	Excavation of unconsolidated material by TSHD Break hard consolidated rock by CSD Second excavation of unconsolidated material by TSHD	~117,000		Spoil disposal ground
7. Potential Pre-Sweep Area 5	~103.6	~101.8	~1.8 km	TSHD pre sweep & CSD	Excavation of unconsolidated material by TSHD		~30,000	Spoil disposal ground
11. Sand Waves Area	~94.4	~92.2	~2.2 km	TSHD	Excavation of unconsolidated material by TSHD	~15,000		Spoil disposal ground
	Expected volume to be disposed at offshore spoil disposal ground					~203,000	~112,000	~325,000
	Maximum volume to be disposed at offshore spoil disposal ground					~750,000		

[1] Pre-sweep areas are only potential trench areas and will only be trenched in targeted areas if pre-lay span rectification if required.

[2] This zone encapsulates the intertidal zone between KP122.2 and KP122.4.

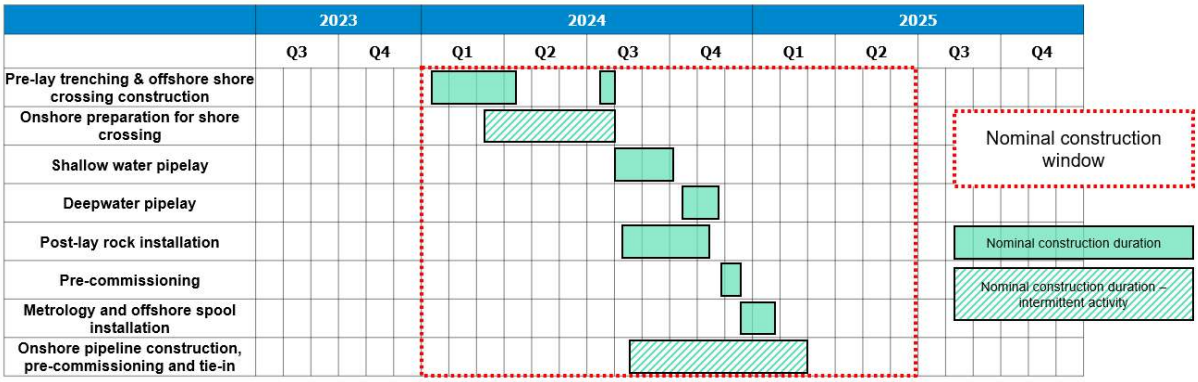
2.5.2 Spoil disposal method

Spoil collected by the TSHD will be discharged via bottom doors. This method of discharging has been identified as the optimal method of spoil disposal in high energy unconfined ocean environments (PIANC 100 workshop). SHBs will also be used to transport and discharge material trenched by BHD in the intertidal and nearshore area. The expected and maximum volumes to be disposed are presented in Table 2-1.

2.6 Indicative dredging and disposal schedule

Santos is targeting to have all DPD regulatory approvals in place by Q1 2024 to ensure construction activities do not delay Barossa first gas in the first half of 2025. A nominal DPD construction sequence and schedule is shown in **Table 2-2** representing a start of construction activities at the beginning of nominal construction window. The construction activities will span a nominal cumulative period of 15-months in the field. The actual construction sequence and schedule will be subject to the timely receipt of all regulatory approvals and drivers such as vessel availability, operational issues, and weather. Santos' regulatory approvals and stakeholder consultation consider construction activities at any time between Q1 2024 to mid-2025.

Table 2-2: Preliminary pre-lay, construction, installation, and pre-commissioning schedule for DPD.



3 Legal and other obligations

The following sections describe the legislative framework governing the environmental assessment and approval of trenching and spoil disposal activities during the construction of the DPD Pipeline (NT).

3.1.1 Commonwealth environmental approval

The DPD Project including the DPD pipeline section in Commonwealth waters was referred to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the EPBC Act on 7 October 2022 (EPBC 2022-9372). On 6 December 2022 the DPD Project was determined to be a Controlled Action requiring further assessment based on Preliminary Documentation. Further information was requested under section 95A(2) of the EPBC Act on 23 December 2022.

It was determined that the Project may have a significant impact on the following controlling provisions under the EPBC Act:

+ Listed threatened species and communities (sections 18 & 18A)
+ Listed migratory species (sections 20 & 20A)
+ Commonwealth marine areas (sections 23 & 24A)

The Preliminary Documentation is currently being prepared for submission to DCCEEW.

This TSDMMP will be updated to reflect any relevant regulatory conditions associated with this approval.

3.1.2 Northern Territory environmental approvals

The DPD Project was referred to the NT EPA on 14 January 2022 under Section 55 of the EP Act. The NT EPA determined the Santos Barossa DPD Project proposal required assessment by supplementary environmental report (SER) (Tier 2) in accordance with the Environment Protection Regulations 2020 (EP Regulations). The SER is required to address public and government submissions and include information additional to the referral document in relation to specific aspects of potential significance. This draft TSDMMP will be updated to reflect any relevant regulatory conditions associated with this approval.

This TSDMMP has been prepared for submission as a draft to the NT EPA with approval documents including the SER (BAS-210 0020). This TSDMMP will additionally be submitted to DITT for approval under the *Energy Pipelines Act 1981.*

The following additional approvals related to trenching and spoil disposal are also required under NT legislation:

+ Development Consent (dredging) and Occupational Licence (spoil disposal) from NT Department of Infrastructure, Planning and Logistics (*Planning Act 1999*).
+ DITT – Energy Division "Consent to construct and Consent to test" (*Energy Pipeline Act 1981* and *Petroleum (Submerged Lands) Act 1981)*
+ Pipeline licences (*Energy Pipeline Act 1981*)
+ Fisheries Permit (*Fisheries Act 1998*)
+ Underwater Heritage Clearance (*Heritage Act 2011*)

Conditions with these permits, where they are relevant to the environmental management of works will be incorporated into future revisions of the TSDMMP.

3.1.3 Aboriginal Areas Protection Authority certificates

Aboriginal Areas Protection Authority (AAPA) certificates aim to protect indigenous sacred sites preventing damage from nearby works and outlines conditions to be followed when carrying out works on land and sea near to sacred sites across NT. The AAPA administer these certificates under the *National Territory Aboriginal Sacred Sites Act 1989*.

Santos has received an AAPA Authority Certificate (C2022-098) on 23 December 2022 and will ensure the requirements of the certificate (including avoidance of restricted work areas) and the *Northern Territory Aboriginal Sacred Sites Act 1989* are met.

3.2 Legislative framework

Environmental legislative requirements governing the DPD project are described in the following sections. All activities will comply with legislative requirements established under relevant Commonwealth and Northern Territory legislation. Key legislation is described below in **Sections 3.2.1.1** and **3.2.1.2**. Other relevant legislation is described in **Table 3-1** and **Table 3-2**.

3.2.1 Key legislation

3.2.1.1 Environment Protection and Biodiversity Conservation Act 1999 (Cth)

The EPBC Act is administered by the Commonwealth DCCEEW. The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places, which are defined in the EPBC Act as matters of national environmental significance. There are nine matters of national environmental significance to which the EPBC Act applies these are: world heritage properties, national heritage places, wetlands of international importance, nationally threatened species and ecological communities, migratory species, Commonwealth marine areas, the Great Barrier Reef Marine Park, nuclear actions, and water resources (in relation to coal seam gas development and large coal mining development) (DAWE, 2021). When a person proposes to take an action that they consider may need approval under the EPBC Act, they must refer the proposal to the Commonwealth Minister for Environment.

Section 3A of the EPBC Act sets out the principles of ecologically sustainable development (ESD), which are:

+ Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations
+ If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
+ The principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
+ The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making
+ Improved valuation, pricing and incentive mechanisms should be promoted.

The construction and operation of the DPD Project (including the Commonwealth waters section) has been referred to DCCEEW under the EPBC Act and assessed to be a Controlled Action (referral number EPBC 2022/9372) requiring further assessment based on Preliminary Documentation (in progress). (**Section 3.1.1**).

3.2.1.2 Environmental Protection Act 2019 (NT)

The EP Act is administered by Department of Environment, Parks and Water Security (DEPWS). The EP Act protects the environment and related purposes of the Northern Territory. The Act also:

+ Promotes ecologically sustainable development
+ Recognises the role of environmental impact assessment and environmental approval in promoting the protection and management of the environment of the Territory
+ Provides for broad community involvement during the process of environmental impact assessment and environmental approval
+ Recognises the role that Aboriginal people have as stewards of their country as conferred under their traditions and recognised in law, and the importance of participation by promotion of ecologically sustainable development

This TSDMMP has been developed under the guidance of this act incorporating the identified core aspects above and will be submitted to NT EPA with DPD SER (BAS-210 0020) for approval (refer **Section 3.1.2** for further information).

3.2.1.3 Waste Management and Pollution Control Act 1998 (NT)

The duties under the *Waste Management and Pollution Control Act* 1998 (NT) require that a proponent must take all measures that are reasonable and practicable to prevent or minimise the pollution or environmental harm and reduce the amount of the waste. The management actions detailed in **Section 8** demonstrate how the Santos will comply with these duties.

Further the duties under the Act require proponents to understand:

a. the nature of the potential environmental harm and the sensitivity of the environment which may be impacted (refer to **Sections 7** and **5**, respectively)
b. technical information relating to the activity and the likelihood that the management actions would minimise environmental impact (refer to **Sections 2, 6 7.3 and 7.4**, respectively)
c. the financial implications of implementing management actions

Finally, Santos will comply with the duty to notify NT EPA of incidents causing or threatening to cause pollution.

3.2.2 Other relevant legislation

3.2.2.1 Commonwealth

Other commonwealth legislative requirements relevant to the DPD trenching and spoil disposal activities are outlined in **Table 3-1**.

Table 3-1: Other commonwealth legislation relevant to DPD trenching activities.

Title	Description
Aboriginal and Torres Strait Islander Heritage Protection Act 1984	The purpose of this act is to preserve and protect places and objects in Australia and in Australian waters from injury or desecration; places or objects in question must be of particular significance to Aboriginal people with Aboriginal tradition.
Biosecurity Act 2015	The Act describes how to manage biosecurity threats to plant, animal and human health in Australia and its external territories, ensuring a very low level of risk. This involves balancing between protecting Australia from pests and disease and maintaining the ability to trade (DAFF, 2021).
Environment Protection (Sea Dumping) Act 1981[1]	The Act regulates the disposal of wastes at sea, and the creation of artificial reefs and applies to all vessels, aircraft, and platforms in Australian waters, and to all Australian Vessels and aircraft in any part of the sea.
Petroleum (Submerged Lands) (Management of Environment) Regulations 1999[2]	The Petroleum (Submerged Lands) (Management of Environment) Regulations 1999, under *Petroleum (Submerged Lands) Act 1981* (linked via the NT Petroleum (Submerged Lands) (Application of Commonwealth Laws) Regulations 2004), allows for the creation of provisions with respect to the exploration for and the exploitation of the petroleum resources, and certain other resources, of certain submerged lands adjacent to the coasts of the Northern Territory and for related purposes. Aiming to ensure that proponents carry out all petroleum activity in a way that is consistent with the principles of ecologically sustainable development, in accordance with an environment plan that has appropriate environmental performance objectives and standards as well as measurement criteria for determining whether the objectives and standards are met.
Protection of the Sea (Harmful Anti-fouling Systems) Act 2006	This Act relates to the protection of the sea from the effect of harmful anti-fouling systems. It covers the application or use of harmful anti-fouling systems and the issue and endorsement of the required certificates and anti-fouling declarations.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	This Act relates to the prevention of pollution (in any form) from ships. MARPOL requirements are implemented under this Act.
Underwater Cultural Heritage Act 2018 *Underwater Cultural Heritage (Consequential and Transitional Provisions) Act 2018*	This Act provides for the protection of shipwrecks, sunken aircraft and their associated artefacts that have lain in territorial waters for 75 years or more. It is an offence to interfere with any shipwreck covered by the Act. Some sites also have a protected zone around them. The Act came into effect on 1 July 2019.

Notes:

1. The *Environment Protection (Sea Dumping) Act 1981* does not apply as spoil disposal will be within NT waters and therefore a sea dumping permit is not required.
2. There will be no trenching of the pipeline route or spoil disposal between the territorial baseline and NT coastal waters limit and therefore the activities included in this TSDMMP do not fall under the jurisdiction of the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999.*

3.2.2.2 Northern Territory

Other Northern Territory legislative requirements relevant to the DPD Project offshore construction activities are outlined in **Table 3-2**.

Table 3-2: Other Northern Territory legislation relevant to the Santos Barossa DPD pipeline project

Title	Description
Aboriginal Land Rights (Northern Territory) Act 1976	The Act provides the basis upon which Aboriginal Australian people in the Northern Territory can claim rights to land based on traditional occupation.
Crown Lands Act 1992	This Act provides for the management of crown lands in the Northern Territory. Including the facilitation of land use for economic development.
Dangerous Goods Act 1998	This Act provides for the safe storage, handling, and transport of certain dangerous goods. These being explosives (including fireworks) and fuel gas (including Autogas) (NT WorkSafe, 2020).
Energy Pipelines Act 1981	This Act allows for the creation of provisions for the construction, operation, maintenance and cessation of use or abandonment of pipelines for the conveyance of energy-producing hydrocarbons, and for related purposes. The NT *Energy Pipelines Act 1981* and subsidiary Energy Pipelines Regulations require the proponent to operate licensed pipelines in accordance with an accepted Pipeline Management Plan (PMP).
Environmental Offences and Penalties Act 2011	This Act defines levels and penalties for environmental offences
Fisheries Act 1988	This Act provides for the regulation, conservation and management of fisheries and fishery resources to maintain their sustainable utilisation, to regulate the sale and processing of fish and aquatic life, and for related purposes.
Heritage Act 2011	This Act provides a framework for the identification, assessment, recording, conservation, and protection of the Northern Territory's cultural and natural heritage.
Marine Act 1981	This Act is to regulate shipping within the Northern Territory and to provide for the application to the Northern Territory of the uniform shipping laws code and for related matters.

Title	Description
Marine Pollution Act 1999	This Act protects the marine and coastal environment by minimising intentional and negligent discharges of ship-sourced pollutants into coastal waters, and for related purposes.
Native Title Act 1993	This Act provides for the recognition and protection of native title and provides or permits for the validation of past acts and intermediate period acts, invalidated because of the existence of native title. It additionally establishes ways in which future dealings affecting native title may proceed and sets standards for those dealings and establishes mechanisms for determining claims to native title.
Northern Territory Aboriginal Sacred Sites Act 1989	This Act aims to provide a practical balance between the recognised need to preserve and enhance Aboriginal cultural tradition, in relation to certain land in the Northern Territory and the aspirations of the Aboriginal and all other peoples of the Northern Territory for their economic, cultural, and social advancement; by establishing a procedure for the protection and registration of sacred sites, providing for entry onto sacred sites and the conditions to which such entry is subject, establishing a procedure for the avoidance of sacred sites in the development and use of land and establishing an Authority for the purposes of the Act and a procedure for the review of decisions of the Authority by the Minister.
Northern Territory Environment Protection Authority Act 2012	This act aims to: a) promote ecology sustainable development; b) to protect the environment, having regard to the need to enable ecologically sustainable development; (c) to promote effective waste management and waste minimisation strategies; and (d) to enhance community and business confidence in the environmental protection regime of the Territory.
Petroleum (Submerged Lands) Act 1981[1]	The *Petroleum (Submerged Lands) Act 1981* allows for the creation of provisions with respect to the exploration for and the exploitation of the petroleum resources, and certain other resources, of certain submerged lands adjacent to the coasts of the Northern Territory and for other purposes.
Planning Act 1999 Planning Regulation 2000	This Act provides a framework of controls for the orderly use and development of land in the Northern Territory. The Development Assessment Services is responsible for the development assessment and control processes within the provisions of the Act. Approval for the DPD Project will be obtained under the Planning Act 1999 (NT), Santos is consulting with the NT Department of Infrastructure, Planning and Logistics regarding the pathway for this approval.
Ports Management Act 2015	This Act provides for the safe, efficient, and effective control, management, and operation of Northern Territory ports.
Territory Parks and Wildlife Conservation Act (TPWC Act) 1976	This Act provides for the establishment of Territory Parks and other parks and reserves and for the study, protection, and conservation of wildlife in Northern Territory. This includes provisions on changes and revocation of

Title	Description
	parks, reserves and sanctuaries, the preparation and implementation of plans of management, the creation and management of sanctuaries and on the management of wildlife, flora, and fauna.
Waste Management and Pollution Control Act (WMPC Act) 1998	This Act provides for the protection of the environment through encouragement of effective waste management and pollution prevention and control practices and for related purposes. It additionally outlines the general environmental duty that proponents must comply with (**refer to Section 3.2.1.3**).
Water Act 1992	The Act provides for the investigation, allocation, use, control, protection, management, and administration of water resources in the NT. Under the Act a waste discharge licence is the regulatory instrument used to regulate the quality and quantity of waste discharged to water in the NT. As mentioned previously a WDL is not required as the spoil disposal ground is outside the remit of the *Water Act 1992*.

Notes:

1. There will be no trenching of the pipeline route or spoil disposal between the territorial baseline and NT coastal waters limit and therefore the activities included in this TSDMMP do not fall under the jurisdiction of the Petroleum (Submerged Lands) Act 1981.

3.2.3 International conventions and agreements

Australia is signatory to numerous international conventions and agreements that obligate the Commonwealth government to prevent pollution and protect specified habitats for flora and fauna. Those which are relevant to the activity re outlined in **Table 3-3**.

Table 3-3: International agreements and conventions relevant to the activity

International agreements and conventions	
Title	**Description**
International Convention for the Prevention of Pollution from Ships (MARPOL)	This convention is to eliminate international marine environment pollution through hydrocarbons and other toxic substances and to reduce the accidental discharge of such substances.
Japan-Australia Migratory Bird Agreement (JAMBA)	This agreement recognises the special international concern for the protection of migratory birds and birds in danger of extinction that migrate between Australia and Japan. Implemented in the EPBC Act.
China-Australia Migratory Bird Agreement (CAMBA)	This agreement recognises the special international concern for the protection of migratory birds and birds in danger of extinction that migrate between Australia and China. Implemented in the EPBC Act.
Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)	This agreement recognises the special international concern for the protection of migratory birds and birds in danger of extinction that migrate between Australia and Korea. Implemented in the EPBC Act.
United Nations Convention on Biological Diversity – 1992	An international treaty to sustain life on earth.

International agreements and conventions	
Title	**Description**
United Nations Framework Convention on Climate Change (1992)	The objective of the convention is to stabilise GHG concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system. Australia ratified the convention in December 1992, and it came into force on 21 December 1993.

3.2.4 Standards, codes and guidelines

There are several Australian Standards, Codes of Practise and Guidelines relevant to this TSDMMP, which have been identified below.

+ AS/NZS 4801 Occupational Health and Safety Management
+ AS/NZS ISO 14001:2004, Environmental management system – Requirements with guidance for use
+ AS/NZS ISO 31000:2009, Risk management – Principles and guidelines
+ HB 203:2006 Environmental Risk Management – Principles and Process
+ Australian Ballast Water Management Requirements. Version 8 (ABWM Requirements; Commonwealth of Australia, 2020a).
+ National Assessment Guidelines for Dredging (NAGD; Commonwealth of Australia, 2009a)
+ National Biofouling Management Guidance for Non-trading Vessels (NSPMMPI; Commonwealth of Australia, 2009b)
+ National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000)
+ Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (ANZG, 2018)
+ Declaration of Beneficial Uses and Objectives, Darwin Harbour Region, Northern Territory Government Gazette No. G27, 7 July 2010
+ Darwin Port Environmental Management Plan (Darwin Port 2020)
+ Darwin Harbour Water Quality Protection Plan (Department of Land Resource Management, 2014)
+ Guidelines for Environmental Assessment of Marine Dredging in the Northern Territory (NT EPA 2013)
+ Draft Guidelines for the Preparation of an Environmental Management Plan (NT EPA, 2015)
+ Guideline for Reporting on Environmental Monitoring (NT EPA, 2016).

4 Environmental management framework

4.1 Santos Management System (SMS)

Santos's Management System (known as the SMS) exists to support its moral, professional, and legal obligations to undertake work in a manner that does not cause harm to people or the environment. The framework of policies, standards, processes, procedures, tools, and control measures that, when used together by a properly resourced and competent organisation, result in:

+ A common HSE approach is followed across the organisation.
+ HSE is proactively managed and maintained.
+ The mandatory requirements of HSE management are implemented and are auditable.
+ HSE management performance is measured, and corrective actions are taken.
+ Opportunities for improvement are recognised and implemented.
+ Workforce commitments are understood and demonstrated.

The Implementation Strategy and Stakeholder Consultation sections within this TSDMMP (**Section 10** and **Section 11**) aligns with the SMS structure and are designed to require that:

+ Environmental impacts and risks continue to be identified for the duration of the activity and reduced to as low as reasonable possible (ALARP);
+ Controls are effective in reducing environmental impacts and risks to ALARP and acceptable levels;
+ Environmental performance outcomes and standards set out in this TSDMMP are met; and
+ Consultation with relevant and interested persons is maintained throughout the activity as appropriate.

4.2 Santos' Environment, Health, and Safety Policy

Santos' Environment, Health and Safety Policy (**Appendix 1**) clearly sets out its strategic environmental objectives and the commitment of the management team to continuous environmental performance improvement. This TSDMMP has been prepared in accordance with the fundamentals of this policy. By accepting employment with Santos, each employee and contractor is made aware during the recruitment process that he or she is responsible for the application of this policy.

4.3 DPD Project Environmental Management Plans

This TSDMMP falls under the overarching Offshore CEMP (BAS-210 0024). The Offshore CEMP covers all DPD Project construction activities from the Commonwealth/NT waters boundary to the shore pull onshore termination point. This TSDMMP sit under the Offshore CEMP and addresses all trenching and spoil disposal activities associated with the construction of the pipeline up to the onshore termination point. These activities are described in **Section 2**.

4.4 Supporting management processes and procedures

4.4.1 Contractor health, safety and environment requirements

The Santos HSE Contractor Management Operating Standard (SMS-HSS-OS08) and the Contracting and Procurement Operating Standard (SMS-PRC-OS01) supports the minimum requirements and

expectations for HSE management of Contractors and subcontractors. It includes the following minimum requirements:

+ Contractors to comply with all applicable HSE laws and regulations and any additional guidelines, operating standards and policies provided to the Contractor.
+ A review of the Contractor HSE Management System is completed before being contracted.
+ Provisions for Santos to conduct audits/inspections of the Contractor's operations, equipment and emergency procedures at any time.

In addition, the DPD Project has a contractual HSE Exhibit for scopes of work. The HSE Exhibit has a detailed environmental requirements section including:

+ Contractor to develop environmental implementation plan to demonstrate how applicable environmental legislation and environmental approval requirements under this TSDMMP will be met
+ Contractor to use an Environmental Management System for managing environmental impacts and risks throughout the activity. Requirements for demonstrating leadership and accountability, organisational capability, and training/induction processes and performance against environmental requirements
+ Key activities to support continuous environmental improvement
+ Definition of the operational area of the work
+ Chemical selection, approvals and chemical register requirements
+ Prohibition of materials and chemicals
+ Vessel environmental requirements, including trenching and spoil disposal requirements, marine discharge requirements, waste management requirements, unplanned discharge requirements, marine fauna interaction requirements, lighting requirements and invasive marine species requirements.

4.4.2 Santos marine vessel vetting process

Santos manages marine vessel vetting and assurance using a hierarchy of procedures, outlined below. These requirements for vessel acceptance criteria include technical, personnel (e.g. crew competencies) and operational requirements for marine vessels engaged by Santos.

4.4.2.1 Marine Assurance

The Marine Offshore Assurance Criteria (1530-045-STN-0001) is a standard that requires all vessels (including MODUs) used by Santos to be vetted. The vetting process is based on industry standards and best practices along with considerations of guidelines and recommendations from recognised industry organisations such as Oil Companies International Marine Forum (OCIMF) and International Maritime Contractors Association (IMCA), and international regulatory agencies like the IMO and vessel Classification Societies. Marine Offshore Assurance Criteria (1530-045-STN-0001) requires a valid Offshore Vessel Inspection Database (OVID) report or Common Marine Inspection Document (CMID) report as required for vessel operation types. For vessels where the OVID and/or CMID are not valid or available, a Santos Approved Inspection Report is required.

4.4.2.2 Marine Standards and Compliance

The standards and guidelines that Santos expects the chartered vessels to operate to are:

- Flag State Legislation
- Coastal State Legislation for Marine Operations including Biosecurity Compliance
- MCA Code of Safe Working Practices for Merchant Seamen (2015)
- IMCA – M117
- IMCA – M182
- OCIMF – OVID and OVMSA
- A.714(17) Code of Safe Practice for Stowage and Securing (CSS Code) 2011 (IMO)
- Guide for Offshore Marine Operations (GOMO) (Previously NWES Guidelines)
- International Convention for the Safety of Life at Sea (SOLAS) 1974, as amended (IMO).
- International Maritime Dangerous Goods (IMDG) Code (IMO)
- Guidelines for the Preparation of cargo Securing Manual (MSC.1/Circ.1353 – IMO)
- IACS - International Association of Classification Societies Rules

Santos performs a risk assessment or HSE Qualification Evaluation process for each vessel to identify any HSE issues or specific management requirements prior to commencing activities.

4.4.3 Santos waste management process

As per the Santos Environment Hazard Controls Procedure (SMS-EXA-OS01-PD02), Santos requires that for all waste generated at its facilities and by contractors under its influence, the hierarchy of waste management applies whereby wastes are (in order of preference) avoided, reduced, re-used, recycled, treated and/or correctly disposed. A waste inventory must be documented and onshore waste disposal records standardised (Waste Monitoring and Reporting Procedure – SMS-EXA-OS01-PD02-PD01) to allow accurate and consistent waste tracking. Contractors under this TSDMMP will demonstrate waste management processes aligned with regulatory and Santos requirements through a Waste Management Plan.

4.4.4 Ballast water management

4.4.4.1 Summary of requirements

The Australian ballast water requirements set out the obligation on vessel operators with regards to the management of ballast water and ballast tank sediment when operating within Australian seas. All internationally operating vessels entering Australia will require:

- An approved Ballast Water Management Plan
- Maintenance of a complete and accurate record of all ballast water movements including those conducted in Australian waters
- An international Ballast Water Management Certificate.

Ballast water exchange should be conducted in areas at least 12 nm from the nearest land and in water at least 50 m deep. Volumetric exchange must be at least 95% of the relevant tank. Records on ballast water exchange shall include the start and finish times and geographic coordinates of the operation.

All ballast water management equipment such as pumps will be maintained as per the vessel preventive maintenance system and regularly tested to ascertain accurate calculations for ballast water exchange operations.

4.4.4.2 Australian pre-arrival report

All international vessels must submit a Ballast Water Report and a Pre-Arrival Report (PAR), 96 to 12 hours prior to arriving in an Australian port through the Maritime Arrival Reporting System (MARS), for the Australian Department of Agriculture to review and process.

MARS is the online portal for commercial Vessel Masters and Shipping Agents to submit reports required of all international vessels seeking Australian biosecurity clearance; and request services such as coastal strip, waste removal, ship sanitation certification and crew change.

Department of Agriculture will request evidence from vessels with a ballast water management system of:

+ Valid ballast water management plan specific to the vessel (consistent with the Convention)
+ Valid ballast water management certificate, or certificate of compliance, that is approved by a port state administration, or a recognised survey authority (consistent with the Convention)
+ Ballast water management records that clearly demonstrate the ballast water management has been operated consistent with the ballast water management plan.

A Department of Agriculture biosecurity officer will board the vessel to verify the Pre-Arrival Report and Vessel Master must ensure the vessel and personnel are available and able to demonstrate proficiency in the operation and maintenance of the ballast water management system.

4.4.5 Biofouling management

IMS may be present as biofouling on the vessel hull, or within piping, sea chests, etc. The biofouling which may be found on and in a vessel reflects the vessel's design, construction, maintenance, and operations. Each of these aspects introduces biofouling vulnerabilities but also offers opportunities to limit the extent and development of biofouling, with commensurate reduction in biosecurity risks.

4.4.5.1 Vessel risk assessment

Vessels mobilised to Darwin Harbour/DPD Project Area from international or domestic waters will comply with the Australian National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (DAFF; Commonwealth of Australia, 2009). This includes:

+ Completion of a biofouling risk assessment
+ Implementation of mitigation measures commensurate with the level of risk.

Figure 4-1 presents the risk assessment process. Factors that will inform risk are:

+ Timing of marine pest risk assessment relative to vessels selection and movement to the title area to ensure there is sufficient time to implement control measures in cases where management is warranted
+ History of the vessels including time spent in ports of call since last dry dock and clean to inform whether the facility or vessel may have been exposed to high-risk ports/locations
+ Level of biofouling and the presence of species of concern (in particular the presence of marine pests) within biofouling communities on the vessels associated with the activity (often informed by biofouling record books and/or maintenance/cleaning or inspection programs)
+ Operational profile relevant to biosecurity risk such as operating speed, time alongside a facility and the need for ballast exchanges within the title area

- Receiving environment including the presence of shallow water sensitivities within proximity to the activity and the presence and area of non-biocidal surfaces on facilities that could harbour marine pests
- Presence and effectiveness of external and internal marine growth prevention systems including effectiveness and integrity of antifouling coatings and functionality of internal treatment systems
- Qualifications and competency of personnel conducting and reviewing the risk assessment and making management decisions.

4.4.5.2 Vessel risk status

There are three outcomes from the risk assessment which categorise the vessels risk status as outlined below. Vessels are required to have a 'low' risk status to demonstrate to the government that Santos has taken all reasonable measures to minimise the risk of IMS.

- Low – low risk of introducing IMS; no additional management measures required
- Uncertain – risk of introducing IMS is not apparent; precautionary approach adopted, additional management measures required to achieve low status
- High – high risk of introducing IMS; additional management measures will be required.

4.4.5.3 Potential management measures to achieve low risk status

The outcome of the risk assessment will determine management measures required. If the vessel is deemed as 'low' risk status, no other measures are required (providing the vessel does not exceed the seven-day threshold at stationary or slow speed, in waters outside Australia (similar region).

For vessels that present an 'uncertain' or 'high' risk, Contractors will engage a qualified IMS inspector to conduct inspections and/or provide advice on obtaining low status. lists mitigation measures that can be applied to achieve 'low' risk status.

Table 4-1: Biofouling mitigation measures

No.	Mitigation Measure	Overview
1	IMS inspection	Visual inspection of submerged surfaces and niche areas by a qualified biosecurity inspector to better understand the actual biosecurity risk. IMS Inspectors will have the qualifications and align inspections and reports with DPIRD guidance in: + Criteria for Suitably Qualified Invasive Marine Pest Experts (DPIRD, 2017a) + Best Practice Guidelines for Invasive Marine Species Inspections (DPIRD, 2017b) + Invasive Marine Species Inspection Report Requirements (DPIRD, 2017b).

No.	Mitigation Measure	Overview
2	In-water cleaning	The appropriateness of in-water cleaning operations must be a decision made closely with IMS inspector on a case-by-case basis. Many factors will be considered, including: + Degree and type of biofouling; + Location of biofouling on the vessel. Prior to undertaking in-water cleaning within Australia, approval from the relevant state/territory authority must be granted and conditions may be imposed. Application for administering authority (Harbour Master, local government or state environmental protection agency) at least five working days prior to the proposed commencement of the work.
3	Dry docking cleaning	Dry docking and the removal/cleaning of biofouling will include hull surfaces, niche areas such as sea chests, all retractable equipment such as thrusters, intakes and outlets, anodes and voids.
4	Temporal or spatial controls	Temporal or spatial controls to limit vessel exposure to sources of risk.
5	Application of anti-fouling coating	Depending on the age the vessel may require application of new anti-fouling coating. The anti-fouling coating type will be based on technical advice and carried out by professional operators. All vessels greater than 400 gross tonnes will retain Antifouling System Certificate.
6	Treatment of internal seawater systems	In the absence of a marine growth prevention system, cleaning of internal seawater systems may be required, which may include: + Dehydration + Heat + Physical removal + Chemical treatment. Treatment of Internal Seawater systems will ideally be undertaken prior to mobilisation to Australia. Where chemical treatments are to be undertaken within Australian waters, advice will be sought from the Australian Pesticides and Veterinary Medical Authority (www.apvma.gov.au) in relation to permit and reporting requirements as it is prohibited to clean internal systems without a permit.

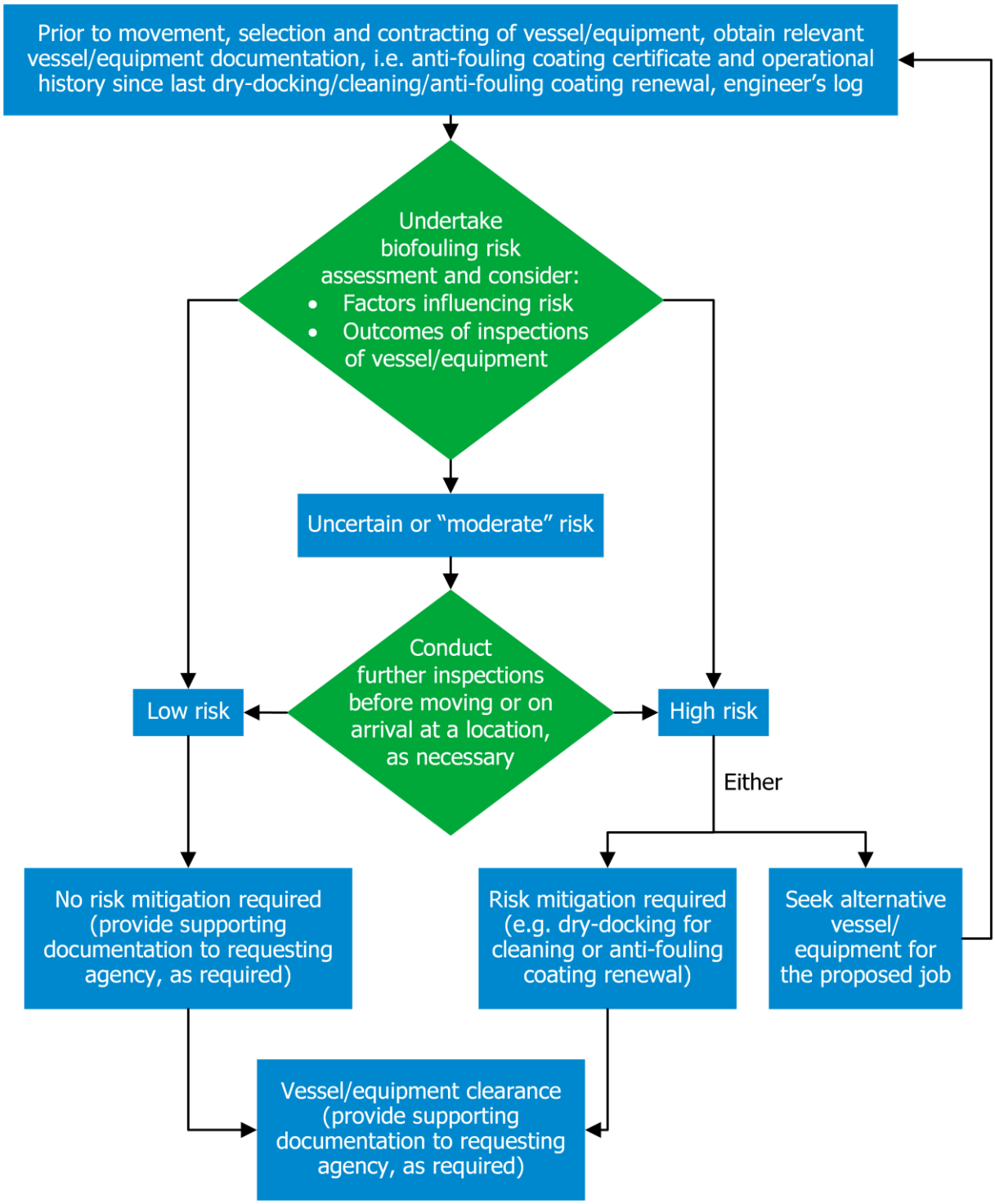


Figure 4-1: Generic biofouling risk assessment process (from Department of Agriculture, Fisheries and Forestry, 2009)

5 Existing Environment

This section describes the key physical, biological, socio-economic, and cultural characteristics of the Project Area. Based on the existing environment description in the Darwin Pipeline Duplication (DPD) Project - NT EPA referral (BAA-201 0003; Santos, 2021a) supporting document, Santos Barossa DPD – Pipeline Benthic Survey Report (RPS, 2022) and the following documents:

+ Darwin Pipeline Duplication (DPD) Project – EPBC Referral Supporting Information (BAA-201 0004; Santos, 2022)
+ Darwin Pipeline Duplication (DPD) Project – NT EPA referral (BAA-201 0003; Santos, 2021)
+ Santos Barossa DPD – Pipeline Benthic Survey Report (BAS-210 0014; RPS, 2022)
+ Ichthys Gas Field Development Project – Draft Environmental Impact Statement (EIS) (INPEX, 2010)
+ INPEX Ichthys GEP Dredging and Spoil Disposal Management Plan (INPEX, 2014)
+ Darwin Harbour – A Summary of the Ichthys LNG Project Nearshore Environmental Monitoring Program (Cardno, 2014)

5.1 Physical environment

The Darwin region is host to unique physical environmental conditions described below. Further details of the physical environment can be found in DPD Project NT EPA Referral (BAA-201 0003, Santos, 2021).

5.1.1 Meteorological conditions

5.1.1.1 Climate

The project area resides within the monsoonal (wet-dry) tropics of Northern Australia, which is subject to two distinct seasons a hot wet season from November to March and a warm dry season from May to September, with both April and October acting as transitional months between wet and dry seasons, respectively.

Temperatures are hot all year round with mean maximum temperature >30°C, November is the hottest month of the year ranging from 25°C mean minimum temperature to 33°C mean maximum temperature. While June and July are the coolest months in the year ranging from 19 – 20°C mean minimum temperature to 30°C mean maximum temperature (BOM, 2022).

5.1.1.2 Rainfall

The annual mean rainfall for Darwin is 1723.8 mm with the majority of this (87%) rainfall coming in wet season months between November and March. Mean monthly evaporation ranges from 160 mm in February to 245 mm in October, with annual daily evaporation of 6.7 mm. Mean 9am and 3pm relative humidity is also higher in the wet season following similar trends to rainfall (BOM, 2021). Monthly and annual mean, max and min rainfall averages from 1941 to 2021 for Darwin International Airport are provided in **Table 5-1**.

Table 5-1: Average monthly and annual mean, max and min rainfall from 1941 to 2021 for Darwin International Airport (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	431.3	369.0	310.7	101.6	20.7	1.8	1.1	4.7	16.6	70.2	141.8	252.0	1723.8
Max	940.4	1110.2	1013.6	396.2	295.9	50.6	26.6	83.8	129.8	338.7	370.8	664.5	2776.6
Min	136.1	103.3	88.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	17.2	18.8	1024.7

5.1.1.3 Wind direction and speed

During the wet season winds are predominately consists of light westerly and west-north-west winds, whilst in the dry season winds are varying from the south-east through to the north. Mean wind speeds are generally stronger in the afternoon than in the morning throughout the year. Mean morning wind speeds are typically stronger in the dry season, whilst mean afternoon wind speeds increase during the late dry season and build into the wet season where stronger winds are associated with afternoon storm cells.

5.1.1.3.1 Cyclone activity

The monsoonal tropics are also subject to intermittent cyclone activity usually resulting in the strongest winds and heaviest amount of rainfall in the occur during the cyclone season (November to April). Cyclones in the Anson-Beagle region are known to occur with low to moderate frequency. Most of the damage caused by cyclones occurs near to the coast, within 50 km from the coastline. Storm surges often result in flooding, raised tidal levels, and increased wave heights resulting in damage, causing concern for vessels and coastal developments in the area. Storm surges are hard to predict and dependent on the characteristics of the associated cyclone such as speed, intensity, and the angle it crosses the coast. Bathymetry also contributes to the risk level of storm surges (BOM, 2022).

5.1.2 Coastal morphology

5.1.2.1 Offshore Northern Territory waters

The bathymetry of the project area in offshore NT waters has been thoroughly investigated and is well understood. Recent surveys have shown that the seabed along the project pipeline route in offshore NT waters and within the spoil disposal ground is generally flat and featureless, with a typical depth of <30m.

5.1.2.2 Darwin Harbour

Darwin Harbour is a large, drowned river system approximately 500 km^2 in extent. It is comprised of three arms (East Arm, West Arm, and Middle Arm) which along with the smaller Woods Inlet, converge into a single channel before opening to the ocean and into Beagle Gulf in the north.

Freshwater inflow from the Elizabeth River into the East Arm and the Blackmore and Darwin rivers into the Middle Arm generally occurs between January and April creating more estuarine conditions (Hanley, 1988).

Port Darwin's main channel is approximately 1525 m wide and 15 – 25 m deep, with a maximum recorded depth of 36 m. The channel is generally deeper on the eastern side of the Harbour, while the western side is broader and shallower with more extensive intertidal flats and shoal areas. The channel extends into the East Arm with depths of more than 10 m below LAT, the bathymetry of this area has

been modified by dredging associated with the development of East Arm Wharf. There is a slightly deeper channel in the Middle Arm extending up to the western side of Channel Island.

5.1.3 Oceanography

5.1.3.1 Offshore Northern Territory waters

The North Marine Region has no major ocean currents. However, there are tidal currents that play a role in the movement of water, biota, and benthic sediments. There are three recognised large-scale ecological systems in the North Marine Region which are the:

+ Gulf of Carpentaria
+ Arafura
+ Joseph Bonaparte Gulf.

The offshore NT waters project area traverses two meso-scale bioregions, the Bonaparte Gulf and Anson-Beagle bioregions. The Bonaparte Gulf bioregion is predominately within offshore Commonwealth waters, but overlaps with NT coastal waters, south of Bathurst Island.

The extent of the continental shelf in Beagle Gulf in the Anson-Beagle bioregion means ocean currents only have a minor influence on this region. Beagle Gulf has limited oceanic interaction and is strongly influenced by strong internal circulation. During the dry season (May to September) there is a south westerly drift due to south easterly winds, the Indonesian flowthrough, and South Equatorial Current. Whilst during the wet season (November to March) there is a north easterly drift due to the north westerly monsoonal winds. The gulfs tides range from 6 to 8 m (IMCRA Technical Group, 1998).

Wave action in Beagle Gulf is seasonal; monsoonal north westerly winds during the wet season increase wave energy within Beagle Gulf and at the entrance to Darwin Harbour, due to the uninterrupted fetch over the Timor Sea. Whilst in the dry season south easterly trade winds generate low wave energy due to limited fetch.

Further offshore oceanic currents within the Bonaparte Gulf are influenced by the Indonesian flowthrough and South Equatorial Current. During the dry season (May to September) nearshore currents are generally westerly, whilst in the wet season (November to March) nearshore currents are easterly. Tides are semi-diurnal (two highs and two lows each day) and vary throughout the bioregion from offshore microtidal range (2 to 3 m variation) to inshore mesotidal range (3 to 4 m variation).

5.1.3.2 Darwin Harbour

Darwin Harbour has a macrotidal (more than 4 m) regime with tide range reaching 8 m. Tides are generally semidiurnal (two highs and two lows each day) with some inequality between successive tides in a single day. Neap tides result in a two-day period where tidal conditions are nearly diurnal (one high and on low each day). There is a great degree of variation in daily tidal range with the presence of spring-neap tide cycle approximately every 15 days. The spring phase of the cycle has an average tidal range of 6 m, while the neap phase average tidal range is 3 m (Cardno, 2014). Large tidal movements and to a lesser extent wind, drives rapid and regular exchange of large volumes of water between Darwin Harbour and Beagle Gulf.

Darwin Harbour is sheltered, with tsunamis and swell waves unlikely to occur due to the harbour's orientation, shallow bathymetry and protection afforded by the Tiwi Islands. Most waves are generated within Darwin Harbour or Beagle Gulf and are well below 1 m with periods of 2 – 5 seconds, under non-cyclone conditions. Tropical cyclones can cause extreme wave conditions producing significant wave height of 4.5 m and approximate periods of 7.5 seconds at the entrance to Darwin

Harbour. Inside the harbour waves heights are reduced by the bathymetry to approximately 0.7 m (GHDM, 1997).

5.1.4 Water quality

5.1.4.1 Offshore Northern Territory waters

Ichthys NEMP monitoring found that waters in Beagle Gulf were highly turbid in the wet season compared to the dry season likely due to stronger winds, larger waves, greater rainfall, and increased freshwater input (Cardno, 2014).

Environmental surveys to support the Barossa GEP Installation EP investigated water quality within the Barossa field (seasonal through 2015) and along the Barossa Gas Export Pipeline (GEP) (July to August 2017). This included areas close to the Project Area in Offshore NT waters, in which results showed metal concentrations below Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) dissolved metal trigger values (Santos, 2021).

In 2021, water sampling and analysis along the DPD pipeline route and at the spoil disposal ground in the offshore NT waters of the Project Area was completed (RPS, 2022 BAS-210-0014). Concentrations of three metals in water samples were detected above ANZG (2018) default guideline values (DGVs) (for slightly to moderately disturbed marine offshore ecosystems, at the 95% species protection level) Copper concentrations ins samples from three sites at western end of the offshore pipeline route were above the DGV; one of these exceedances was much higher than the DVG with the other two only slightly greater than the DVG, therefore it is likely an outlier and indicative of a potential contaminant. Lead concentrations were found to be much higher in the offshore Darwin Harbour samples than in samples taken at the spoil ground, with one sample above the DGV. Zinc concentrations were found at or above the DGV in 5 samples collected from the western end of the offshore pipeline route and across the proposed spoil disposal ground, with no clear trend in exceedances between surface and bottom waters. Arsenic was recorded below the ANZG (2018) DGV (RPS, 2022).

All nutrient concentrations were below the associated ANZG (2018) DGV (RPS, 2022). Dissolved hydrocarbons were below the limits of reporting (LoR) for all samples. Naturally Occurring Radioactive Material (NORMs) were detected in near-seabed samples at two sites along the offshore pipeline route in low concentrations.

Total Suspended Solids (TSS) concentration were all above the LoR and ranged from 1.7 to 8.6 mg/L at offshore sites and 1.4 to 6.2 mg/L at spoil disposal grounds. There was no correlation between depth and TSS at either location.

Water column profiles at sites along the offshore pipeline and at the spoil ground showed no indications of stratification of the water column.

5.1.4.2 Darwin Harbour

Typically, water quality is high in the harbour, although naturally turbid as well. Water quality is highly variable within Darwin Harbour dependent upon tide, location, and season (**Table 5-2**). Darwin Harbour water quality is affected by high levels of surface runoff in the wet season (November to March), which can extend until April or May depending on rainfall received. Tides also influence water quality in the harbour, neap tides promote water clarity while spring tides reduce it by resuspending fine sediment from the harbour floor and fringing mangroves (DHAC, 2008).

The Darwin Harbour Water Quality Report Card (NT Government, 2021) found the Harbour's water quality was largely graded very good in 2021 with an overall grade of 'A', except for Buffalo Creek estuary which was impacted by wastewater discharge from the Leanyer-Sanderson sewage treatment plan. However, Buffalo Creek is outside the Project Area.

Table 5-2: Summary of processes affecting water quality in Darwin Harbour

Parameter	Influencing factors	
	Open Harbour	Tidal creeks
Temperature	Season	Season
Salinity	Season, location	Season, tide
Dissolved Oxygen	Tide (minor)	Tide
pH	(none)	Season, tide
Turbidity and light attenuation	Season, tide	Tide
Nutrients	(none)	Location

Water temperatures within Darwin Harbour are predominately high with some seasonal variation, averaging 30.6°C in the wet season and 24.5°C in the dry season. The lowest water temperatures occur in June and July (23°C) while the highest occur in October and November (33°C) (Padovan, 1997).

Salinity within Darwin Harbour is also subject to some seasonal variation, with mean salinity levels in the harbour being lower during the wet season, due to freshwater influence being greater. Sea water salinity has a global average of 35 ppt, however salinities throughout the harbour are approximately 37 ppt during the dry season. Salinity is higher in the dry season due to increased evaporation and less freshwater inflow. Areas in the middle of the harbour such as Weed Reef can experience salinity as low as 27 ppt due to monsoonal inflow during February and March (Parry & Munksgaard, 1995). Salinities in the arms are heavily influenced by freshwater inflow in the wet season and can drop to 17 ppt. The water column during this time is heavily stratified with Parry and Munksgaard (1995) reported salinities on the bottom of the harbour to be up to 12 ppt higher than the surface.

Darwin Harbour waters remain well oxygenated throughout the year with Padovan (1997) finding no seasonal effects. Dissolved oxygen levels range from 74% to 96%, averaging approximately 84%. Dissolved oxygen levels are slightly higher at the harbours mouth compared to further into the estuary. Additionally, during spring tide cycles oxygen levels increased by 7% at high tide compared low tide (Padovan, 1997).

Darwin Harbour waters have a narrow pH range of 8.3 – 8.6. Padovan (1997) found no seasonal, spatial, or tidal effect on the pH of the harbour.

Turbidity in the Darwin Harbour is higher in the wet season compared to the dry season, mainly due to influx of terrigenous sediment and somewhat due to surface water sheet flow. Light levels at the bottom of the harbour can be as low as 1% of surface light levels during the wet season (Padovan, 1997). However, the most important factors affecting turbidity are tidal cycle and location (Padovan, 1997). Spring tides are associated with higher current velocities, and therefore higher capacity of water to move sediment, which results is greater turbidity (DHAC, 2005).

5.1.5 Sediment quality

5.1.5.1 Offshore Northern Territory Waters

The Bonaparte Gulf has been reported to have relatively uniform sediments mainly consisting of sand. Within offshore NT waters, sediments are a mixture of gravelly, sandy sediments (Rochester *et al.*, 2007).

In 2021 sediment sampling and analysis along the DPD pipeline route and the at the spoil disposal ground in the offshore NT waters of the project area was completed (RPS, 2022). The offshore pipeline route was found to predominately consist of sand (RPS, 2022). Particle size was seen to transition from gravelly silty sand at sites further offshore, to less gravelly more silty sand with higher proportions of clay at sites closer to Darwin Harbour (RPS, 2022). The particle size distribution was consistent across the spoil ground, with sediments comprising of sand with some gravel and silt. Total recoverable hydrocarbons (TRH) and benzene, toluene, ethylbenzene, xylene and naphthalene (BTEXN) results were both below LoR for samples collected along the DPD Project pipeline and in the spoil disposal ground (RPS, 2022). All metal and metalloids with National Assessment Guidelines for Dredging (NAGD) screening levels (CoA, 2009a) had concentrations below the associated screening level, except for Arsenic concentrations that are naturally high but below NAGD SQG-High value (RPS, 2022). Nutrient and Total Organic Carbon (TOC) concentrations were all low and exhibited low variability (RPS, 2022). NORM concentrations were well below the NAGD screening level (effects range-low) (CoA 2009a).

5.1.5.2 Darwin Harbour

Darwin Harbour sediments can be split into four types (Michie, 1988):

+ Terrigenous gravels mainly found in the main channel
+ Calcareous sands with >50% biogenic carbonate, largely derived from mollusc shell fragments, found among or close to small coral communities at East Point, Lee Point and Channel Island.
+ Terrigenous sands predominately consisting of quarts and clay, with 10 – 50% carbonate largely derived from molluscs.
+ Mud and fine sand found on broad gently inclined intertidal mudflats that occur in areas with low current and tidal velocities.

Soft surfaces with varying amounts of sand and gravel occur in the main channel and near the mouth of the harbour. Although, spatial extent is hard to define due to the gradual transition between muddy, sandy, and coarser sediments and sediment movement caused by large tidal influences (Fortune, 2006). Coarser sediments are in the central channels of tributaries and the main body of the harbour rather than landward margins.

Sediment quality assessments completed for the Ichthys Gas Field Development Project identified a range of potential contaminants. Metal concentrations recorded in surface sediments were typically consistent between the East Arm, Middle Arm, and main body of Darwin Harbour. Arsenic concentrations are naturally high in Darwin harbour sediments, although bioavailability testing indicated only a very small proportion would become bioavailable (INPEX, 2010). Chromium and Mercury mean concentration levels were below guideline screening levels. Hydrocarbon and tributyltin were generally all below laboratory detection limits (INPEX, 2010). Total organic carbon levels were within the range to support biomass growth, averaging 0.3% w/w in East Arm and the main body of the harbour, and 0.5% w/w in Middle arm (INPEX, 2010). Soluble nitrogen (nitrite and nitrate) levels were low throughout the harbour and therefore considered an insignificant portion of the total nitrogen pool (INPEX, 2010). Mean total phosphorus (TP) levels were recorded within the range of

previous study by Parry et al. (2002). Potential acid sulfate soil (ASS) risk was identified at sites throughout the East Arm and along the Ichthys project pipeline.

Further sediment sampling and analysis along the DPD Project pipeline route within Darwin Harbour in 2021 (RPS, 2022) indicated:

+ Particle size distribution varied from north to south along the pipeline route in Darwin Harbour. The northmost site was found to have high proportions of silt and clay, while the sand wave area in the outer section of the harbour had very high proportions of sand and the southern end of the pipeline route consisted of gravelly silty sand.
+ TPH, TRH and BTEXN were detected at Darwin Harbour sites, at low levels. Normalised TPH and TRH concentrations met the relevant guidelines across all sites. PAH concentrations at all sites were below the LoR.
+ Concentrations of naturally occurring radioactive materials, pesticides and tributyltin were all below limits of detection in harbour sediments.
+ There is low potential for acid sulfate soils as, although inorganic sulphur is present in the sediments, there is significant acid neutralising capacity kinetically available to neutralise the oxidation products from the inorganic sulphur.
+ All metal and metalloids were above the LoR, with the exception of mercury. Of these metals and metalloids with NAGD screening levels (CoA, 2009a) only arsenic had concentrations above the screening level; however, arsenic levels were below the NAGD SQG-High value (RPS, 2022).
+ No contaminants of concern were found in the sediments along the pipeline route or at the potential spoil disposal ground. The elevated levels of arsenic found are considered to be naturally occurring. Therefore, the sediments along the pipeline route are suitable for unconfined ocean disposal, as per the NAGD (CoA, 2009a) and the NT EPA: Draft Guidelines for the environmental Assessment of Marine Dredging in the Northern Territory (NT EPA, 2013).

5.1.5.3 Acid sulfate soils

ASS are formed naturally and often occur in low lying coastal areas (BAA-201 0003; Santos, 2021). Coastal estuarine and mangrove environments develop ASS due to its typical waterlogged nature, saltwater influences and anaerobic soils.

ASS mapping over the Darwin region indicates that the Project Area shore crossing has a high potential for ASS to occur (BAA-201 0003; Santos, 2021). Considering the historical earthworks undertaken as part of the development of the DLNG facility, the natural material has been removed across the onshore zone and replaced by imported (non-ASS) fill material (generally sand) up to a depth of approximately 6 m below ground level (Santos, 2022c).

5.1.6 Underwater noise

Underwater noise, excluding naturally occurring noise, within Darwin Harbour is influenced by the existing shipping traffic, biological sources, and weather. Vessel traffic in Darwin Harbour is a year-round source of noise with the Port of Darwin recording 1,510 trade vessels in the 2021 – 2022 financial year (Darwin Port Operations, 2022). Further information regarding ambient noise levels in Darwin Harbour including measures is detailed in the MMNMP (BAS-210 0022).

5.2 Benthic habitats

The Darwin region supports several benthic habitats including mangroves, coral, seagrass, macroalgae, filter feeders and soft-bottom benthos described below. Further details of benthic habitats can be found in DPD Project NT EPA Referral (BAA-201 0003; Santos, 2021) and DPD Project Supplementary Environmental Report (BAA-201 0020, Santos, 2021a).

5.2.1 Offshore Northern Territory waters

Baseline investigations for the DPD Project were completed in October 2021 and June 2022 using drop/towed video at 30 sites and ROV video transects at 42 sites, respectively (BAS 210 0014; RPS, 2022). These surveys were used to describe the seabed of the offshore Project pipeline route. The results are included in full in the Santos Barossa DPD – Pipeline Survey Report (BAS 210 0014; RPS, 2022) and are summarised below.

The benthic habitats along the offshore Project pipeline route verified the predictions of the AIMS (2021) habitat modelling and comprised silty shelly sand with burrows and polychaete worm tubes. Biota commonly associated with this habitat included sparsely distributed hydroids, soft corals (gorgonians*, Junceella* and Alcyoniidae), sea stars and sponges. Within three of these silty shelly sand sites, there were sections of sand waves, roughly one metre high, with silty sand in the troughs and coarse shelly sand at the peaks. This substrate was associated with very sparse epibiota. The proposed sand waves trenching area (**Figure 2-8**) was found to contain rippled coarse sand with very little epibiota (<1% abundance), consisting of soft corals and crinoids.

The spoil disposal ground sites all consisted of the same soft substrate habitat. This habitat is defined by silty/clay sediment with medium density biota. Biota commonly seen at this habitat were soft corals (gorgonians*, Junceella,* and Alcyoniidae), branching and encrusting sponges, Bryozoa (lace coral), invertebrate burrows, polychaete tubes, brown algae and occasional motile crinoids.

5.2.2 Darwin Harbour

Benthic habitat surveys were completed in Darwin Harbour in October 2021 and in June 2022 (BAS 210 0014; RPS, 2022). The October 2021 survey was completed systematically to describe habitats along the proposed pipeline route. The June 2022 survey targeted sites which were predicted by the AIMS 2021 benthic habitat map (AIMS, 2021) to have unique habitat or showed features from geophysical surveys, that were considered to potentially represent maritime heritage features. The comparison between the AIMS and survey datasets revealed differences between predicted and observed habitat types, particularly with the level of information provided (approximate densities of biota, substrate types are not available in AIMS data).

Overall, the benthic habitat and communities survey indicated the Barossa DPD pipeline route is a transitional environment, with soft sediment habitats along the offshore pipeline route and spoil ground, and with areas of both soft and hard substrate habitat within Darwin Harbour. The soft sediment habitats support very sparse to sparse epibiota, and the rocky substrates support low to medium density filter-feeder communities.

Sections 5.2.2.1 and **5.2.2.2** summarise the findings of the October 2021 and June 2022 surveys respectively.

5.2.2.1 October 2021 survey

Darwin Harbour benthic habitats comprised soft sediment and two hard substrate habitats. Hard substrates were recorded along the section of the pipeline route offshore from Fannie Bay and low-profile reef was recorded offshore of Woods Inlet with medium to high density epibiota. The soft

substrate habitat adjacent to hard substrate habitats in Darwin Harbour were generally silty, shelly sand with very sparse soft corals to no conspicuous epibiota. As this habitat was recorded both adjacent to and between hard substrate habitats, this soft substrate habitat is potentially a veneer overlying submerged geology. Other recorded soft sediment benthic habitats in Darwin Harbour included:

+ Sand waves <1 m with coarse shelly sand and very sparse epibiota
+ Silt/clay, shelly sand, with very sparse to sparse biota (soft corals and crinoids) (at the southern end of the pipeline, near the shore crossing)
+ Silty, shelly sand with sparse epibiota (soft corals) and scattered bombora (at the southern end of the pipeline, near the shore crossing).

5.2.2.2 June 2022 Survey

Key objectives of the June 2022 survey were to ground truth AIMS (2021) habitat mapping at selected sites within Darwin Harbour and to increase the number of benthic survey sites along the pipeline route. Ground-truthing within Darwin Harbour focused on sites predicted to be suitable for rarer high-value biota types (e.g., macroalgae, hard corals and seagrass) that were closest to the proposed pipeline route (and therefore had the greatest potential to be influenced by DPD Project construction activities, including trenching). This included an area west of the pipeline route where the route comes closest to the shoreline of Cox Peninsula (including sites HAB 1-4), an area west of the pipeline route where the route comes closest to Weed Reef (including sites HAB 6-8) and sites close to the shore crossing (HAB 9 and 10) (refer to **Figure 5-1**).

Results from these surveys showed that the selected sites which were predicted as suitable for macroalgae, seagrass and/or hard coral by AIMS (2021) mapping typically did not show presence of these biota types (BAS 210 0014; RPS 2022, **Figure 5-1 - Figure 5-3**). Additional to these benthic habitat ground-truthing sites, a number of benthic habitat monitoring sites used by INPEX during the Ichthys project were ground-truthed including hard coral sites (INPHCMAN, INPHCWED, INPHCCHI, INPHCSSI and INPHCNEW) and seagrass sites (INPSGWOD and INPSGCPW) (refer **Figure 5-1 - Figure 5-3**). Surveys from these sites generally confirmed the presence of seagrass or hard coral as expected, although seagrass was observed at very low densities. The additional sites surveyed along the pipeline route within Darwin Harbour in June 2022 provided results consistent with surveys in October 2021 in that sites comprise a mix of hard substrate and sediments supporting varying densities of filter-feeding biota such as soft corals, hydroids, crinoids and sponges but with an absence of photosynthetic biota such as hard corals, seagrass and algae (BAS 210 0014; RPS, 2022; **Figure 5-1 – Figure 5-3**).

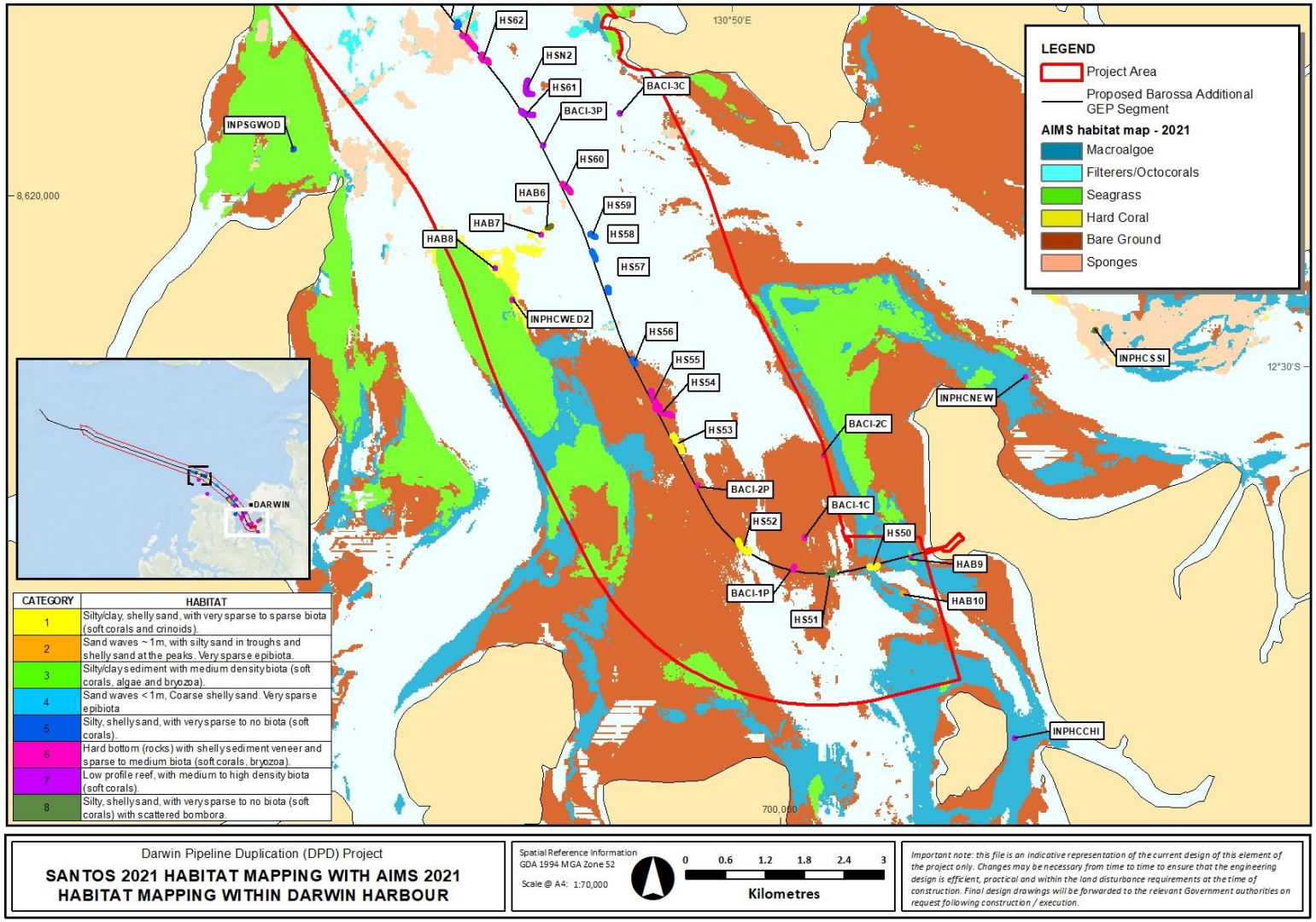


Figure 5-1: RPS surveys habitat mapping against AIMS 2021 habitat mapping within Darwin Harbour (AIMS, 2021)

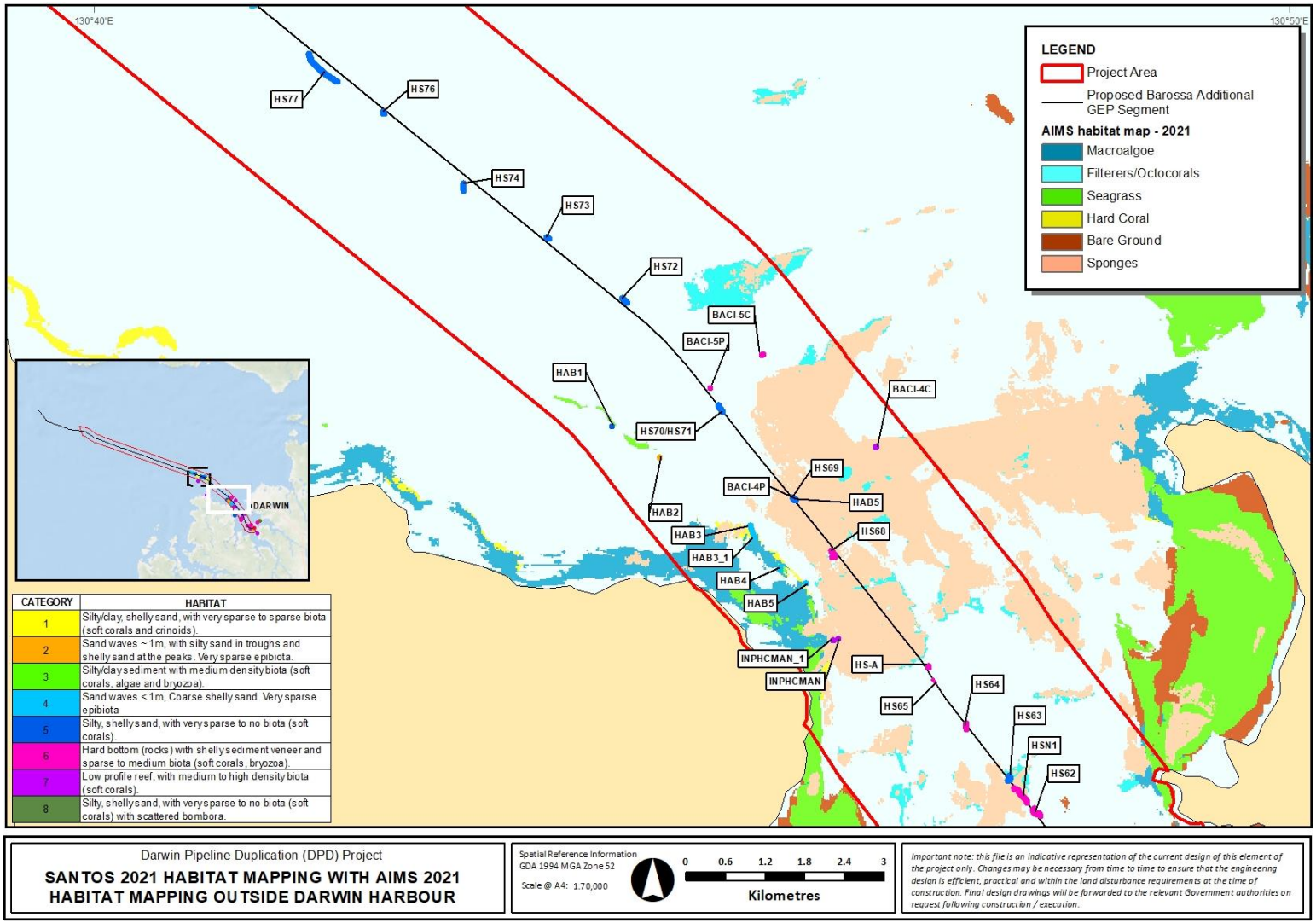


Figure 5-2: RPS surveys habitat mapping against AIMS 2021 habitat mapping outside Darwin Harbour (AIMS, 2021)

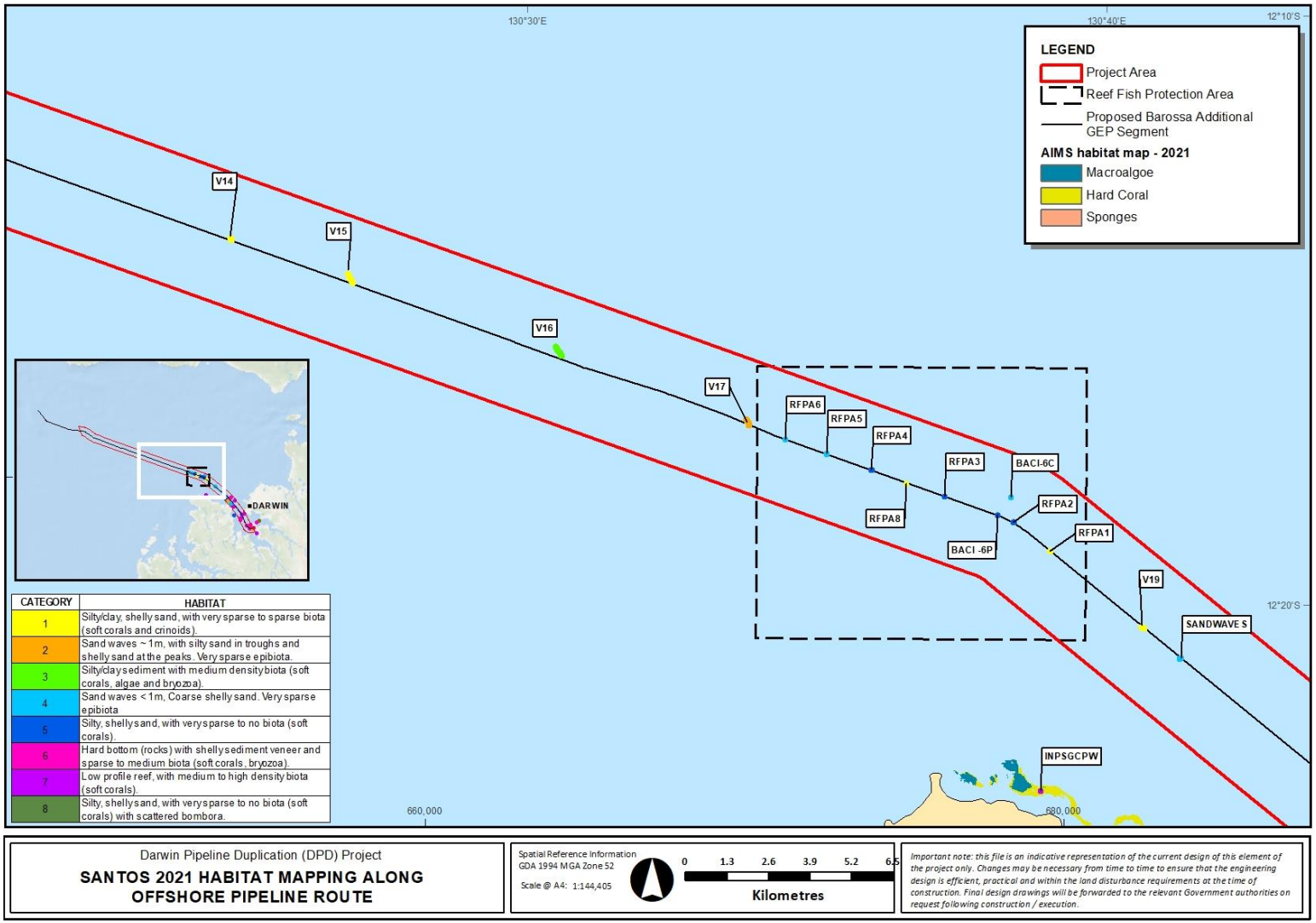


Figure 5-3: RPS surveys habitat mapping along offshore pipeline route

5.2.3 Hard Coral

Hard coral communities in Darwin Harbour mainly consist of low-relief encrusting, small massive, sub-massive and low-profile foliose types found in the lower intertidal and upper subtidal areas, down to depths of 5 – 10 m below LAT (Cardno, 2014). Coral communities are sparse and consist of patches of individual colonies occupying approximately 20% of the seabed. A total of a 123 species have been reported to inhabit the Darwin region with Ichthys NEMP identifying 48 species within the Darwin Harbour (Wolstenholme *et al*., 1997; Cardno, 2014). Coral species inhabiting the harbour tolerate variable salinity, high turbidity, low light availability and high sedimentation. Additionally, corals can be impacted by high water temperatures and exposure due to spring low tides, making them vulnerable to desiccation and possibly freshwater impacts if tides coincide with heavy rainfall events (Cardno, 2015). In addition to specific environmental pressures coral communities are also subject to natural biological pressures such as predation, disease, and competition (Cardno, 2014).

Hard coral communities were found within the Project Area during the June 2022 RPS survey at Weed Reef (INPHWED2), Mandorah (INPHCMAN & INPHCMAN_1) and at sites in the central portion of the harbour and outside the Project Area at Channel Island (INPHCCHI), Northeast Wickham Point (INPHCNEW), and South Shell Island (INPHCSSI) (BAS 210 0014; RPS, 2022; **Figure 5-1** and **Figure 5-2**). All these sites were predicted to be suitable to support hard corals by AIMS 2021 habitat mapping. Charles Point Wide (INPSGCPW) was additionally predicted to support hard corals although the June 2022 survey found no hard corals present (**Figure 5-3**). Channel Island coral communities are protected under the *Heritage Act 2011* (NT) due to their high diversity despite being well inside a large, drowned river valley characterised by multiple stressors (DCCEEW, 2022).

5.2.4 Filter Feeders

The DPD Project October 2021 and June 2022 habitat surveys found varying densities of soft corals occurring at sites both within and outside the harbour, including along the pipeline route and at the spoil ground. Soft coral types consisted of gorgonians*, Junceella sp* and Alcyoniidae with *Neptheidae* only found at offshore sites (BAS 210 0014; RPS, 2022). Other filter feeding biota observed from benthic habitat surveys along the pipeline route included hydroids, bryzoa, crinoids, anemones, and sponges (BAS 210 0014; RPS, 2022).

5.2.5 Seagrass

Seagrass meadows have been identified to occur along the Cox Peninsula near Charles Point and Woods Inlet as well as along the eastern shore from Fannie Bay to Lee Point (Cardno, 2014). This seagrass habitat is dominated by early colonising seagrass species *Halodule uninervis* and *Halophila decipiens*. These species are fast growing and known to survive well in unstable and depositional environments (Green & Short, 2003).

Other than these areas, Darwin Harbour is not known to host significant seagrass meadows. Very sparse *Halophila sp* and sparse *Halodule uninervis* and *Halophila decipiens* coverage has been recorded during other environmental surveys at Weed Reef and Wickham Point respectively (INPEX, 2010).

The AIMS 2021 benthic habitat mapping predicted seagrass habitat north of Mandorah within the Project Area and Woods Inlet outside the Project Area. However, the habitat surveys completed in June 2022 only found low density seagrass meadows at Woods Inlet (BAS 210 0014; RPS, 2022).

5.2.6 Macroalgae

Within Darwin Harbour macroalgae communities are typically located between the intertidal and subtidal zones, a few metres either side of the low-water mark and generally are associated with coral

or sponge dominated communities. Macroalgae community composition is dependent on seasonality, INPEX (2010) suggests that this is regulated by the amount of time exposed during spring low tides. Turf algae is more dominate during the build-up season (October to December), due to large tidal range and extreme spring low tides occurring during the middle of the day, causing larger macroalgae dieback. Larger macroalgae species are more dominant during the dry season when the tidal range is less extreme.

The AIMS 2021 benthic habitat mapping predicted macroalgae habitat sites at the opening of Darwin Harbour north of Mandorah, and sites close to Wickham Point including Channel Island and northeast Wickham Point. However, macroalgae communities were only found to occur at sites at the opening of Darwin Harbour north of Mandorah with very low coverage and in the central portion of the harbour in moderate densities (BAS 210 0014; RPS, 2022).

5.2.7 Soft-bottom benthos

It is estimated that approximately 80% of available substrate in the Darwin Harbour consists of soft substrates (McKinnon *et al.*, 2006). This was confirmed by DPD Project benthic habitat surveys which found that soft sediment benthic habitats were well represented along the pipeline route (BAS 210 0014; RPS, 2022). The Barossa DPD surveys recorded filter feeders at sparse densities across almost all soft substrate types. The outer offshore pipeline route was observed to be dominated by fine sand/silt with sparse epibiota, consisting of occasional sponges and soft corals, and bioturbation with some sand waves. The habitat just outside the mouth of Darwin Harbour consisted mainly of course rippled sand, with low overall epibiota. Spoil ground sites consisted of the same silty/clay soft substrate habitat with medium density of biota (BAS 210 0014; RPS, 2022). This biota mostly consisted of soft corals (gorgonians, *Junceella*, Alcyoniidae), branching and encrusting sponges, Bryzoa (lace coral), invertebrates, polychaetes, brown algae, and occasional motile crinoids (BAS 210 0014; RPS, 2022).

5.3 Terrestrial ecosystems

5.3.1 Flora

A search of the DEPWS Natural Resource (NR) Maps database for threatened flora and significant flora within 5 km of the onshore Project Area identified one significant flora species, Byblis (*Byblis aquatica*) (DEPWS, 2022). This species is listed as near threatened under the *Territory Parks and Wildlife Conservation Act 1976* (TPWC Act) and was recorded approximately 5 km to the south-east of the onshore Project Area. It grows in semi-aquatic conditions and is insectivorous to acquire nutrients in nutrient-poor environments (Atlas of Living Australia, 2022). This species is commonly found in areas specifically between Darwin and Berry Springs.

Previous flora surveys of the DLNG Facility disturbance envelope did not identify the presence of any threatened or conservation significant flora species (BAA-201 0003; Santos, 2021). The Byblis is unlikely to occur within the onshore Project Area as it has been previously disturbed and there are no permanent freshwater habitats present (BAA-201 0003; Santos, 2021).

5.3.2 Mangroves

Darwin Harbour is known for its mangrove diversity with 36 of the 50 known mangrove species found in the fringing coastal area (Lee, 2003). The most common species in Darwin Harbour are *Rhizophora stylosa*, *Ceriops tagal*, *Sonneratia alba*, *Bruguiera exaristata*, *Avicennia marina* and *Camptostemon schultzii* (NTG, 2002). Mangroves cover approximately 27,350 ha of intertidal mudflats in the greater Darwin Harbour area and are an integral part of the ecosystem acting as nursery and spawning grounds

for fish and crustacean species, as well as having recreational value (McKinnon *et al.*, 2006; Semeniuk, 1985; NTG, 2011).

5.4 Fauna

The Darwin region supports several marine fauna including marine reptiles, marine mammals, and fish/sharks with key species described below. Further details of key species can be found in DPD Project NT EPA Referral (BAA-201 0002; Santos, 2021) and SER (BAS-210 0020)

5.4.1 Marine mammals

Darwin Harbour is classified as a Biologically Important Area (BIA) for three species of coastal dolphin (Australian Snubfin dolphin, Indo-Pacific Spotted bottlenose dolphin and Indo-Pacific humpback dolphin).

Dolphin species are the most recorded marine mammal in Darwin Harbour and within Darwin Harbour, with the Australian snubfin (*Orcaella heinsohni*), Indo-Pacific humpback (*Sousa chinensis*) and Indo-Pacific spotted bottlenose (*Tursiops aduncus*) having known resident populations in Darwin Harbour. There are approximately 150 individuals across all species thought to inhabit the Darwin region (Brooks & Pollock, 2015). Other than the dolphins, occasional pods of false killer whales (*Pseudorca crassidens*) are known to inhabit Darwin Harbour.

Dugongs (*Dugong* dugon) are also known to occur in the Darwin region. Ichthys NEMP dugong monitoring estimates approximately 180 to 300 individuals inhabit the Darwin Region (Cardno, 2014). Within the Darwin Harbour Region Marine Management Area, dugongs have been observed to be associated with seagrass habitat at Casuarina Beach and Lee Point with greater abundance in these areas, as recorded by visual surveys (Cardno, 2014).

5.4.2 Marine reptiles

Six species of marine turtle (all listed as threatened under the EPBC Act) are known to occur in NT waters, of these only green, hawksbill and flatback turtle are known to inhabit Darwin Harbour regularly (**Table 5-3**). While olive ridley and loggerhead turtles are known to occasionally inhabit Darwin Harbour, leatherback turtles are unlikely to occur in Darwin Harbour as they are an oceanic species (Whiting, 2001; Whiting, 2003). Within Darwin Harbour, the closest nesting sites are at Casuarina Beach and Cox Peninsula, although these sites are not considered a significant nesting area (Chatto & Baker, 2008; Pendoley, 2022). Important turtle nesting sites in the region include Bare Sand Island and Quail Island located approximately 50 km from Darwin near the mouth of Bynoe Harbour.

Saltwater crocodiles (*Crocodylus porosus*) are known to commonly inhabit Darwin Harbour (**Table 5-3**). Saltwater crocodiles breed during the wet season between October and May. Nesting within Darwin Harbour is known to be limited.

Table 5-3: Marine reptile conservation status.

Scientific name	Common name	Conservation status	
		Commonwealth	Northern Territory
Chelonia mydas	Green turtle[1]	Endangered/Migratory	Vulnerable
Eretmochelys imbricata	Hawksbill turtle[1]	Vulnerable/Migratory	Near threatened
Natator depressus	Flatback turtle[1]	Endangered/Migratory	Critically endangered
Caretta	Loggerhead turtle[2]	Vulnerable/Migratory	Vulnerable
Lepidochelys olivacea	Olive ridley turtle[2]	Endangered/Migratory	Vulnerable
Dermochelys coriacea	Leatherback turtle	Vulnerable/Migratory	Data deficient
Crocodylus porosus	Saltwater crocodile[1]	Migratory	Least concern

Notes:
1. Regularly frequent Darwin Harbour
2. Occasionally frequent Darwin Harbour

5.4.3 Fish and sharks

Darwin Harbour supports an abundance of fish species across an array of habitats. There is a diverse range of species within the harbour, from small site-specific species such as gobies, cardinals, and pipefish to larger species of recreational and commercially importance such as mackerel, trevallies, and barramundi. Barramundi is the most targeted recreational species in the NT accounting for 26% of total recreational catch, however, barramundi only accounts for 5% of total catch in Darwin Harbour. Jewfish are the most targeted species in Darwin Harbour followed by Golden snapper (Cardno 2015f) Juvenile recreationally and commercially important species such as mackerel, trevallies and barramundi utilise mangroves within Darwin Harbour for habitat.

There are three EPBC Act listed sawfish species, the dwarf sawfish (*Pristis clavate*), freshwater sawfish (*Pristis prisitis* or *Prisitis microdon*) and green sawfish (*Pristis zijsron*), which have been occasionally recorded in the Darwin area however, they are considered unlikely to occur with the Project Area.

Whale sharks are known to migrate to Australian waters seasonally, aggregating at Ningaloo Reef and in the Coral Sea following surges in food productivity. The migratory paths of whale sharks are not known to include Darwin Harbour and records from NT coastline are anecdotal (Woinarski *et al.*, 2007).

5.4.4 Seabirds and shorebirds

Of the 37 species of migratory shorebirds that regularly visit Australia (Commonwealth of Australia, 2017b; Lilleyman *et al*., 2018), 25 of them occur along the coastlines of Darwin Harbour, which has a variety of coastal habitats that migratory shorebirds use during the non-breeding season (Lilleyman *et al*., 2018). This includes natural sites such as beaches, rocky reefs, intertidal sand and mud flats, but also an artificial site – the dredge spoil disposal ponds at Darwin Port's East Arm Wharf.

Lilleyman *et al*. (2018) undertook aerial surveys of Darwin Harbour and recorded 724 individuals of 19 species of bird during the low tidal phase of the survey and at high tide recorded 789 individual shorebirds belonging to 13 species. The study was focused on the Far Eastern curlew (*Numenius madagascarensis*), two flocks of which were identified in numbers that meet the threshold for protection of threatened shorebirds under the EPBC Act. One flock was recorded at East Arm Wharf,

where large congregations assemble frequently. The other flock was at a saltpan, south-east of East Arm Wharf, adjacent to the Darwin LNG Plant (although it was noted that this roosting site may not be available at the highest tides) (Lilleyman *et al*., 2018).

5.4.5 Phytoplankton

Inner Darwin Harbour is known to have low concentrations of bio-available nutrients, low light levels and high turbidity which limits the growth of phytoplankton, additional the large tidal range also ensures that the Harbour is well flushed (Cardno, 2014). Ichthys NEMP monitoring found low biomass of phytoplankton indicated by low Chlorophyll-a fluorescence, although there was a slight increase in phytoplankton biomass during the wet season compared to the dry season (Cardno, 2014). This could be due to the additional nutrient input from increased rainfall and subsequent runoff (Cardno, 2014). Variations in phytoplankton biomass within Darwin Harbour follows complex patterns indicating that multiple factors may influence the productivity of phytoplankton in the Harbour (Cardno, 2014).

5.5 Parks, reserves and reef protection areas

The conservation, control and management of parks and reserves within NT is the responsibility of the DEPWS. Parks and reserves located within the Darwin Harbour management area, and a summary of their values are stated in **Table 5-4**. None of these parks and reserves overlap with the DPD Project area.

Additionally, East point (~365 ha) and Doctors Gully (~14 ha) Aquatic Life Reserves (**Figure 5-4**) have been established under the *Fisheries Act* (NT), to provide protection of marine life and habitats. East Point Aquatic Life Reserve allows for restricted recreational fishing while Doctors Gully Aquatic Life Reserve prohibits all fishing (NTG, 2016). Both of these Aquatic Life Reserves are within Darwin Harbour but outside of the DPD Project area.

Table 5-4: Parks and reserves in the Darwin area.

Name	Description
Charles Darwin National Park	The national park is located a short distance from Darwin City centre in Frances Bay and is approximately 4 km from the DPD Project Area at its closest point. The park encompasses approximately 1,040 ha protecting natural, cultural, recreational, and historical values (PWC NT, undated). Natural values protected within the park consists of mangrove communities and sections of relatively undisturbed woodland/grassland communities, which host diverse flora and fauna communities and intertidal mudflats rich in birdlife (PWC NT, undated). In addition to these natural values the park has Aboriginal cultural values. The Larrakia people have strong links to the land, including Aboriginal shell middens. There is also historical significance as the area was used by the defence force during World War Two (PWC NT, undated).

Name	Description
Casuarina Coastal Reserve	The Reserve covers approximately 1,361 ha and is located 15 km from Darwin City centre and is approximately 10 km from the DPD Project Area at its closest point. It encompasses woodlands, monsoonal vine forest and a pristine coastline, making it a popular area for locals and visitors to frequent (PWC NT, 2016). Although the reserve is primarily used for recreation it also possesses natural and cultural values of significance locally. Key natural values protected in the reserve include feeding and roosting sites for migratory shorebirds, significant seagrass meadows and nesting sites for three marine turtle species (PWC NT, 2016). The reserve falls within land traditionally owned by the Larrakia people and is still very important and regularly used by the traditional custodians, with the being several sacred sites throughout the reserve (PWC NT, 2016). There is additionally historical significance, as it was developed as part of the coastal defence strategy after World War Two. Ten of the original eleven 'Singapore-style' observation posts remain in the reserve and are open to visitors (PWC NT, 2016).
Shoal Bay Coastal Reserve	The Coastal Reserve is 40 km east of Darwin and protects a vast coastal area from Howard River to Gunn Point's eastern boundary (Top End Tourism, 2022). It is approximately 30 km from the DPD Project Area. Extensive mud and sandflats are the most predominant habitat throughout Shoal Bay, although the site does include several swamps and remnants of monsoonal vine forest (Harrison *et al*., 2009). The vast tidal flats throughout Shoal Bay provide essential roosting and feeding habitat for the migratory shorebirds in the non-breeding season (Harrison *et al*., 2009). Shoal Bay also protects large areas of cultural significance to the Larrakia people, with 1,000-year-old shell middens being present within the higher ground near the swamps (NTG, 2022).
Tree Point Conservation Area	The Conservation Area protects a section of the Shoal Bay coast on Tree Point Peninsula, an extensive mangroves habitat and a tidal creek, which runs toward the Shoal Bay Coastal Reserve (PWC NT, undated). It is approximately 30 km from the DPD Project Area. The area is fringed with coastal vine thickets and a swampy floodplain and hosts several bird species throughout the year (PWC NT, undated). The area is only open to the public during the day and is primarily used for walking, bird watching and fishing (PWC NT, undated).

The DPD Project pipeline intersects the Charles Point Wide Reef Fish Protection Area (RFPA) (NT) and is approximately 9 km to the east of the Lorna Shoal RPA (**Figure 5-4**). The objectives of the reef protection areas are specific to impacts from the fishing industry. No fishing activities are permitted within RPAs as the protection of these areas is to prevent over-fishing and/or barotrauma related injury of Golden snapper, Black jewfish and other vulnerable reef species. NT Fisheries also identified a known jewfish aggregation area within the RFPA. This is approximately 2.5 km to the south-west of the pipeline route. The Charles Point Wide RFPA is outside of Darwin Harbour and no DPD Project trenching and spoil disposal activities will occur within this area.

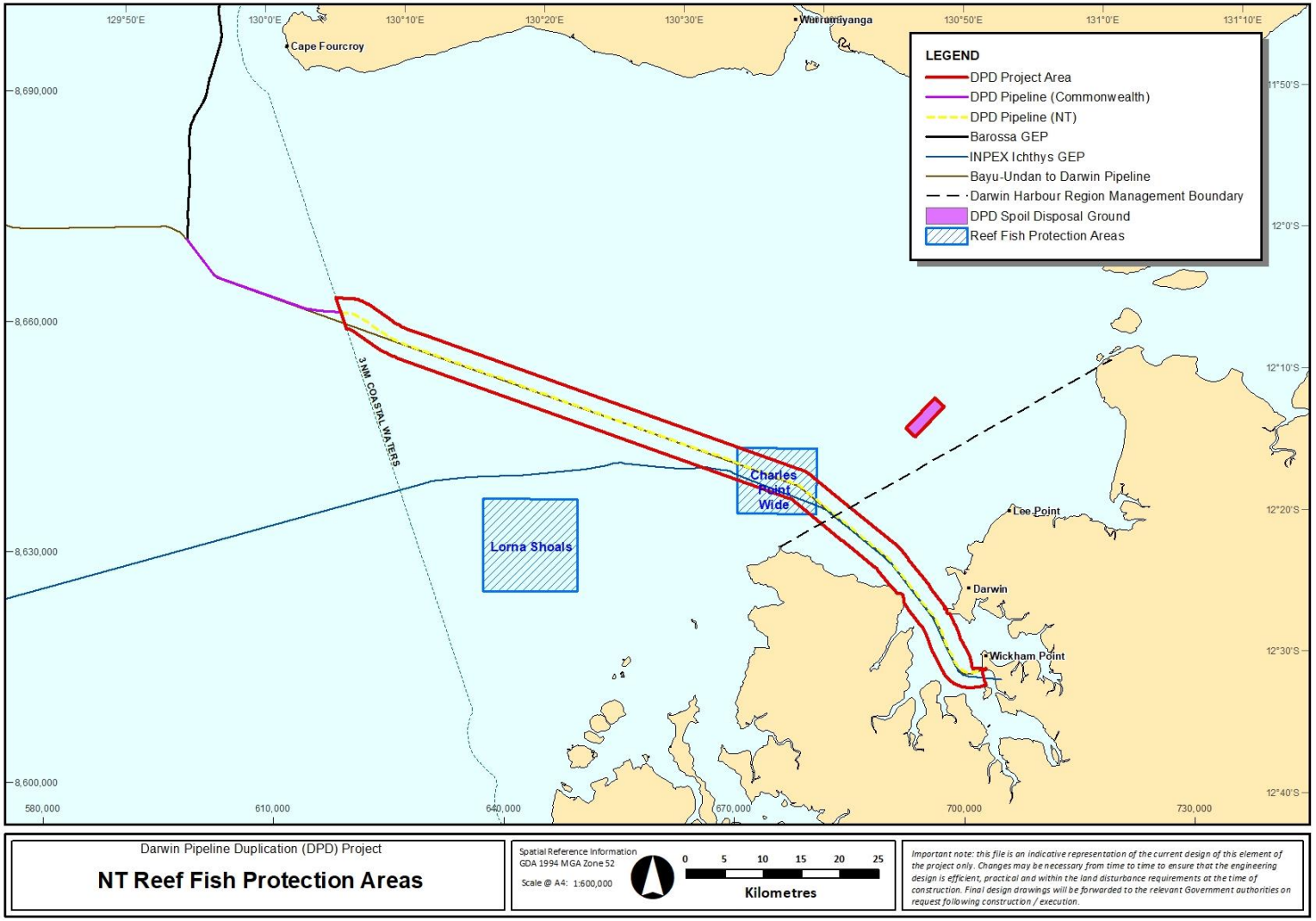


Figure 5-4: Charles Point Wide and Lorna Shoals reef fish protection areas

5.6 Socio-economic environment

Socio-economic activities that may occur within the Project Area and surrounds including commercial fishing, oil and gas exploration and production, and to a lesser extent, recreational and traditional fishing, defence activities, heritage places and tourism, as summarised in **Table 5-5.**

More detailed descriptions of socio-economic considerations are provided in DPD Project Offshore CEMP (BAS-210 0024) and DPD Project Supplementary Environmental Report (SER) (BAS-210 0020).

Table 5-5: Summary of socio-economic activities that may overlap with the Project Area.

Value/ sensitivity	Description
Commercial fishing – Commonwealth	The Northern Prawn Fishery is the only active Commonwealth fishery that overlaps the Project Area. There are three other inactive or low operating (less than five vessels active in the fishery each year since 2005) Commonwealth managed fisheries overlapping the Project Area: Southern Bluefin Tuna Fishery, Western Tuna and Billfish Fishery and the Western Skipjack Tuna Fishery (DoAWR, 2016).
Commercial fishing and aquaculture – state (NT)	There are five NT State fisheries which intersect the Project Area: Coastal line, Demersal, Offshore net and line, Spanish mackerel, and Aquarium Fishery.
Recreational fishing	Recreational fishing does occur within the Project Area. The Darwin Harbour/Surrounds fishing zone supporting 63% of total fishing effort within the Greater Darwin Area (Matthews *et al.*, 2019).
Traditional fishing	Traditional Australian Indigenous fishing in NT waters predominately occurs within inshore tidal waters. Approximately 55% of NT's coastline is owned by Traditional Aboriginal Owner groups in the Northern Land Council region (NLC, 2022).
Tourism	Within Darwin Harbour common tourism/recreational activities include fishing, boating, scuba-diving, sailing, water-skiing, and beach use (INPEX Browse, 2010).
Shipping	The closest major commercial port to the Project Area is Darwin. The Darwin Port Corporation serves multiple shipping and cargo markets, including cruise and naval vessels, livestock exports, dry bulk ore, offshore oil and gas rig services, and container and general cargo.
Defence	The Project Area intersects a Central Defence Practice Area of the Darwin Air Weapons Range (AWR), a maritime military zone administered by the Department of Defence. The Project Area is also nearby to the Australian Exercise Area (NAXA) Defence Training Area approximately 3km to the South. Additionally, the Project Area borders the HMAS Coonawarra Naval Base in Darwin Harbour.

Value/ sensitivity	Description
Petroleum industry	Several offshore petroleum projects are in operation and there is considerable exploration activity within the region; however, only the existing INPEX Ichthys and Santos Bayu-Undan to Darwin gas export pipelines overlap with the Project Area.
Cultural heritage – Aboriginal sacred sites	The AAPA certificate (C2022/098) issued to Santos for the DPD Project has identified a restricted works area associated with an underwater sand and rock bar outside the mouth of the Harbour, north of Cox Peninsular where no works or damage is to occur.
Cultural heritage – Non-Indigenous heritage sites.	Five Historic shipwrecks listed under the *Commonwealth Cultural Heritage Act 2018* are overlapped by the Project Area: I-124 Japanese Submarine (1942) 800 m radial protection zone, Yu Han 22 unlisted protection zone, Song Saigon (1982) unlisted protection zone, Mauna Loa USAT (1942) 100 m radial protection zone and Meigs USAT (1942) unlisted protection zone (DAWE, 2022). Additional potential maritime heritage objects have been identified within the Project Area through surveys and third-party maritime heritage assessment, the majority of which will be avoided by Project activities (Cosmos, 2022). Two identified heritage objects have been identified along the DPD Pipeline route that cannot be avoided, further assessment and intervention works will be undertaken prior to construction in accordance with NT Heritage Branch requirements to minimise disturbance to these objects.

5.6.1 Commercial fishing and aquaculture

5.6.1.1.1 Commonwealth fisheries

The Northern Prawn Fishery is the only active Commonwealth managed fishery that overlaps the Project Area (Santos, 2021). The Commonwealth managed Southern Bluefin Tun Fishery, the Western Tuna and Billfish Fishery and the Western Skipjack Tuna Fishery overlap with the project area but have been excluded from assessment as these fisheries are either inactive or operate at extremely low levels (< 5 vessels active each year since 2005) within or nearby the project area (DoAWR, 2016; Santos, 2021).

5.6.1.1.2 Northern Territory fisheries

Northern Territory fisheries include the NT Aquarium Fishery, the Offshore Net and Line Fishery, the Spanish Mackerel Fishery, the Coastal Line Fishery, the NT Demersal Fishery (Santos, 2021). The NT Aquarium Fishery includes freshwater, estuarine, and marine habitats to the outer boundary of the Australian Fishing Zone (AFZ), which is 200 nm offshore (Santos, 2021). Offshore Net and Line Fishery and Spanish Mackerel Fishery extend from the high-water mark of NT waters to the outer boundaries of the AFZ (Santos, 2021). The NT Demersal Fishery extends 15 nm from the NT low water mark to the outer limit of the AFZ, excluding the area of the Timor Reef Fishery (Santos, 2021). The Coastal Line Fishery extends seaward from the high-water mark to 15 nm from the low water mark, covering the entire NT coastline (Santos, 2021).

Most fisheries are not permitted to operate within Darwin Harbour, except for the Coastal Line Fishery and NT Aquarium Fishery (Department of Primary Industry and Resources , 2015). There are 51 licences for the Costal Line Fishery with only 7 – 8 being active in 2019 (Department of Primary Industry and Resources, 2018). Therefore there is little to no commercial fishing taking place within Darwin Harbour (INPEX, 2018).

The Darwin Aquaculture Centre is located on Channel Island in the Middle Arm Peninsula. It is a research facility undertaking a range of research and development projects on several species including pearl oysters, sea cucumbers, giant clams, prawns, barramundi, mud crabs, reef fish (NT Government, 2018). As well as undertaking several disease investigations (NT Government, 2018).

5.6.2 Shipping

Darwin Harbour is Australia's nearest port to Asia and is the 'northern gateway' for Australasian trade. Operations mainly consists of marine traffic from non-commercial vessels and trading vessels, which includes commercial vessels carrying cargo and passengers, rig tenders, tankers and bulk-cargo vessels that utilise East Arm Wharf and the cruise ship terminal at Fort Hill Wharf (Darwin Port, 2020).

In 2021/22 the port of Darwin was visited by 1,510 trade vessels and 36 cruise ship vessels, cruise ship numbers in 2020/21 and 2021/22 have been significantly lower than previous years likely due to COVID-19 restrictions (Darwin Port Operations, 2022).

5.6.3 Recreational activities and tourism

During 2021 there were 1,283,000 visitors to the Northern Territory, which contributed an estimated $1.84 billion to the local community. This was substantially lower than 2019, with 2,001,000 visitors contributing an estimated $2.6 billion, likely due to the reduction in international visitation resulting from border closures (Northern Territory Government, 2022).

The Darwin Harbour supports a range of commercial and recreational uses, including fisheries, tourism and recreational shipping and boating activities. Fishing tours often frequent Fenton Patches located approximately 30 km north-west of Darwin Harbour. Recreational fishers also visit Casuarina Bay and Lee Point (INPEX, 2010).

The INPEX Nearshore Environmental Monitoring Plan identified the presence of distinct seasonal behaviour of recreational anglers, with barramundi commonly targeted in the wet season and golden snapper, black jewfish, mackerel and tuna commonly targeted in the dry season (Cardno, 2014).

The water surrounding Middle Arm Peninsula is used for recreational fishing, sailing, and boating. However, tour boats tend to avoid this section of the harbour due to navigational hazards associated with the shallow nearshore waters (URS, 2002).

5.6.4 Traditional fishing

Approximately 55% of NT's coastline is owned by Traditional Aboriginal Owner groups in the Northern Land Council region (NLC, 2022). Several areas within this coastal region have been declared Aboriginal sacred sites, which are restricted from other recreational and commercial fishing. Within Darwin Harbour, fishing and foraging for food and other resources occurs within the intertidal regions, mainly around Nightcliff, Coconut Grove, Kululuk, Sadgroves Creek, and Lee Point (INPEX, 2010). As such, Indigenous fishing is likely to occur within the coastal areas of the Project Area but is likely to be restricted mainly to NT coastal waters.

5.7 Cultural environment

Darwin Harbour is host to a wide range of historical, spiritual and heritage values that are significant to the people of the Northern Territory and Australia. These values have been broadly categorised as either Aboriginal and non-Aboriginal values and are described in more detail in the following sections.

5.7.1 Aboriginal sacred sites

Sacred sites are places within the landscape that have a special meaning or significance under Aboriginal tradition, this can include hills, rocks, waterholes, trees, plains, lakes, billabongs (AAPA, 2022). There are many sacred sites within Darwin Harbour and the surrounding waters, all sacred sites within the NT are protected under the *Northern Territory Aboriginal Sacred Sites Act 1989* (Sacred Sites Act). In coastal and sea areas, sacred sites may include features which lie both above and below the water (AAPA, 2022).

Sacred sites within Darwin Harbour, including three rocky areas or shoals on the western side of the Darwin Harbour, and an underwater sand and rock bar outside the mouth of the harbour, north of the Cox Peninsula (INPEX, 2010).

Santos has received an AAPA Authority Certificate (C2022-098) and will ensure the requirements of the certificate (including avoidance of restricted work areas) and the *Northern Territory Aboriginal Sacred Sites Act 1989* are met.

5.7.2 Non-Indigenous heritage sites

Darwin Harbour is host to several shipwrecks and sunken aircraft, some of which are protected under the *Heritage Act 2011* (NT) and/or the *Underwater Cultural Heritage Act 2018* (Commonwealth). Most wrecks are associated with either, the bombing of Darwin in 1942 or Cyclone Tracy in 1974 (INPEX, 2018). The Project Area is within ~2 km east of the oldest known wreck in Darwin Harbour the SS *Ellengowan*, a nineteenth-century Norwegian-built iron steamer, which is of high significance to maritime archaeology (NTG, 1999).

The *Underwater Cultural Heritage Act 2018* may declare a protected zone around wrecks which require a permit to enter, there are currently three protected zones having closed water orders in NT. These are the Japanese submarine I-124 (1942), Florence D (1942) and Sanyo Maru (1937). The regional harbourmaster has also ordered the Booya and Catalina 6 wrecks to have closed water controls over them and permission from the Heritage Branch is needed to enter the zones.

The Australian National Shipwrecks Database has identified five historic wrecks that overlap the Project Area, all of which are listed under the Underwater Cultural Heritage Act (DCCEEW, 2022). These wrecks are the Japanese submarine I-124 (1942) 800 m radial protection zone, Yu Han 22 unlisted protection zone, Song Saigon (1982) unlisted protection zone, Mauna Loa USAT (1942) 100 m radial protection zone and Meigs USAT (1942) unlisted protection zone (DCCEEW, 2022)

No European heritage is currently listed at Wickham Point, with the remnants of artefacts documented and removed prior to the construction of the DLNG facility. There are no World, National or Commonwealth heritage places within or near the Project Area.

The DPD pipeline route has been selected so that potential maritime heritage objects identified within the Project Area, will be avoided by Project activities (Cosmos, 2022). Two identified heritage objects have been identified along the DPD Pipeline route that cannot be avoided, further assessment and intervention works will be undertaken prior to construction in accordance with NT Heritage Branch requirements to minimise disturbance to these objects.

5.8 Windows of sensitivity

Timing of peak activity/sensitivity for marine fauna and flora and socio-economic activities is outlined in **Table 5-6**.

Table 5-6: Windows of sensitivity for environmental receptors in the vicinity of the Project Area

Key	
	Peak activity, presence reliable and predictable
	Lower level of abundance/activity/ presence
	Very low activity/presence
	Activity can occur throughout year

Footnotes

[1] The 'run-off' is towards the end of the wet season and is the peak Barramundi fishing season for recreational fishers (https://northernterritory.com/things-to-do/outdoor-activities/fishing/fishing-seasons/the-run-off)

[2] Chatto & Baker (2008)

Receptors (critical lifecycle stages)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Seagrass												
Coral (spawning periods)												
Larger Macroalgae												
Turf Algae										Build-up season		
Mangroves (increased productivity)												
Other benthic and terrestrial habitats												
Fish/sharks and fisheries species												
Barramundi			'The Run-Off'[1]									
Goldband snapper	Spawning										Spawning	
Black jewfish								Spawning				
Grey mackerel									Spawning			
Narrow-barred Spanish mackerel										Spawning		
Marine mammals												
Dugong (breeding)	Breeding								Breeding			
Australian snubfin Dolphin	Breeding											
Indo-Pacific Humpback Dolphin	Breeding											
Spotted Bottlenose Dolphin									Breeding			
Marine reptiles												
Hawksbill turtle (resident adult and juveniles[2])	Widespread throughout North Australian waters, highest density of adults and juveniles over hard bottom habitat (coral reef, rocky reef, pipelines, etc.)											
Flatback turtle (resident adult and juveniles[2])	Widespread throughout North Australian, increased density over soft bottom habitat 10 to 60 m deep, post-hatchling age classes and juveniles spread across shelf waters											
Flatback turtle (nesting[2])												
Green turtle (resident adult and juveniles[2])	Widespread throughout North Australian, highest density associated with seagrass beds and macro algae communities, high-density juveniles in shallow waters off beaches, among mangroves and in creeks											
Loggerhead turtle (resident adult and juveniles[2])	Widespread throughout the North Australian, increased density associated with soft bottom habitat supporting their bivalve food source, juveniles associated with nearshore reef habitat											
Socio-economic												
Northern Prawn Fishery												
Oil and gas												
Shipping												
Tourism/recreational												

6 Sediment Dispersion Modelling and Water Quality/Benthic Habitat Impact Predictions

6.1 Introduction

Sediment dispersion modelling was completed for the DPD Project (BAS 210 0036; RPS, 2022b) to investigate the potential impact on water quality and benthic habitats from the following sources during construction:

+ Suspended material generated during trenching along the pipeline route
+ Suspended material during spoil disposal at the spoil disposal ground.

This sediment dispersion model included two parts:

1. A Hydrodynamic and Wave model
    i. Existing D-FLOW hydrodynamic and D-WAVE wave model frameworks in Darwin Harbour were reconfigured to increase resolution within the harbour and update the model with the latest bathymetric data. This was followed by re-validation of the model predictions against available measurements of water levels, currents and waves.
    ii. Two years (2019 – 2020) of hydrodynamic and wave simulation data were produced for use as input to the sediment dispersion model.
2. A Sediment Dispersion model:
    iii. Inputs for the trenching program were prepared for the DREDGEMAP model, accounting for all potential concurrent sources of sediment characterised by location, intensity, particle size distribution, vertical distribution in the water column, and levels of cohesivity.
    iv. Two trenching and disposal scenarios were simulated (**Section 6.4**)
    v. Simulation outputs from each separate trenching and disposal activity were post-processed, combined and analysed to determine outcomes including zones of impact and influence for each scenario based on specified threshold criteria (**Section 6.3** and **Section 6.5.2**).

Key model outcomes were provided as spatial datasets in GIS shapefile format. Further details of sediment dispersion modelling methodology can be found in the Santos Barossa DPD Sediment Dispersion Modelling (BAS 210 0036; RPS, 2022).

6.2 Dredge plume sources

To accurately represent the pipeline trenching and spoil disposal operations in DREDGEMAP, a range of information was defined for the proposed operations, including trenching and disposal methodology, production rates, and sediment/rock types and quantities. Six different sources of suspended sediment plumes during trenching and disposal operations, can be broadly defined as:

1. Direct suspension of material from the BHD bucket, from grabbing and lifting sediments and rock through the water column, including sedimentation from dewatering of SHBs accounting for periods of no-dewatering.
2. Disposal of sediment and rock excavated by the BHD from the SHBs to the spoil ground.

3. Direct suspension of material by the TSHD during trenching of sediments, and CSD-crushed material, accounting for no-overflow and overflow periods.
4. Disposal of sediment and CSD-crushed material removed by the TSHD to the spoil ground.
5. Direct suspension of material by the CSD during trenching of rock and casting material behind the dredge at low velocity, just above the seabed.
6. Indirect suspension of material due to the propeller-wash of the SHB and TSHD while trenching.

Each of these sources of suspended sediment plumes will vary in strength and persistence depending on the nature of the operations. In the DREDGEMAP model, each source is defined by specifying the time-varying flux rate, PSD and vertical profile in the water column.

For each source of suspended sediment during trenching and disposal operations the associated loss rates and approximate volumes of suspended sediment expected were determined. The volumes assigned to the respective non-overflow and overflow periods for TSHD trenching, and non-dewatering period for BHD trenching, are based on the modelled cycle times as detailed in the Santos Barossa DPD Sediment Dispersion Modelling report (BAS 210 0036; RPS, 2022).

Note that the currently proposed total trenching volume (detailed in **Table 2-1**) is 6 % greater than that modelled as the modelling was based on the known project information at the time. An increase in trench volume of this magnitude will have a detectable but very small impact on the predicted extents of sediment dispersion. Given the predicted zones of impact and influence are small, restricted to within the trenching area (refer to **Section 6.5.3.4**) and there ae no sensitive habitats directly adjacent, it is considered that this increase will not be significant in terms of potential environmental impact. Further the actual trench volumes will likely be less than those modelled as the Pre-Sweep areas will only be trenched in targeted locations where pre-lay rectification is required.

6.3 Tolerance limits for habitats

Predictions of Suspended Sediment Concentration (SSC) and sedimentation for each scenario were assessed against a series of water quality and sedimentation thresholds to categorise the modelled outcomes into management zones of influence and impact, defined with regard to environmental sensitivities in the study region. The thresholds and the approach applied to the DPD Project are based on the extensive environmental monitoring and threshold work that INPEX completed for the Ichthys project environmental impact statements, and capital and maintenance dredge management plans in Darwin Harbour (INPEX, 2010, 2011, 2013, 2018 and 2022).

To calculate areas of potential impact from trenching-induced excess SSC and sedimentation, INPEX established seasonal tolerance limits/thresholds for sensitive receptors including mangrove, seagrass and hard coral habitats (**Table 6-1**). The INPEX tolerance limits for SSC were derived from comprehensive site-specific water quality monitoring data (covering multiple years and locations), and the tolerance limits for sedimentation were derived from habitat-specific dose-response experiments and field observations reported in the scientific literature (INPEX, 2018). The defined tolerance limits also varied across four trenching impact reporting zones, which were defined based on available water quality monitoring data (INPEX, 2018). The trenching impact reporting zones are named as follows:

+ East Arm
+ Middle Arm
+ Middle Harbour

+ Offshore.

Table 6-1: Tolerance limits for excess SSC and sedimentation (INPEX, 2018)

Habitat	Trenching Impact Reporting Zone	Season	SSC (mg/L)	Sedimentation (mm)
Mangrove	Anywhere	All	N/A	50
Coral	East Arm	Dry	11.9	15
		Wet	23.8	
	Middle Arm	Dry	12.4	15
		Wet	27.0	
	Mid Harbour	Dry	10.7	15
		Wet	28.4	
	Offshore	Dry	17.9	15
		Wet	64.2	
Seagrass	Anywhere	Dry	13.3	40
		Wet	60.6	

6.4 Modelled scenarios

Analysis of wind data in the region from 2012 – 2021 indicated that the period of 2019 – 2020 is likely representative of typical conditions. The modelling simulations therefore used hydrodynamic and wave data from this period, with nominal start dates for model simulations of 1 April 2019 (winter/dry) and 1 October 2019 (summer/wet).

A summary of the scenarios that were modelled is as follows:

+ Scenario 1: trenching works to commence on 1 April 2019 (winter/dry start):
  - TSHD trenching and disposal operations were programmed to occur between 1 April 2019 and 10 May 2019.
  - CSD trenching and disposal operations were programmed to occur between 8 April 2019 and 5 May 2019.
  - BHD trenching and disposal operations were programmed to occur between 1 April 2019 and 30 April 2019.
  - A simulation run-on period was assumed to occur between 10 May 2019 and 10 July 2019. Sediments suspended in the water column during previous operations were subject to settlement and progressively reducing levels of resuspension during this time.
+ Scenario 2: trenching works to commence on 1 October 2019 (summer/wet start):
  - TSHD trenching and disposal operations were programmed to occur between 1 October 2019 and 9 November 2019.
  - CSD trenching and disposal operations were programmed to occur between 8 October 2019 and 4 November 2019.

- BHD trenching and disposal operations were programmed to occur between 1 October 2019 and 30 October 2019.A simulation run-on period was assumed to occur between 9 November 2019 and 9th January 2020. Sediments suspended in the water column during previous operations were subject to settlement and progressively reducing levels of resuspension during this time.

6.5 Results

6.5.1 Sediment fate modelling results

6.5.1.1 General plume movement

Simulations indicated there may be significant spatial patchiness in the distribution of SSC and sedimentation at any point in time during the trenching and disposal operations due to variability in the number of sediment suspension sources, variability in the flux from each of these sources, and the varying dynamics of the transport, settlement and resuspension processes affecting the sediments.

The SSC results presented in the following sections are depth averaged. There is significant variability in the vertical distributions of SSC in the water column, with a distinct increase in concentration towards the seabed. Most material will initially be suspended low in the water column, and material suspended higher in the water column will sink as it moves away from the source. Frequent resuspension of material will also mostly affect the deeper levels. Thus, the spatial area affected above a given concentration is typically greater in the near-seabed layer than in the near-surface layer.

The localised movement and dispersion of the suspended sediment is governed over short time scales by the very strong tidal flows in the trenching areas and at the offshore disposal ground. Additionally, Darwin Harbour is relatively sheltered from the variations in large-scale circulation observed offshore. Beyond the harbour entrance, wind-driven current movements are superimposed on the tidal motion, which drives some seasonal differences in the overall drift patterns of the suspended sediments. However, the tidal currents dominate even in the area offshore of the harbour and seasonal differences are small. The sediment plume extends slightly more southwards during the winter/dry season scenario and slightly more northwards during summer/wet season scenario.

The dominance of the tidal flows means typical sediment plume movements are predicted to reflect the oscillations of the ebbing and flooding tide; towards the Harbour entrance (south-eastwards parallel to the coast) during the ebbing tide and into the Harbour, typically staying close to the western side (Woods Inlet and West Arm) or extending south into Middle Arm, during the flooding tide. At the proposed offshore disposal site sediment plumes from disposal operations move south-west towards Darwin Harbour on the ebbing tide and north-east towards Clarence Strait on the flooding tide. As is expected, the predicted plume drift trajectories during the spring tide periods are much longer than during neap tide periods, with the suspended material being more widely dispersed and SSC becoming patchy.

6.5.1.2 Spatial distribution of suspended sediment concentration

The results observed on any given day will not always be representative of the typical transport patterns, and plume concentrations and distributions are forecast to vary markedly. To explore this variability, statistical distributions for each scenario are examined. Percentile distributions summarise the outcomes over the duration of the trenching and disposal operations (not including the run-on period) and do not represent an instantaneous plume footprint at any point in time.

Forecasts of median depth-averaged SSC values (values exceeded 50% of the time) do not exceed 1 mg/L in both seasonal scenarios, while at the 80th percentile values 1 mg/L or greater are forecast to

be found in small, isolated patches just offshore of West Point (in line with Trench Zone 6) and at Wickham Point near the shore crossing area.

At the 90th percentile, the winter/dry season scenario forecasts show depth-averaged SSC values 1 mg/L or greater are found in a continuous band stretching north-westwards parallel with the coast to just offshore Charles Point, and southwards into Darwin Harbour extending a short way into Woods Inlet and to the eastern side of Talc Head. Smaller patches above 1 mg/L are predicted at other locations: around Wickham Point, in the middle Harbour area, in the vicinity of the proposed offshore disposal site, and in the shallows at South West Vernon Island (**Figure 6-1**). The corresponding summer/wet season scenario forecast shows a similar spatial area affected by SSC levels above 1 mg/L with some slight seasonal differences evident (**Figure 6-3**). In the summer/wet season scenario, the predicted 90th percentile SSC forecast shows the largest band above 1 mg/L has a shorter extent to the south and does not extend into Woods Inlet, a slightly larger area in the middle Harbour, and an extension of 1 mg/L concentrations to the north-east at the offshore disposal site.

At the 95th percentile, the winter/dry season scenario forecasts show depth-averaged SSC values 1 mg/L or greater are found in a continuous band stretching north-westwards parallel with the coast past Charles Point, and southwards into Darwin Harbour extending a short way into Woods Inlet and West Arm, with smaller patches above 1 mg/L extending from Wickham Point into the middle Harbour and a short way into Middle Arm. Depth-averaged SSC values 1 mg/L or greater are also found in the vicinity of the proposed offshore disposal site extending outwards to the east and west, with a larger extent to the east (**Figure 6-2**). Some very small patches above 1 mg/L are predicted in the shallows at South West Vernon Island. As found in the 90th percentile SSC distributions, the corresponding summer/wet season forecast shows a similar spatial area above 1 mg/L with some slight seasonal differences (**Figure 6-4**). Again, during the summer/wet season the largest band above 1 mg/L has a shorter extent to the south and there is an extension of 1 mg/L concentrations to the north-east at the offshore disposal site.

In both scenarios the 95th percentile depth-averaged SSC values are predicted to exceed 2.5 mg/L (but remain below 5 mg/L) in isolated patches in the vicinity of Trench Zone 6, extending ~8 km north-west and also south into Woods Inlet in the winter/dry season scenario, and extending ~13 km north-west with only minimal extent to the south in the summer/wet season scenario. Additionally, in both seasons the 95th percentile depth-averaged SSC values are predicted to exceed 2.5 mg/L in a relatively small patch extending north from Wickham Point and a very small patch in the shallows at South West Vernon Island.

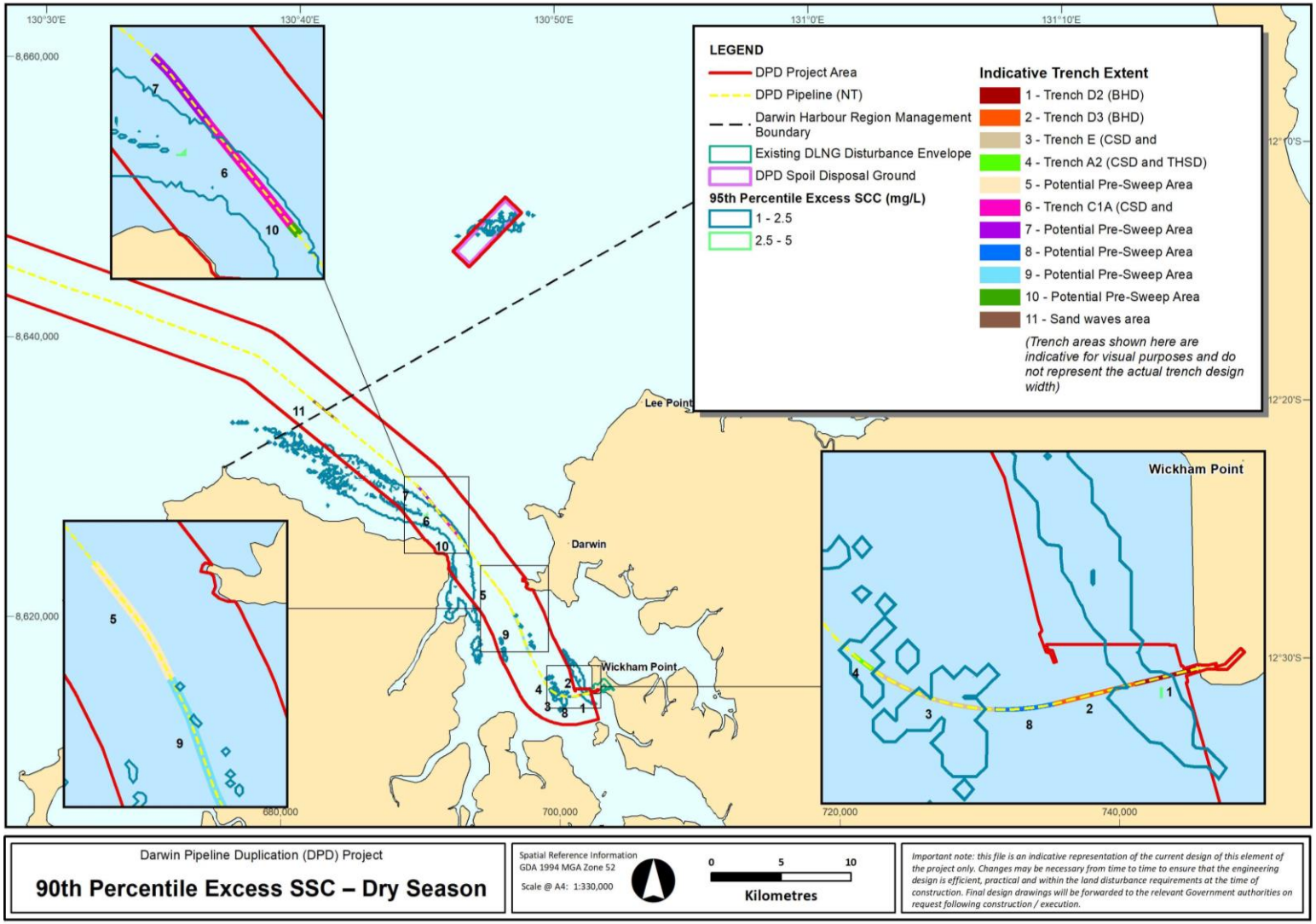


Figure 6-1: Predicted 90th percentile trenching-excess SSC throughout the entire trenching program for the winter/dry season scenario (1st April to 10th May 2019)

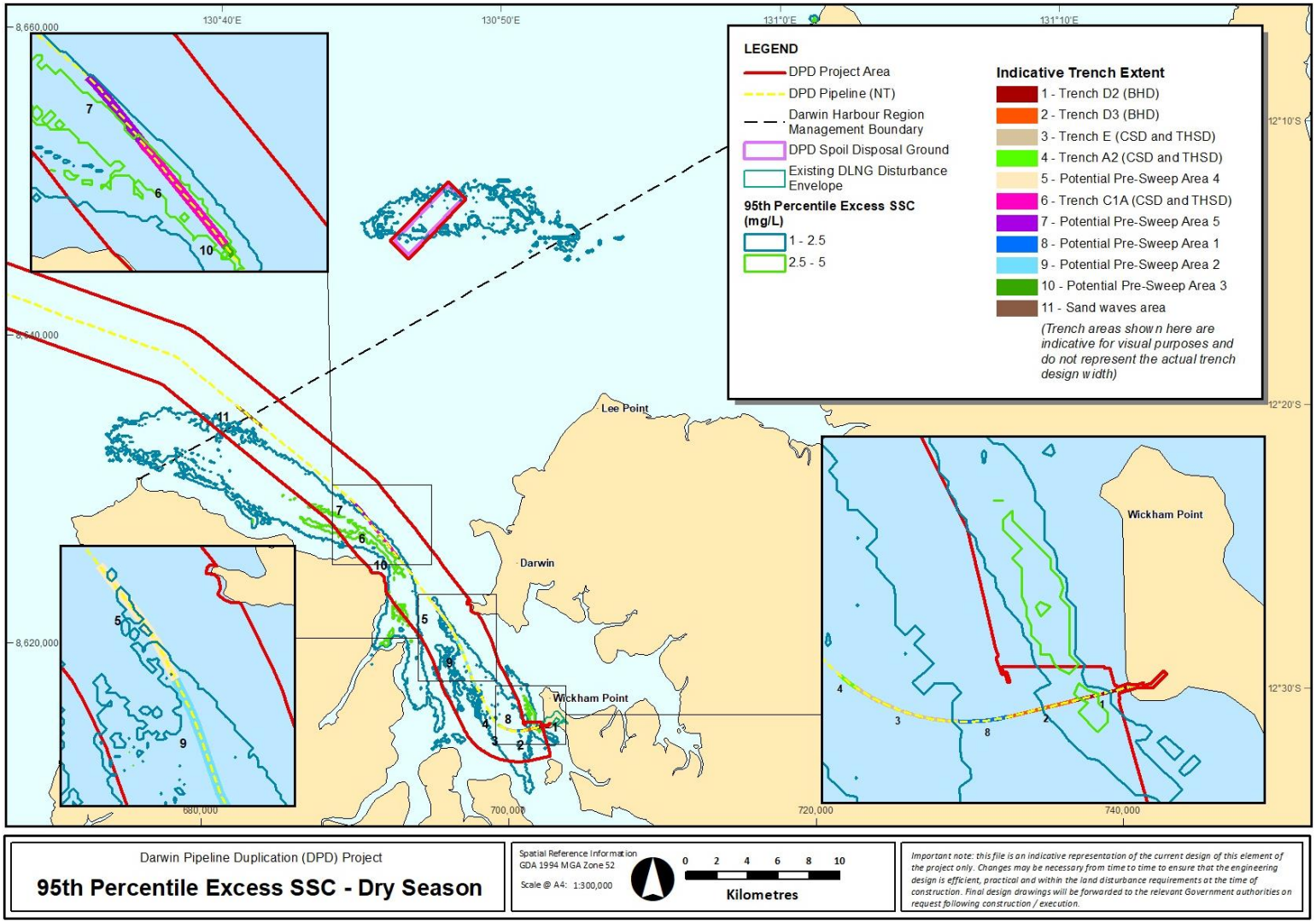


Figure 6-2: Predicted 95th percentile trenching-excess SSC throughout the entire trenching program for the winter/dry season scenario (1st April to 10th May 2019)

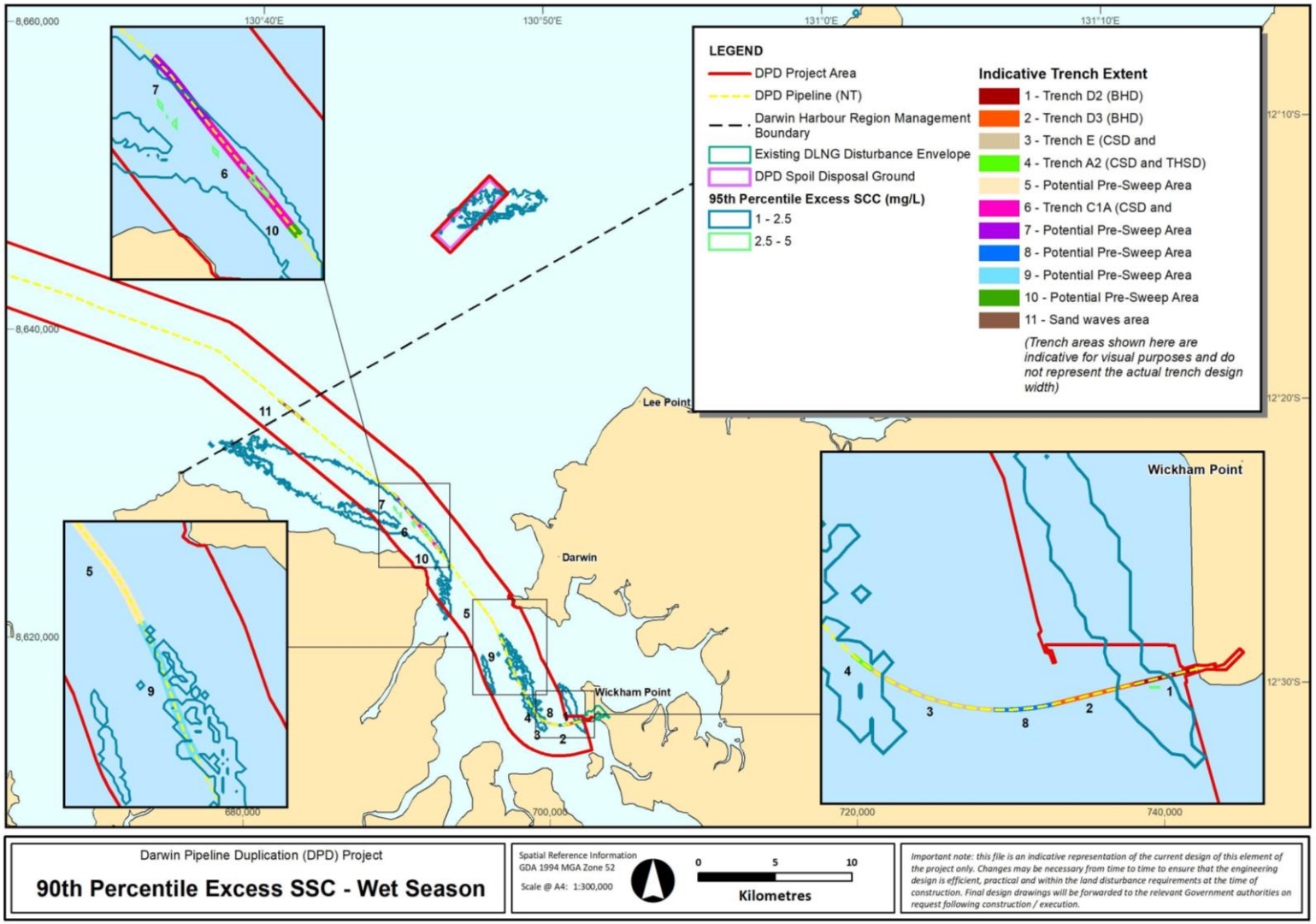


Figure 6-3: Predicted 90th percentile trenching-excess SSC throughout the entire trenching program for the summer/wet season scenario (1st October to 9th November)

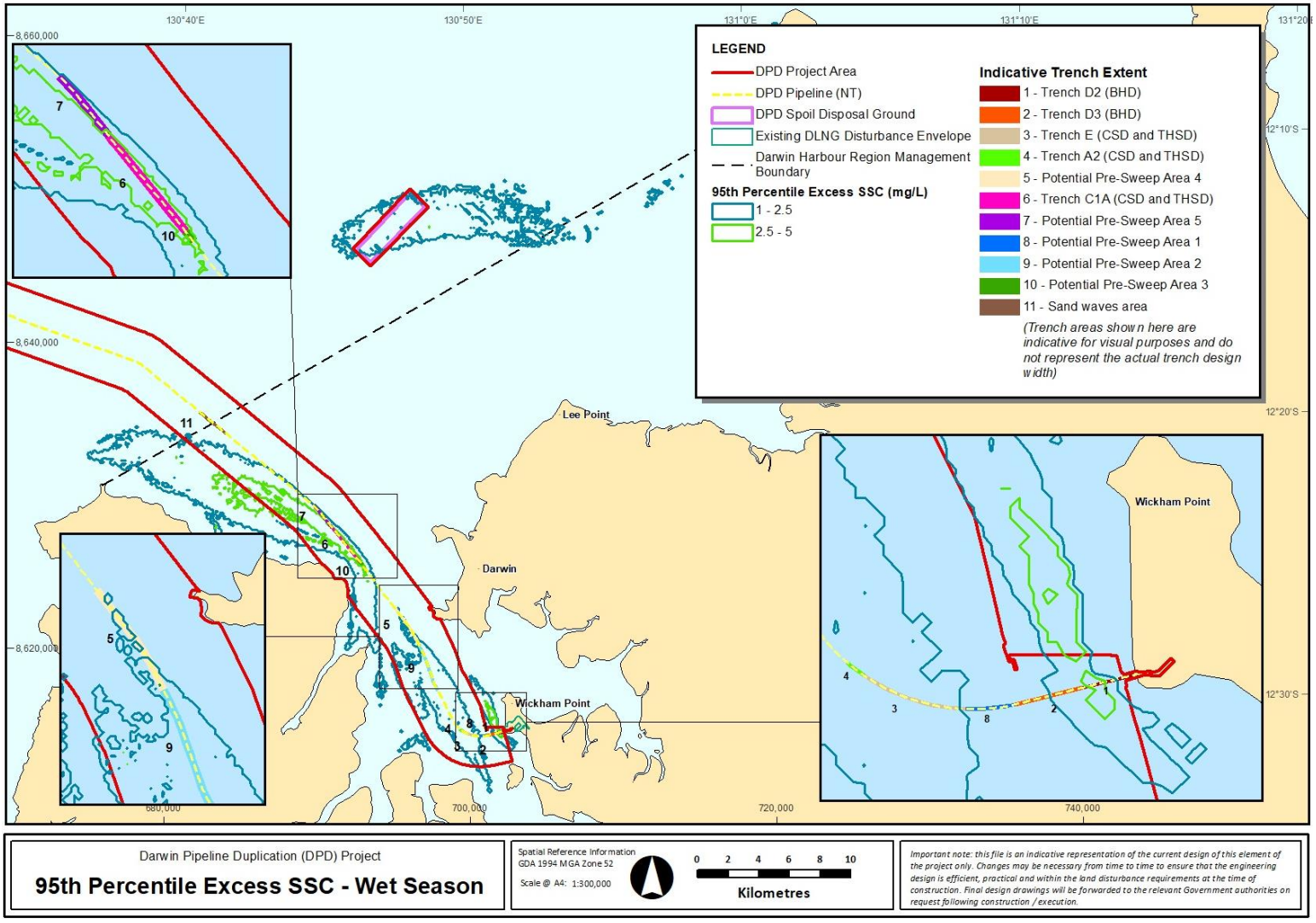


Figure 6-4: Predicted 95th percentile trenching-excess SSC throughout the entire trenching program for the summer/wet season scenario (1st October to 9th November)

6.5.1.3 Temporal variability of suspended sediment concentration

The simulations indicated that there will be significant temporal variability in the distribution of SSC during the trenching and disposal operations. The temporal variation in trenching-excess SSC at analysis sites within Darwin Harbour, outside the harbour and at the offshore disposal area reflect the spatial patchiness of the plumes and the oscillations of the dominant tidal flows in the area, with rapidly changing (over hourly scales) sharp peaks and troughs.

To explore the temporal exposure of sensitive receptor sites, a time series analysis at a set of specific locations has been conducted to supplement the spatial maps. The analysis locations were selected from existing sensitive receptor monitoring sites within the predicted elevated SSC footprint. In addition to the sensitive receptor monitoring sites, locations were defined at the proposed offshore disposal area, and at the Vernon Islands where elevated SSC levels was predicted by the model. **Figure 6-5** presents the locations of the points selected for the time series analysis. For presentation purposes the points have been split into groups as follows:

+ WI_S, CHI and WED1 are the monitoring sites inside Darwin Harbour.
+ CPW_1, MAN and CHP are the monitoring sites outside Darwin Harbour.
+ VI_S and VI_E are the Vernon Island sites.
+ OD1 to OD5 are the offshore disposal ground long cross-section sites (aligned south-west to north-east).
+ OD6 to OD9 are the offshore disposal ground short cross-section sites (aligned north-west to south-east).

Inside Darwin Harbour (**Figure 6-6** and **Figure 6-7**) the intensity of SSC depends on the proximity to the trenching areas, with the plume rarely reaching Channel Island and only at low concentrations typically less than 4 mg/L. At Woods Inlet south the exposures show a clear tidal signal, with plumes predicted to reach the site during spring tidal periods and with minimal SSC exposure during neap tides. This site also shows seasonal differences, with higher peaks during the winter/dry season, reflecting the more southerly drift pattern during the dry season as found in the spatial plots. Weed Reef sees similar levels of SSC to Woods Inlet south, however because it is in the mid-harbour close to the dredging areas there are minimal seasonal differences.

Outside Darwin Harbour along the coast from West Point to Charles Point (**Figure 6-8** and **Figure 6-9**) show a similar pattern of exposure to the sites inside the harbour, with higher predicted SSC levels during spring tide periods, particularly towards the end of the trenching period when the dredging takes place closer to these areas. At Charles Point west and Mandorah the predicted trenching-excess SSC is relatively low, being less than 1 mg/L 98% of the time (**Table 6-2**). Charles Point is predicted to have higher SSC intensities than the other two sites, particularly during the summer/wet season when drift patterns tend towards the north-west along this section of the coast. However, the duration of the peaks in predicted SSC at Charles Point are short, and this is reflected in the 98th percentile SSC values which are less than 7 mg/L in both seasonal scenarios.

The time series of trenching-excess SSC at the Vernon Islands sites (**Figure 6-10** and **Figure 6-11**) show that SSC intensities are predicted to be relatively low, particularly east of Vernon Islands. Peak SSC concentration is predicted to be typically higher in the summer/wet season scenario, showing the effect of increased drift trajectories towards the Clarence Strait during this season.

At the offshore disposal area, the temporal variability in predicted SSC also reflects the tidal oscillations with periods of spring and neap tides evident. However, superimposed on this signal is additional

variability due to the sporadic nature of the disposal sources, which are variable in time and space (**Figure 6-12** to **Figure 6-15**). Locations within the disposal ground (Offshore Disposal 2, 3, 4, 7 and 8) show similar overall patterns with periods of higher and lower SSC; however, the timings and intensities of the individual peaks vary due to the relative proximity of each site to individual disposal events. Elevated SSC levels (in the order of 100 – 200 mg/L) occur immediately after disposal events but are rapidly dispersed and do not persist for long periods of time (scales of hours). The sites along the two cross-sectional alignments lying outside the disposal ground (Offshore Disposal 1, 5, 6 and 9) show that the intensity of the modelled SSC values is predicted to reduce significantly within 1-3 km of the disposal ground boundaries. The intensity of the predicted SSC reduces significantly within 1 – 3 km of the disposal ground boundaries.

Table 6-2: Percentiles (95th and 98th) and maximum predicted trenching-excess SSC (mg/L) (depth-averaged and maximum-in-water-column) for each time series analysis location, throughout the entire trenching program and run-on period for the winter/dry and summer/wet season scenarios. Values presented are rounded to the nearest whole number.

Location	95th percentile				98th Percentile				Maximum			
	Depth-Averaged SSC (mg/L)		Maximum SSC (mg/L) in Water Column		Depth-Averaged SSC (mg/L)		Maximum SSC (mg/L) in Water Column		Depth-Averaged SSC (mg/L)		Maximum SSC (mg/L) in Water Column	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
WI_S	1	1	1	1	2	1	3	1	15	6	16	6
CHI	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	4	2	6	5
WED1	1	1	2	2	1	1	4	4	4	4	17	15
CPW_1	0[1]	0[1]	0[1]	0[1]	0[1]	1	0[1]	1	3	10	5	17
MAN	1	0[1]	1	1	1	1	1	1	6	3	7	4
CHP	1	1	1	2	3	6	3	7	51	55	65	71
VI_S	0[1]	0[1]	1	1	0[1]	1	1	2	2	3	5	8
VI_E	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	2	3
OD1	0[1]	0[1]	1	1	0[1]	0[1]	1	1	1	3	6	19
OD2	1	1	4	4	1	1	8	9	33	9	163	42
OD3	1	1	5	5	1	2	9	10	10	14	52	88
OD4	1	1	4	5	1	1	7	7	6	11	27	50
OD5	0[1]	0[1]	1	1	0[1]	0[1]	2	2	2	2	17	16
OD6	0[1]	0[1]	2	2	1	1	5	5	9	3	47	21
OD7	1	1	5	6	1	2	9	10	18	5	102	36
OD8	1	1	4	5	1	2	8	10	13	12	68	86

Location	95th percentile				98th Percentile				Maximum			
	Depth-Averaged SSC (mg/L)		Maximum SSC (mg/L) in Water Column		Depth-Averaged SSC (mg/L)		Maximum SSC (mg/L) in Water Column		Depth-Averaged SSC (mg/L)		Maximum SSC (mg/L) in Water Column	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
OD9	0[1]	0[1]	2	2	1	1	5	5	6	3	36	19

Note:

1. These values are greater than 0.0 but less than 0.5 mg/L

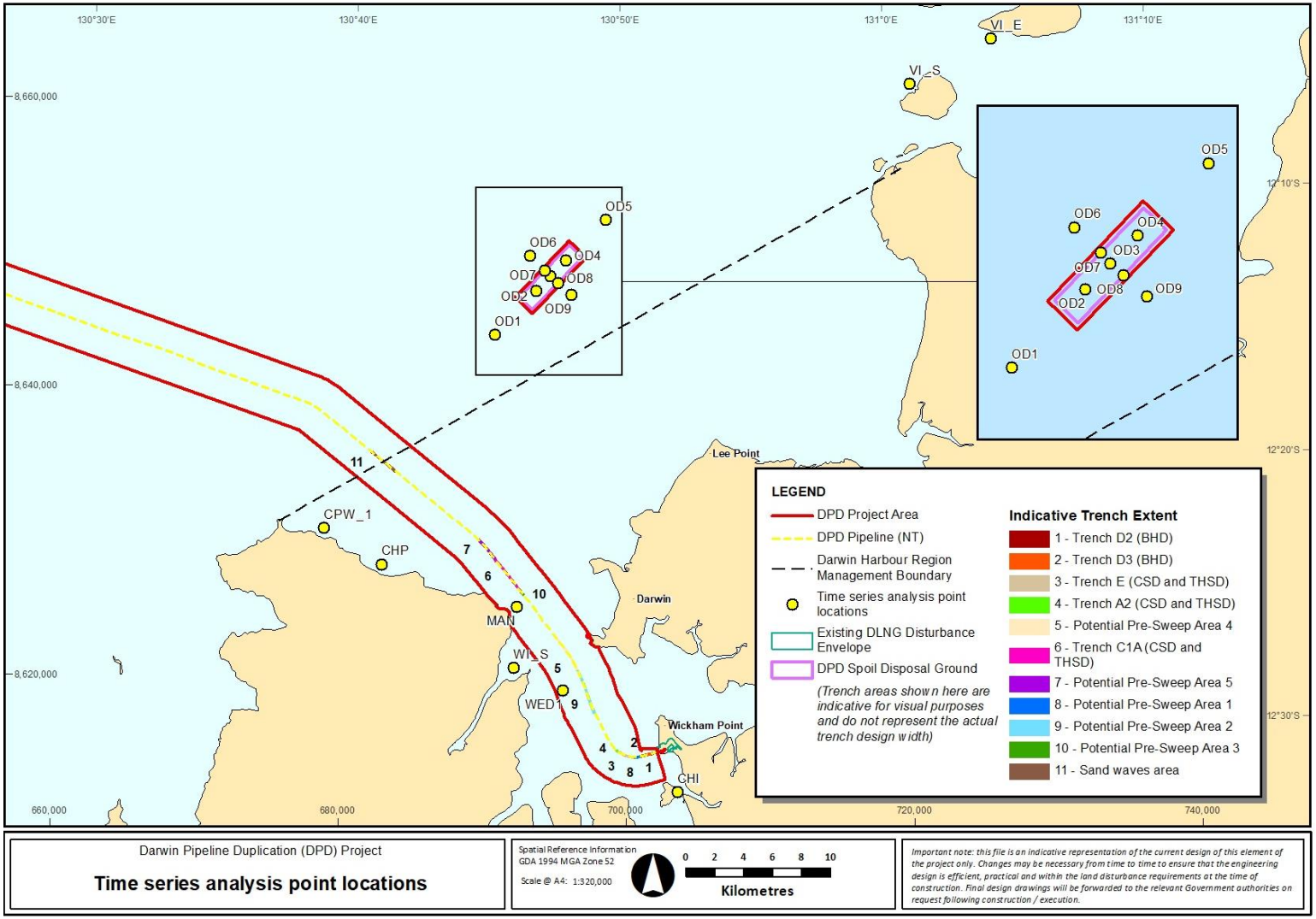


Figure 6-5: Time series analysis point locations

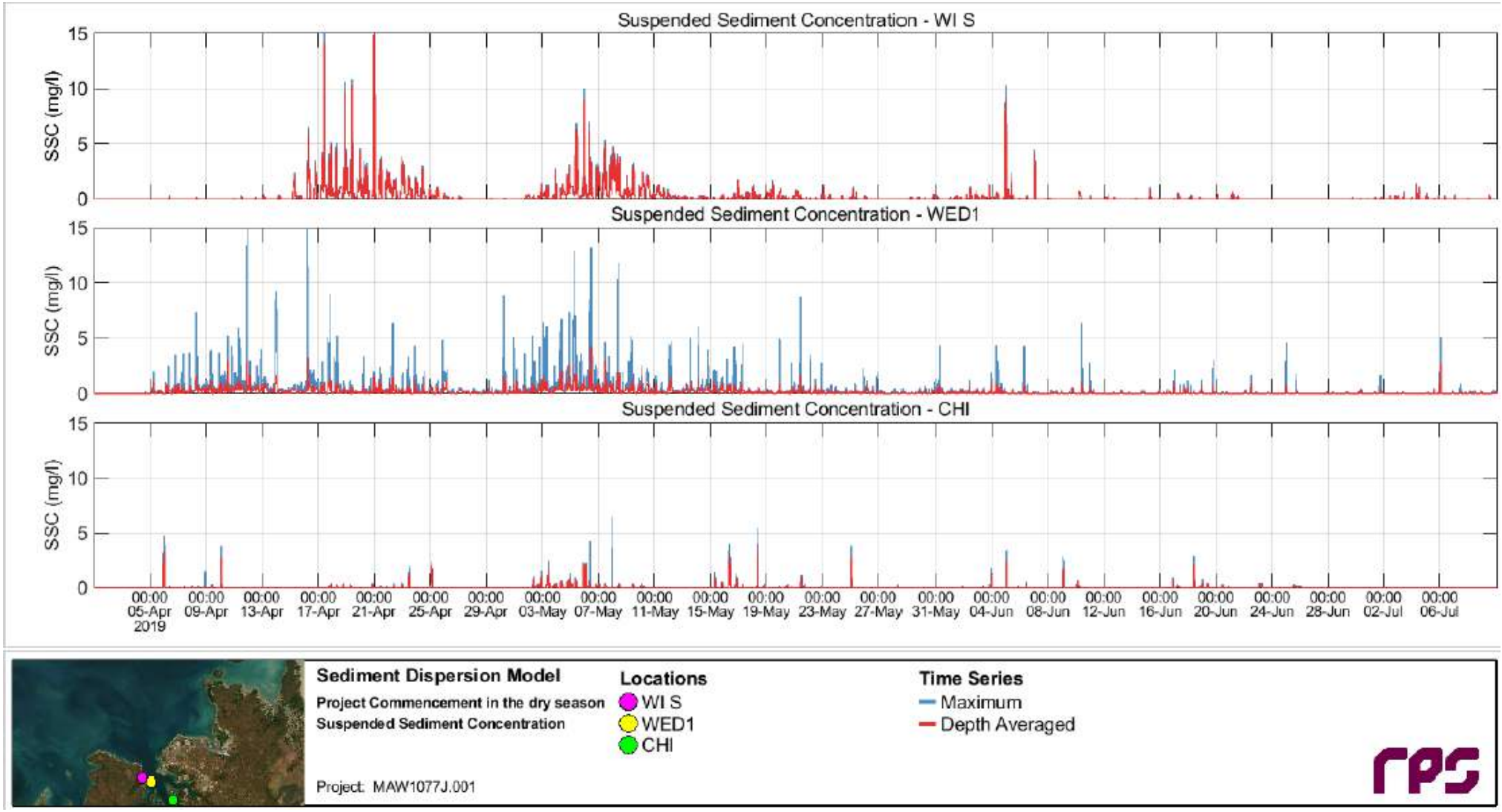


Figure 6-6: Time series of predicted trenching-excess SSC at the Woods Inlet South, Weed Reef 1 and Channel Island sites throughout the entire trenching program and run-on period in the winter/dry season scenario

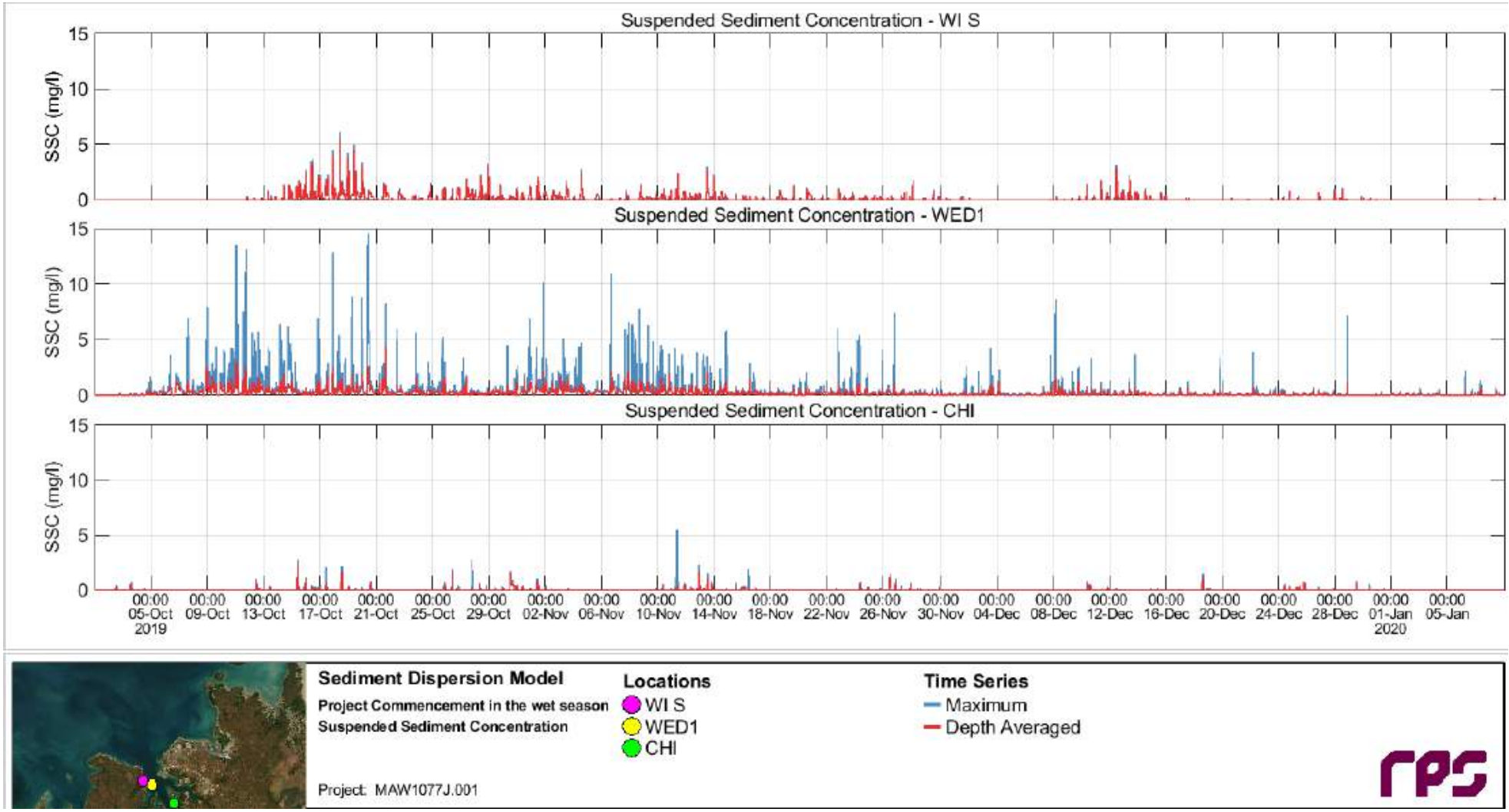


Figure 6-7: Time series of predicted trenching-excess SSC at the Woods Inlet South, Weed Reef 1 and Channel Island sites throughout the entire trenching program and run-on period in the summer/wet season scenario

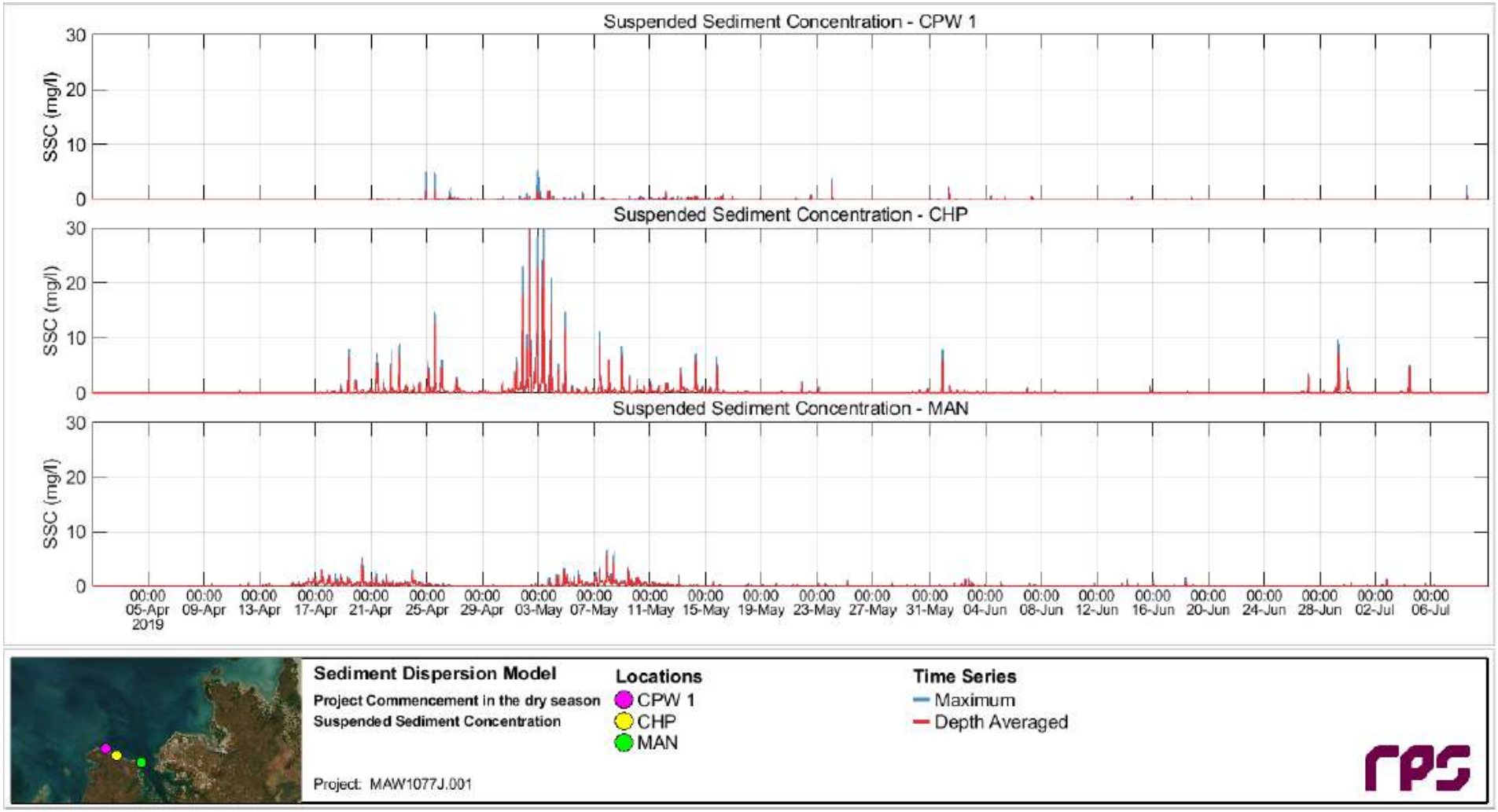


Figure 6-8: Time series of predicted trenching-excess SSC at the Charles Point Wide 1, Mandorah and Charles Point sites throughout the entire trenching program and run-on period in the winter/dry season scenario.

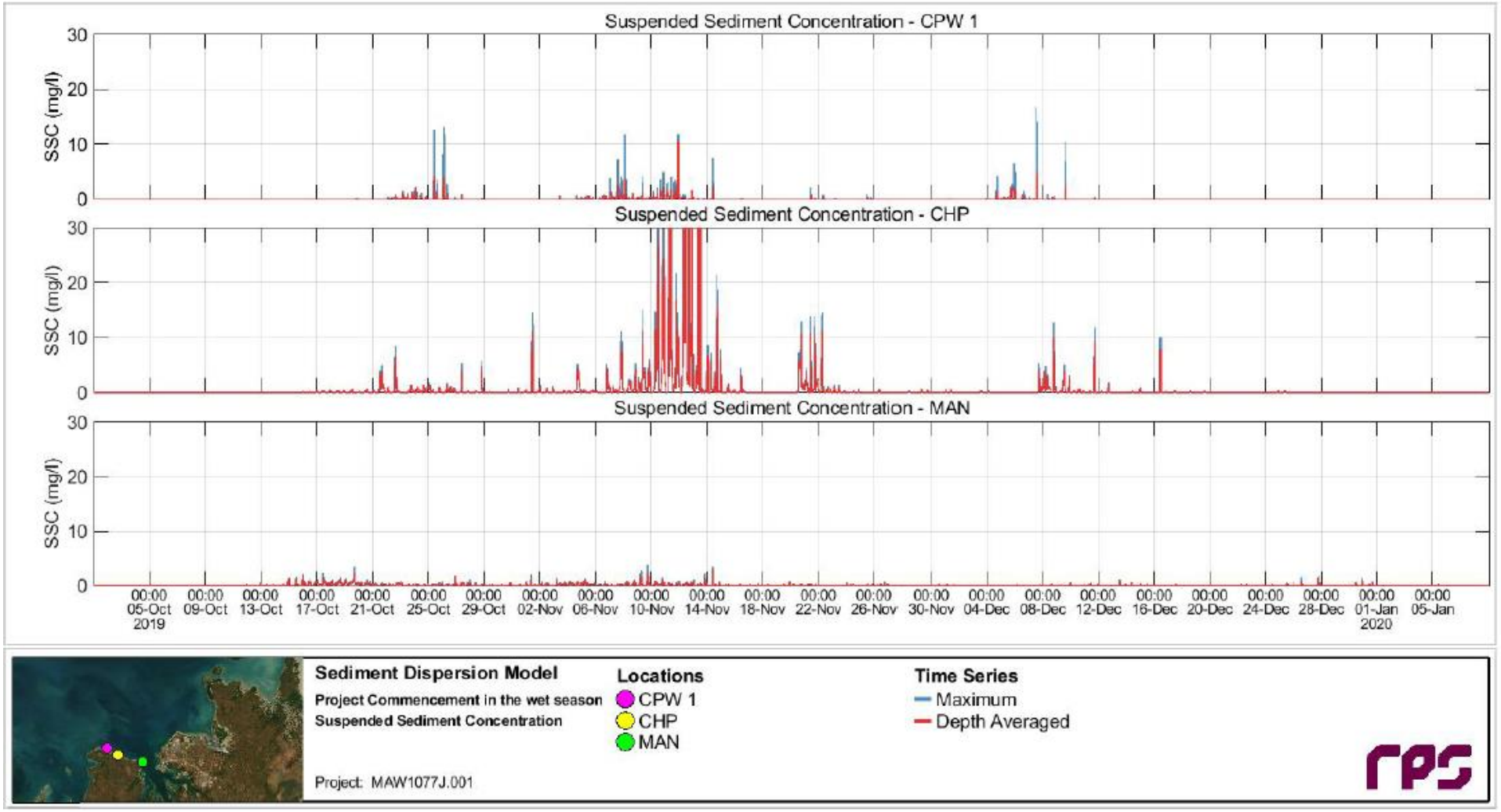


Figure 6-9: Time series of predicted trenching-excess SSC at the Charles Point Wide 1, Mandorah and Charles Point sites throughout the entire trenching program and run-on period in the summer/wet season scenario.

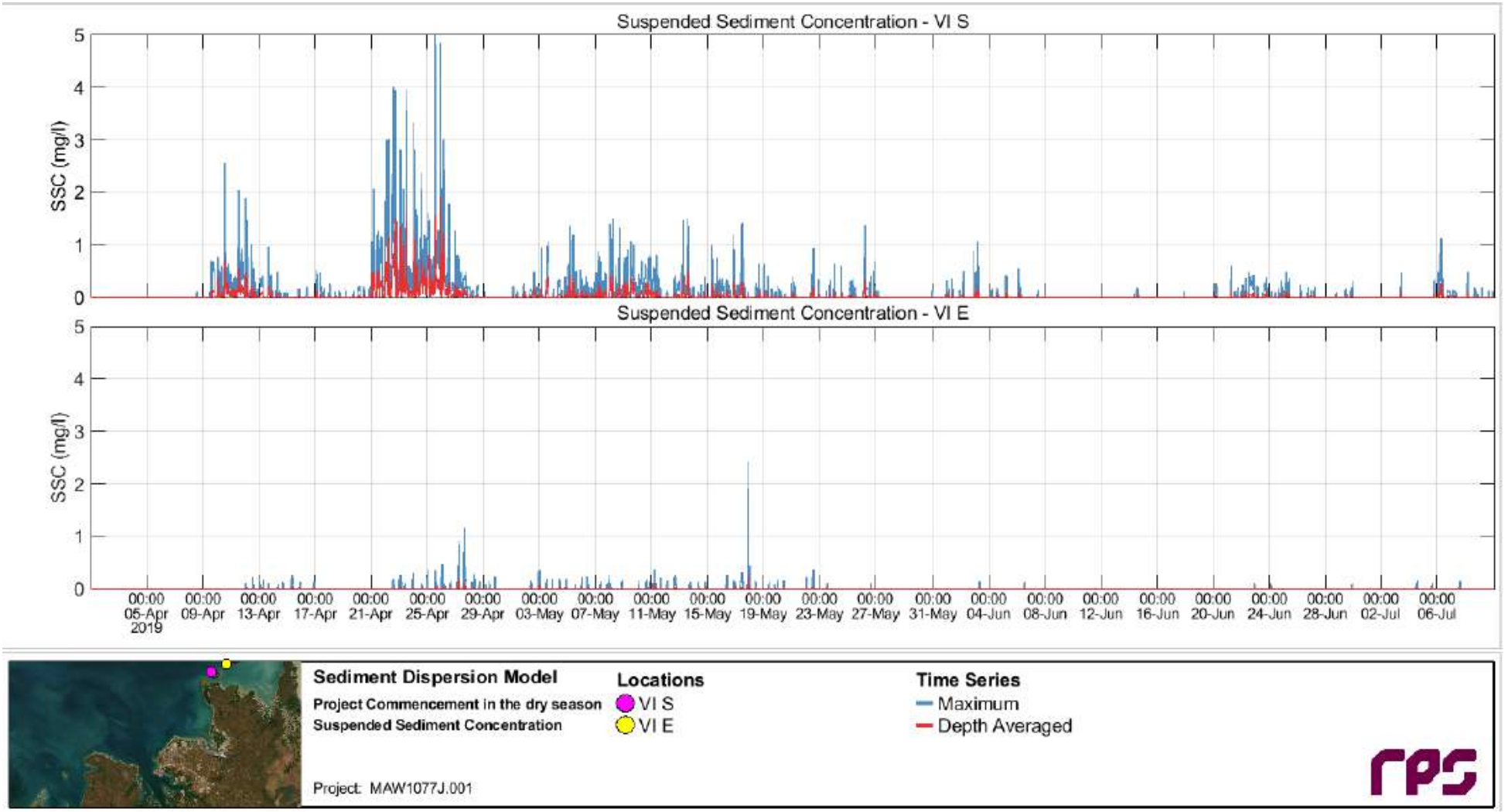


Figure 6-10: Time series of predicted trenching-excess SSC at the Varanus Island S and Varanus Island E sites throughout the entire trenching program and run-on period in the winter/dry season scenario.

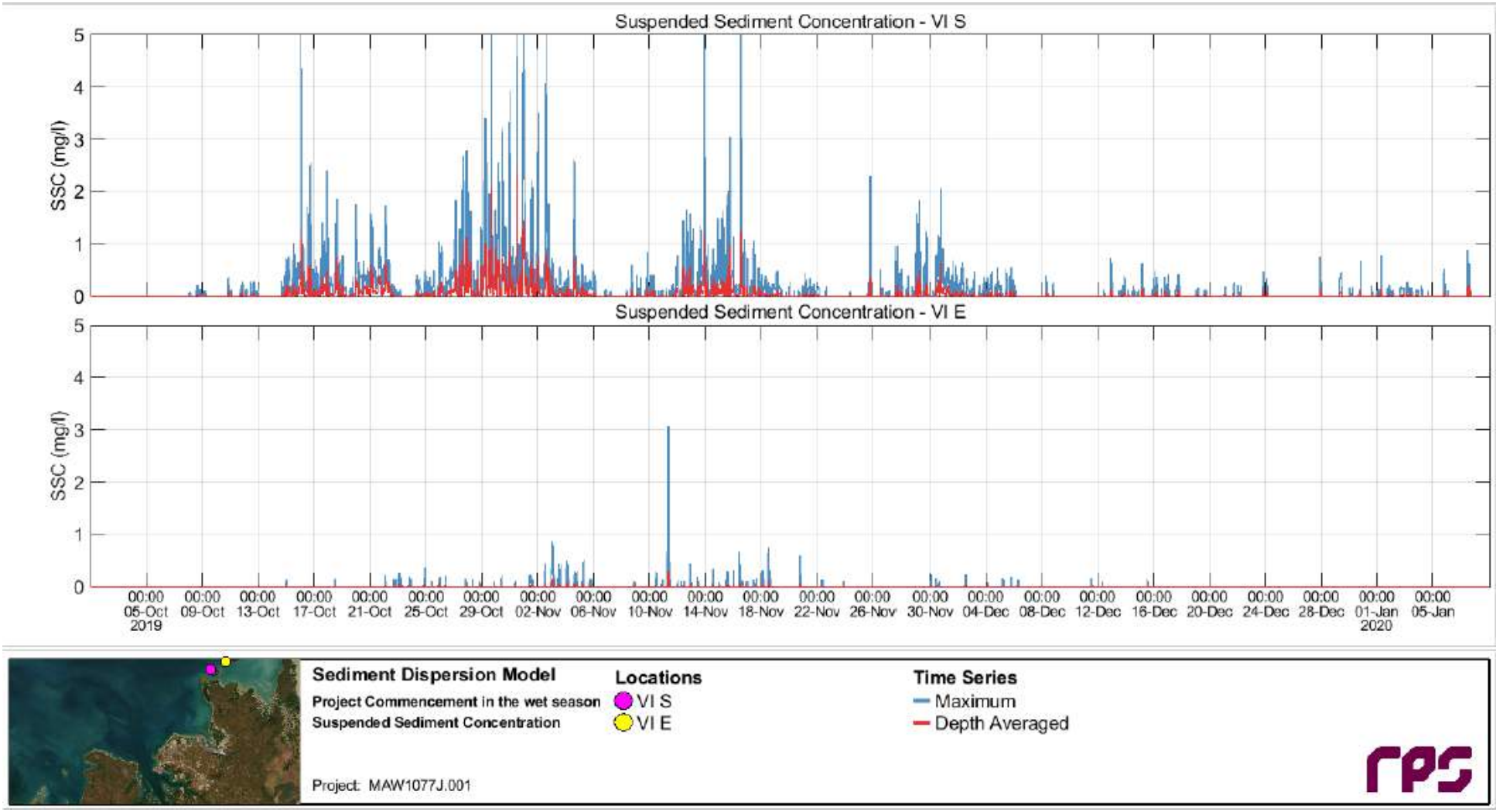


Figure 6-11: Time series of predicted trenching-excess SSC at the Varanus Island S and Varanus Island E sites throughout the entire trenching program and run-on period in the summer/wet season scenario.

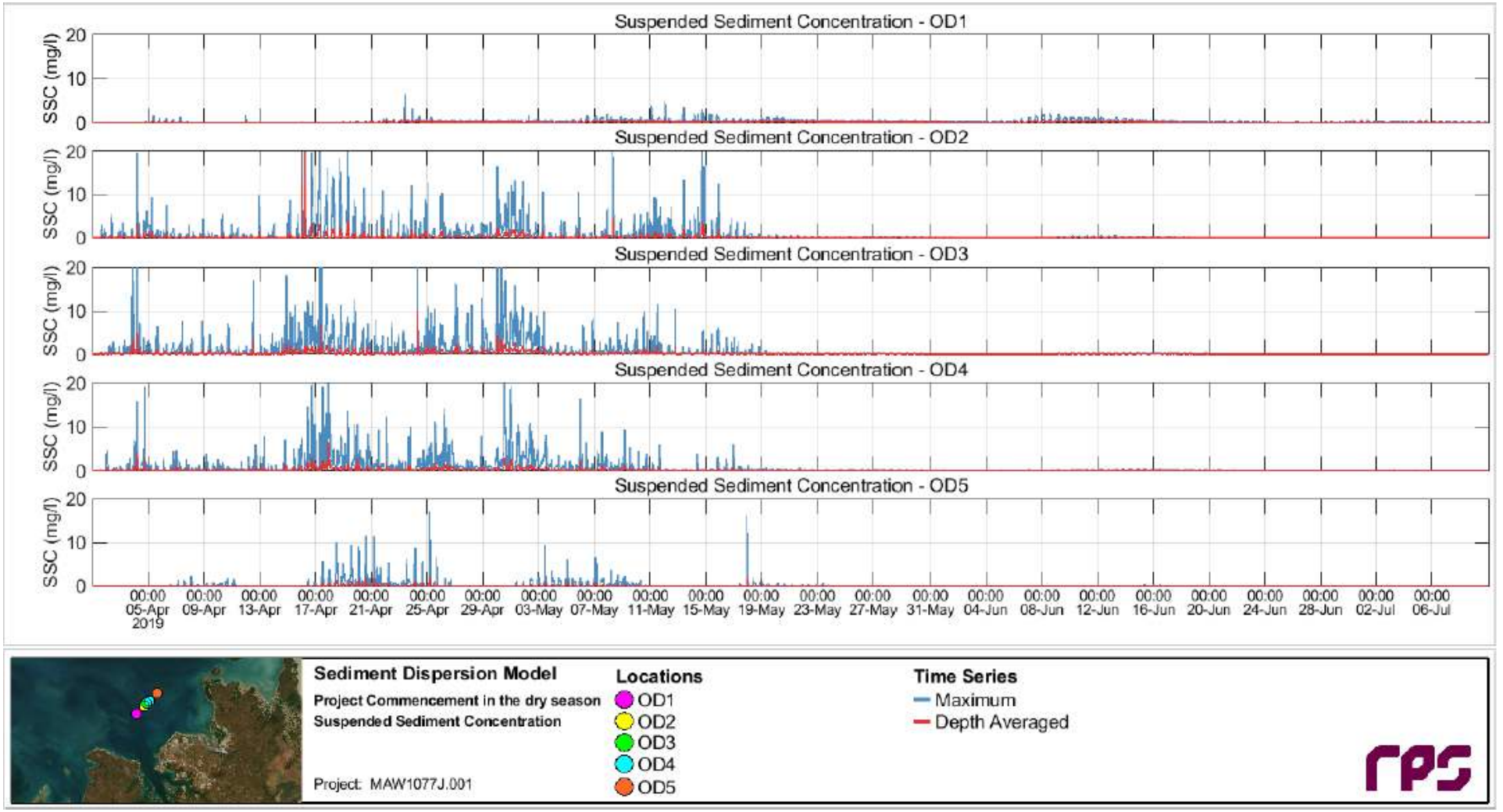


Figure 6-12: Time series of predicted trenching-excess SSC at the Offshore Disposal 1 to Offshore Disposal 5 sites throughout the entire trenching program and run-on period in the winter/dry season scenario.

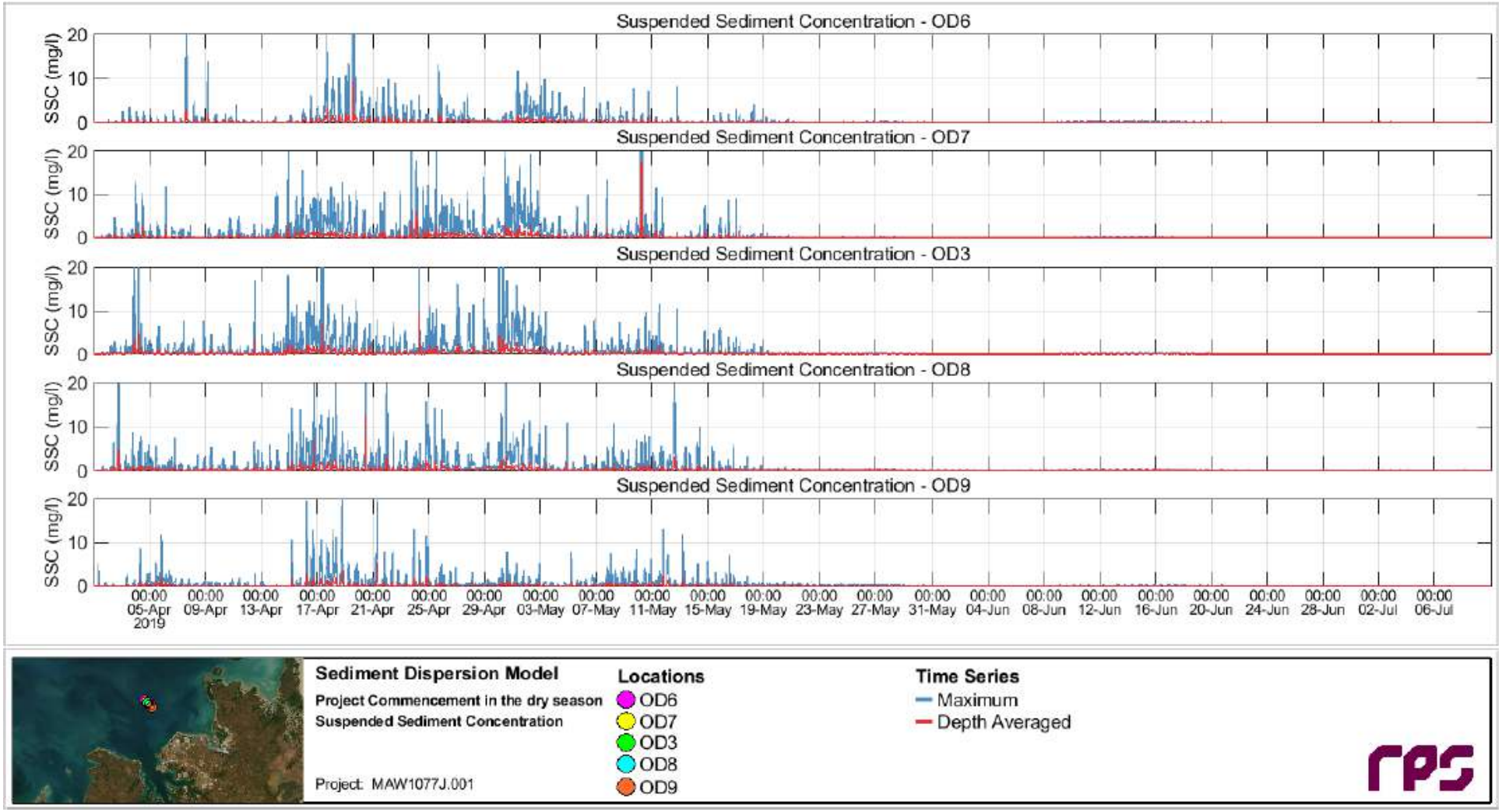


Figure 6-13: Time series of predicted trenching-excess SSC at the Offshore Disposal 6 to Offshore Disposal 9 (via Offshore Disposal 3) sites throughout the entire trenching program and run-on period in the winter/dry season scenario.

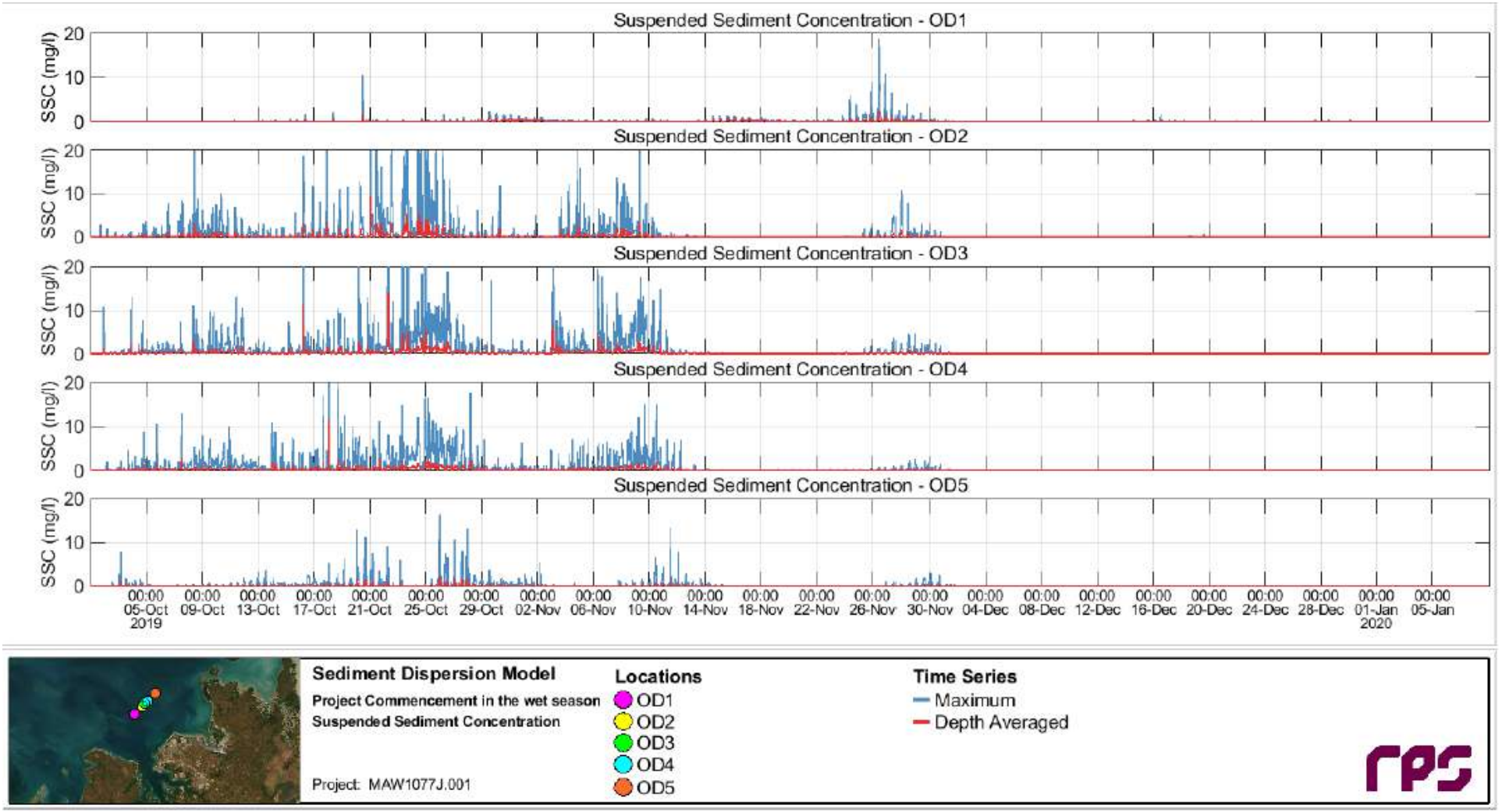


Figure 6-14: Time series of predicted trenching-excess SSC at the Offshore Disposal 1 to Offshore Disposal 5 sites throughout the entire trenching program and run-on period in the summer/wet season scenario.

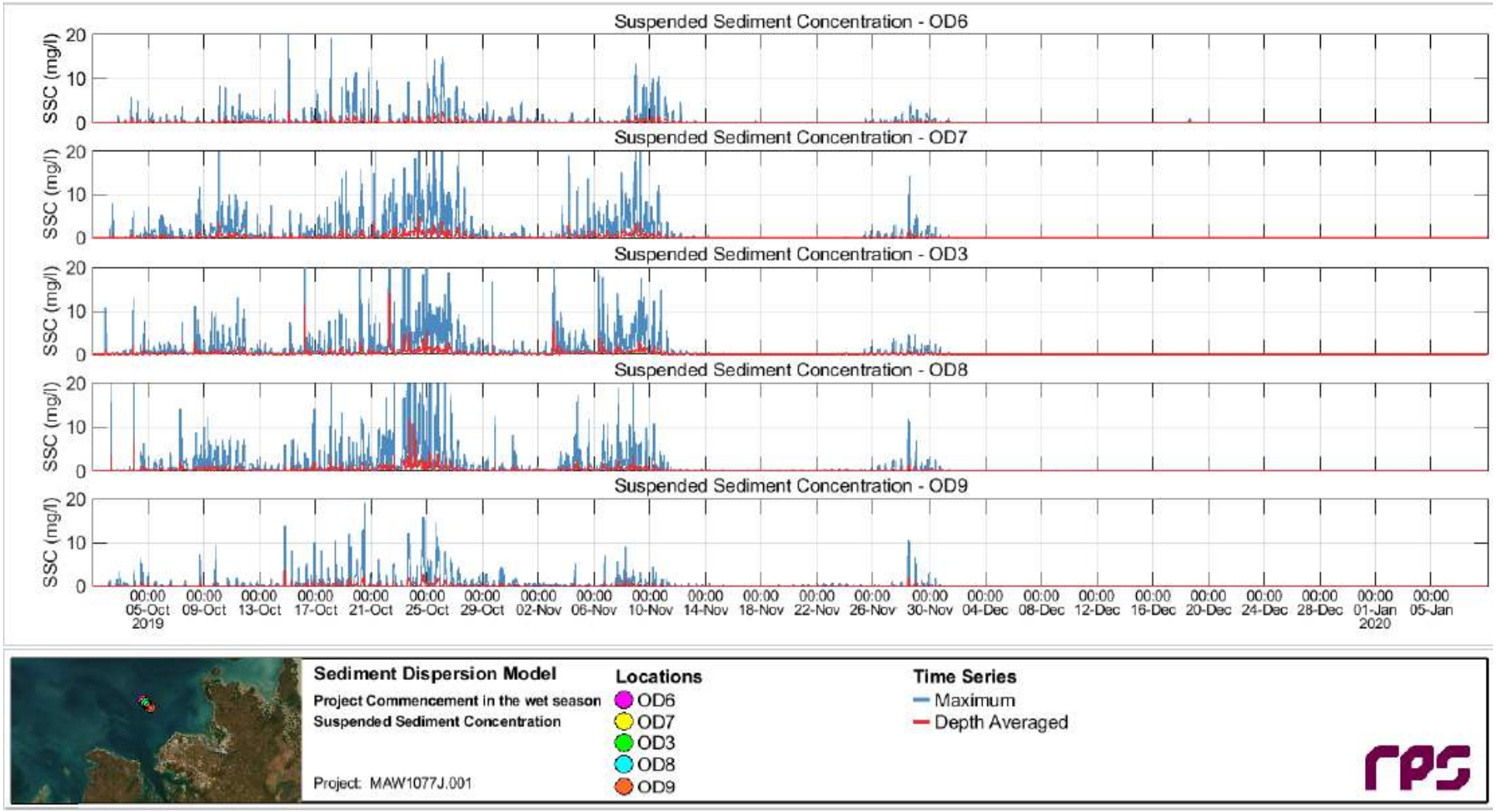


Figure 6-15: Time series of predicted trenching-excess SSC at the Offshore Disposal 6 to Offshore Disposal 9 (via Offshore Disposal 3) sites throughout the entire trenching program and run-on period in the summer/wet season scenario.

6.5.1.4 Spatial distribution of sedimentation

Given the strong tidal flows in the Darwin area, settlement of the finer trenching-generated sediment is minimal with fine material (clay and silts) being continuously resuspended on each tide, particularly during spring tide periods where even fine sand size material is predicted to be resuspended. Coarse material (sand size) is predicted to settle rapidly near the trenching zones and at the proposed offshore disposal area, but the fine material will remain suspended, or will deposit at slack tide only to be resuspended on the following tide. This results in suspended sediment plumes having long drift trajectories, with sediments dispersed widely but at low concentrations, and with sediments deposited in thin layers.

6.5.1.5 Temporal variability of sedimentation

To explore the temporal exposure of sensitive receptor sites to sedimentation generated by the trenching and disposal operations, a time series analysis at analysis sites within Darwin Harbour, outside the harbour and at the offshore disposal area (the same as was used for the time series analysis of SSC).

The deposition rates at distance from the trenching areas and the offshore disposal area are low, forming only very thin layers of material. At all sites other than those around the disposal area, the predicted thicknesses remain less than 0.2 mm and those plots have not been included here. The low rates of deposition are due to the magnitude of the tidal currents in the area: material that is suspended is dispersed rapidly and widely, with material deposited at slack tide being typically resuspended on the next tide – or the following spring tide period.

6.5.2 Spoil stability modelling

Simulation of spoil stability at the proposed spoil ground over the one-year run-on period showed that settlement of the finer spoil material is minimal and there is potential for significant resuspension of the finer proportions. The localised movement and dispersion of the disposal-generated and resuspended sediment is governed by the tide, with very strong tidal flows at the spoil ground.

Coarse material (coarse sand size and above) is predicted to settle rapidly, while available fine material in the spoil is predicted to be continuously resuspended on each tide, particularly during spring tide periods where even fine to medium sand size material is predicted to be resuspended. Deposition is forecast to occur at slack tide, however much of this settled material is resuspended on the following tide. This results in suspended sediment plumes having long drift trajectories, with sediments dispersed widely but at low concentrations, and with sediments deposited in thin layers. Drift trajectories from the spoil ground are predicted to be longest to the north-east towards the Clarence Strait and Van Diemen Gulf.

There is significant variability in the predicted vertical distributions of SSC in the water column at the proposed spoil ground, with a distinct increase in concentration towards the seabed. The higher SSC concentrations near the seabed are due to the resuspended material typically being mixed to the lower reaches (1 – 3 m) of the water column.

6.5.3 Zones of impact and influence

Three management zones were defined based on the approach applied by INPEX (2010, 2013, 2018), determined using the varying levels of impact on sensitive receptor communities:

+ Zone of High Impact (ZoHI)
+ Zone of Moderate Impact (ZoMI)

+ Zone of Influence (ZoI)

These management zones are described in the following sections.

6.5.3.1 Zone of High Impact

The ZoHI is defined as the area where direct impact from trenching and disposal will occur, such as removal of substrate or smothering of substrate (INPEX, 2018). Predicted impacts within this zone are expected to be severe and often irreversible. This zone includes the trench footprint and disposal area with a 20 m buffer extending outwards from these areas. For determining the ZoHI footprint, an indicative 40 m trench width (top of trench), representing a wide trench design, has been used with a 20 m buffer applied either side.

6.5.3.2 Zone of Moderate Impact

The ZoMI is defined as the area where sensitive receptor communities are predicted to be indirectly impacted by elevated SSC and sedimentation due to trenching and disposal activities (INPEX, 2018). Damage/mortality of sensitive receptor communities may occur, but the disturbed areas are considered to have good potential for recovery.

Within the ZoMI the ecological tolerance limits of sensitive receptors for SSC are predicted to be exceeded for 10% of the time or the ecological tolerance limits for sedimentation thickness are predicted to be exceeded at the end of the simulation (INPEX, 2018). In addition, the maximum sedimentation thickness predicted at any time throughout the simulated trenching operations was compared to the sedimentation tolerance limits. This was to account for the variable nature of the sedimentation with tidal cycles and the strong currents in Darwin Harbour which may cause larger amounts of sedimentation earlier in the trenching program.

The predicted ZoMI based on exceedances of the thresholds for SSC was evaluated over the duration of each trenching scenario by:

+ Creating a three-dimensional time series (hourly) of trenching-excess SSC values in each model grid cell for the entire trenching program.
+ Calculating the 90th percentile SSC value of each cell (i.e. the value that is exceeded 10% of the time).
+ Assessing the 90th percentile data against the seasonal threshold SSC values for each sensitive receptor habitat type and trenching impact reporting zone.

The predicted ZoMI based on exceedances of the thresholds for sedimentation was evaluated over the duration of each trenching scenario by:

+ Calculating the maximum trenching-excess sedimentation thickness values in each model grid cell for the entire trenching program. A density of 700 kg/m^2 was assumed for newly deposited sediments in the modelling based on field observations of the in-situ density of surface material present over the mangrove areas of Darwin Harbour (INPEX, 2009).
+ Assessing the maximum trenching-excess sedimentation thickness data against the seasonal threshold sedimentation thickness values for each sensitive receptor habitat type and trenching impact reporting zone.

The overall predicted ZoMI for each scenario was then calculated by combining both predicted ZoMIs SSC and sedimentation thickness.

6.5.3.3 Zone of Influence

The ZoI is defined as the area where sensitive receptor communities are predicted to be indirectly influenced by elevated SSC and sedimentation (INPEX, 2018). Sensitive receptor communities may, at some time experience detectable elevations in SSC and sedimentation (beyond expected background levels). However, no sublethal stress or mortality of benthic communities is expected to occur (INPEX, 2018).

Sensitive receptor communities are predicted to be indirectly influenced where their respective ecological tolerance limits for SSC are exceeded for 5% of the time or where the simulated sedimentation thickness exceeds 3 mm at the end of the simulation (INPEX, 2018). In addition, the maximum sedimentation thickness predicted at any time throughout the trenching operations was compared to the 3 mm sedimentation tolerance limit to account for the potentially larger amounts of sedimentation that may occur earlier in the trenching program.

The predicted ZoI based on exceedances of the thresholds for SSC was evaluated over the duration of each trenching scenario by:

+ Creating a three-dimensional time series (hourly) of trenching-excess SSC values in each model grid cell for the entire trenching program.
+ Calculating the 95th percentile SSC value of each cell (i.e. the value that is exceeded 5% of the time).
+ Assessing the 95th percentile data against the seasonal threshold SSC values for each sensitive receptor habitat type and trenching impact reporting zone.

The predicted ZoI based on exceedances of the thresholds for sedimentation was evaluated over the duration of each trenching scenario by:

+ Calculating the maximum trenching-excess sedimentation thickness values in each model grid cell for the entire trenching program. A density of 700 kg/m^2 was assumed for newly deposited sediments in the modelling based on field observations of the in-situ density of surface material present over the mangrove areas of Darwin Harbour (INPEX, 2009).
+ Assessing the maximum dredge excess sedimentation thickness data against the 3 mm tolerance limit.

The overall predicted ZoI for each scenario was then calculated by combining both predicted ZoIs for SSC and sedimentation thickness.

6.5.3.4 Management zone maps

The calculated extents of the defined management zones – ZoI and ZoMI – over the entire program of trenching and disposal operations for the winter/dry season scenario are presented in **Figure 6-16** and **Figure 6-17**; and for the summer/wet season scenario in **Figure 6-18** and **Figure 6-19**. The predicted ZoMI for the trenching and disposal operations for both seasonal scenarios are restricted to within or very close to the trenching and spoil disposal footprints. The predicted ZoI for the trenching and disposal operations for both seasonal scenarios are also generally restricted to the trenching and spoil disposal footprints, with the exception of a very small patch in the shallows at south west Vernon Island during the summer/wet season scenario. However, this isolated patch may be attributable to the combined effects of model bathymetry and hydrodynamics, representing sediments that are transported into the shallowest possible grid cells and then trapped upon reversal of the tide. While there is a potential for sediments released at the spoil disposal ground to be found in the indicated

area, the persistence of material remaining at the water-land boundary in this location may be overstated.

The management zones shown are the result of exceedance of the sedimentation thresholds only; no exceedance of the SSC thresholds occurred at the predicted 90th (ZoI) and 95th (ZoMI) percentile depth-averaged SSC levels for both modelled seasonal scenarios.

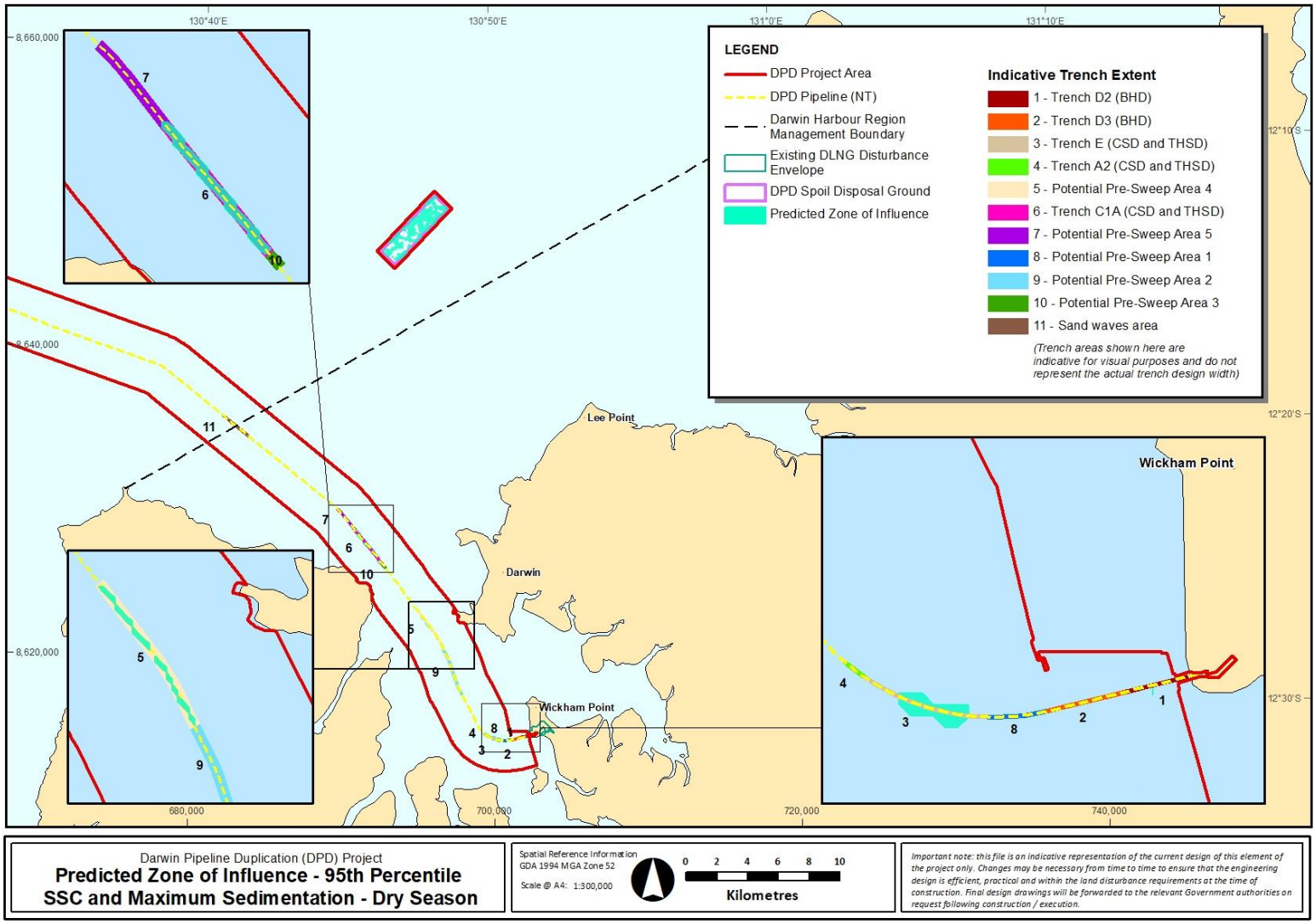


*Figure 6-16: Predicted Zone of Influence following application of the appropriate spatial thresholds in **Table 6-1** to the 95th percentile SSC and maximum sedimentation throughout the entire trenching program for the winter/dry season scenario (1 April to 10 May 2019).*

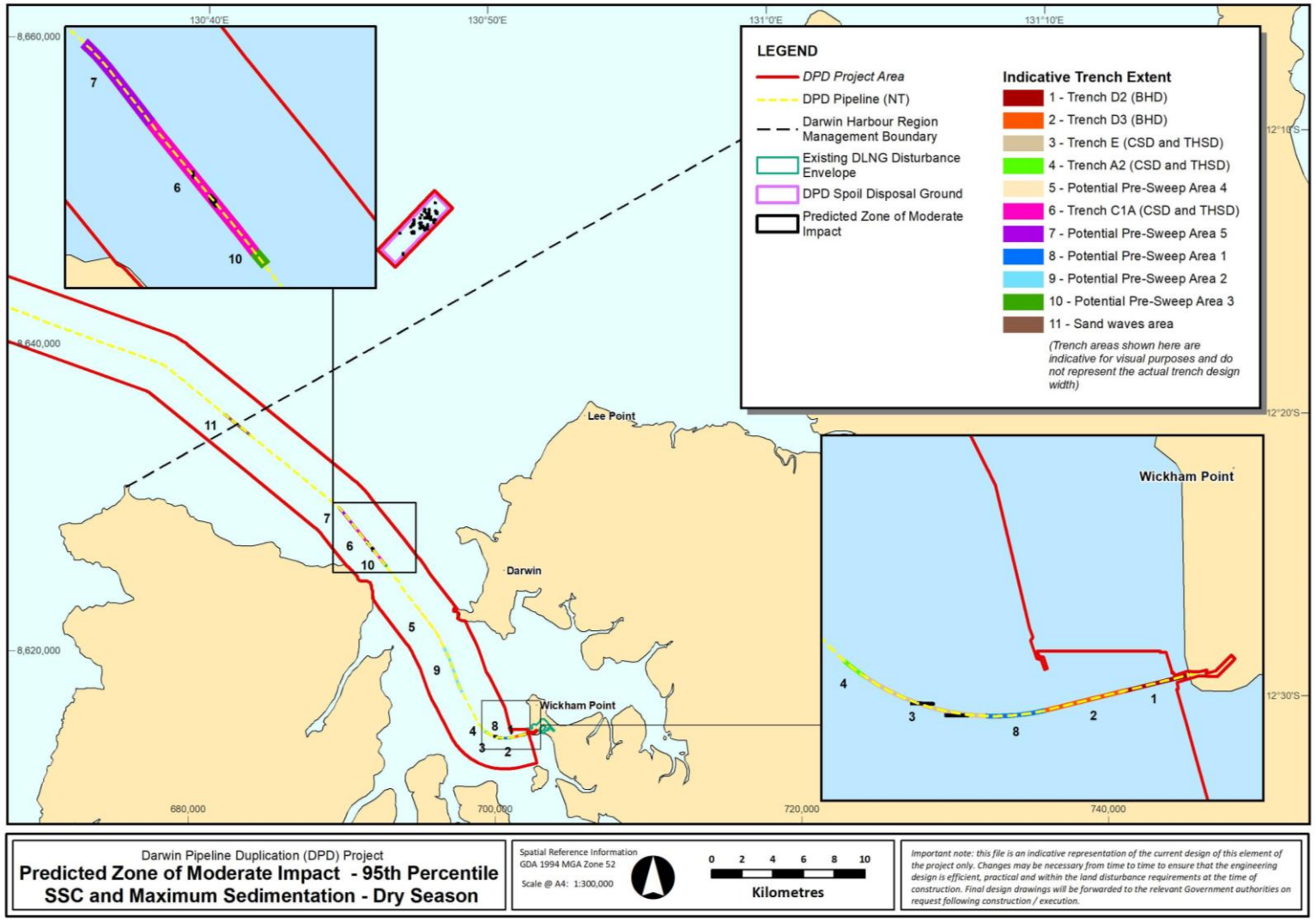


*Figure 6-17: Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in **Table 6-1** to the 90th percentile SSC and maximum sedimentation throughout the entire trenching program for the winter/dry season scenario (1 April to 10 May 2019).*

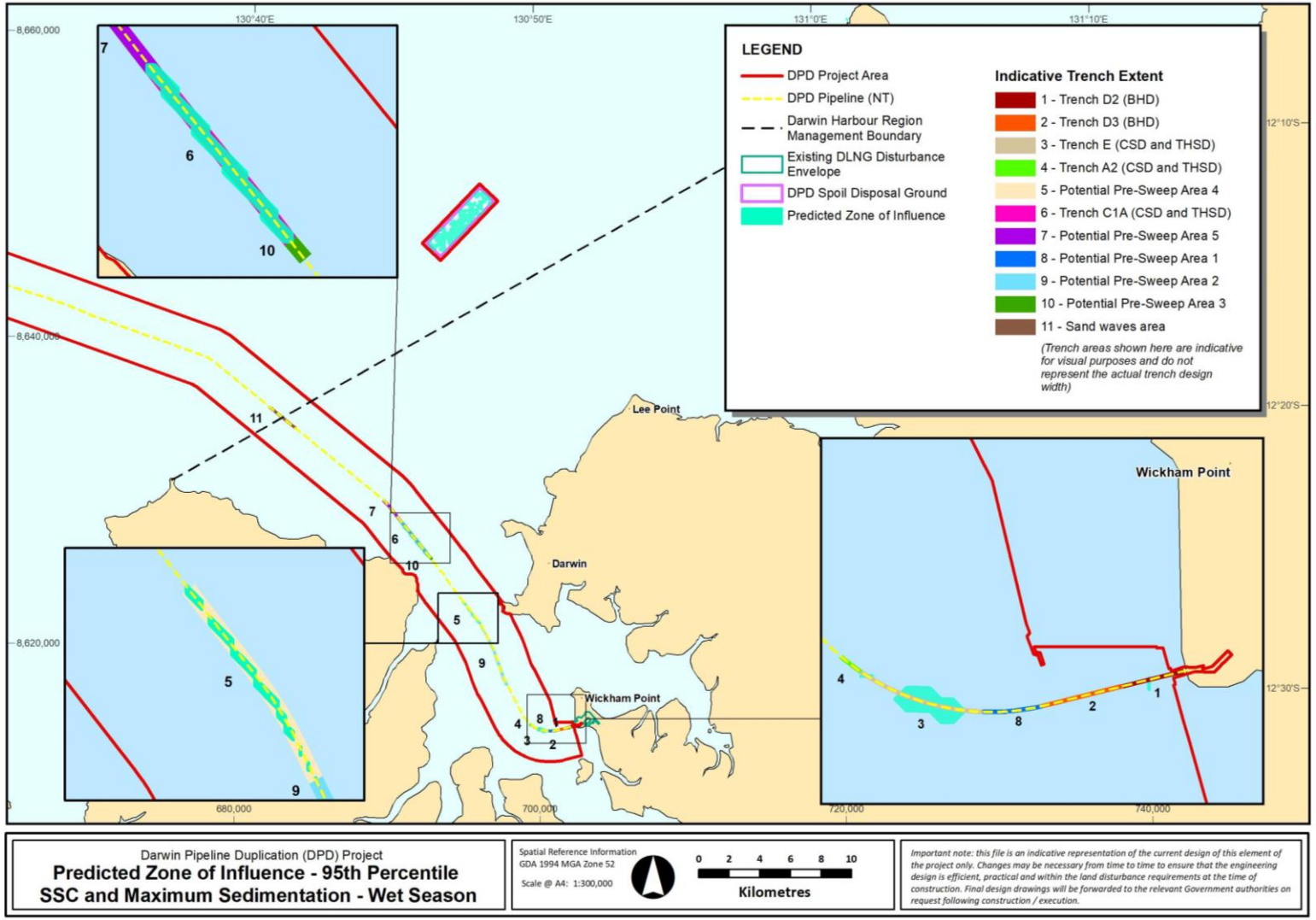


*Figure 6-18: Predicted Zone of Influence following application of the appropriate spatial thresholds in **Table 6-1** to the 95th percentile SSC and maximum sedimentation throughout the entire trenching program for the summer/wet season scenario (1 October to 9 November 2019).*

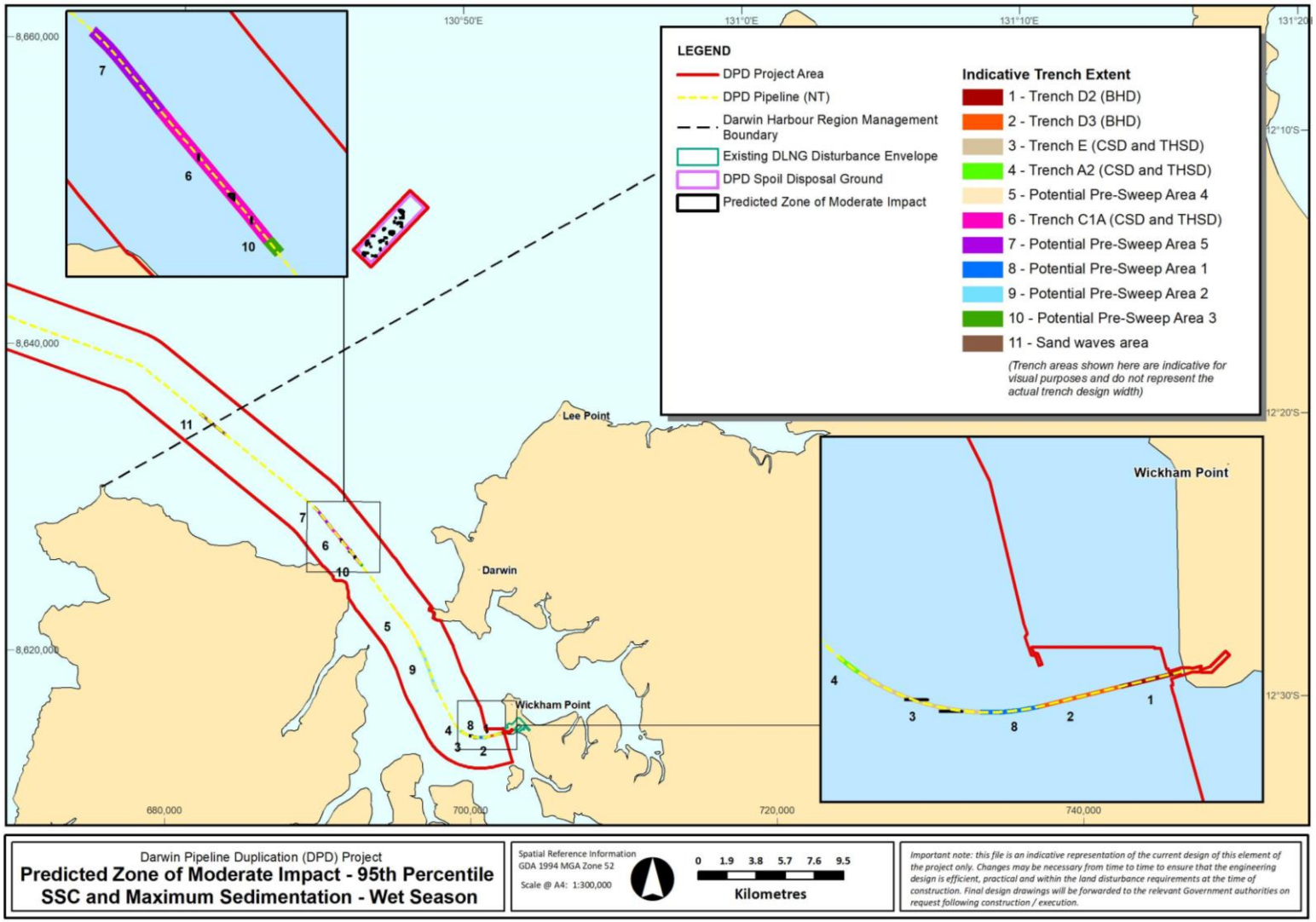


Figure 6-19: Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in to the 90th percentile SSC and maximum sedimentation throughout the entire trenching program for the summer/wet season scenario (1 October to 9 November 2019).

6.6 Predicted habitat impacts

Direct impacts are only expected to occur at the ZoHI which includes the trenching zone and spoil ground with a 20 m buffer extending outwards from these areas. Direct habitat loss is expected to occur within these areas. No sensitive receptor habitat (hard corals and seagrasses) overlap the or are adjacent to these zones based on benthic habitat mapping and therefore these habitats are not predicted to be impacted. The predicted ZoHI does overlap sponges and filter feeder (and to a lesser extent, macroalgae) habitat, therefore loss of these habitats is expected (**Table 6-3**). Further detail on the mapping used to inform direct habitat loss calculations is provided within the DPD Project Supplementary Environmental Report (BAS-210 0020).

No indirect impact (i.e., ZoMI) or influence (i.e., ZoI) from increased SSC is predicted as no exceedance of SSC thresholds is predicted to occur at the predicted 95th or 90th percentile depth-averaged SSC levels for either then winter/dry season, or the summer/wet season. In contrast, zones of impact and influence were predicted for sedimentation. However, the predicted ZoMI for sedimentation for both seasonal scenarios is restricted to the trenching and spoil disposal footprints (**Figure 6-17** and **Figure 6-19**), that is, within the ZoHI. The predicted ZoI for sedimentation is also restricted to within or immediately adjacent to the trenching footprints and spoil disposal footprints, (**Figure 6-16** and **Figure 6-18**). Consequently, the restricted spatial extent of sedimentation above impact thresholds and the lack of sensitive primary producer biota (i.e. seagrass and hard coral) within or adjacent to these zones indicates that indirect impacts to benthic habitats from trenching and offshore spoil disposal are not likely.

Table 6-3: Summary of the areal overlap of Project trenching zone and spoil ground Zones of High Impact (ZoHI) with different benthic habitats. Areal extent of benthic habitat impacted by different activities was calculated by overlaying DPD Project infrastructure over the combined AIMS 2019 and 2021 habitat mapping.

Benthic habitats	Trenching zones ZoHI		Spoil ground ZoHI	
Areal extent	Ha	%	Ha	%
Bare ground	23.6	19.3	53.4	8.2
Hard coral	-	-	-	-
Seagrass	-	-	-	-
Macroalgae	7.4	6.1	-	-
Sponge or sponges/filterers/octocorals	91.4	74.6	596.4	91.8

7 Impact and Risk Assessment

This TSDMMP has employed a systematic impact and risk assessment process for the environmental management of trenching and spoil disposal activities. The impact and risk assessment process has been developed in line with Santos' Environmental Impact Identification (ENVID) process and is consistent with the requirements the NT EPA Draft Guideline for the Preparation of an Environmental Management Plan (NT EPA, 2015).

7.1 Conceptual site model

A Conceptual Site Model as required by the NT EPA, is a written or illustrated representation of the nature, fate and transport of discharges, wastes or contaminants that allows assessment of potential and/or actual exposure of the environment to contaminants (NT EPA, 2015). The Conceptual Site Model for this TSDMMP is embedded within the impact and risk assessment as it details receptors and pathways, refer **Table 7-7**.

7.2 Impact and Risk assessment methods

The TSDMMP environmental impact and risk assessment was performed consistent with the Santos' Risk Matrix Procedure (SMS-LRG-OS01-TP02) and identification of management actions was consistent with Santos' Environment Hazard Controls Procedure (SMS-EXA-OS01-PD02). An environmental aspect, for the purpose of this environmental management plan, is defined as characteristics of the construction activities that could potentially affect the environment.

7.2.1 Identification of environmental hazard

Environmental hazards for this TSDMMP were identified using Santos' DPD Project NT EPA Referral (BAA-201 0002; Santos, 2021), DPD Project Basis of Approval (BAS-210 0005; Santos, 2022) and discussion by DPD Project team and environmental specialists. Key DPD Project construction activities and associated hazards and results from key technical studies were presented during ENVID workshops to inform the impact and risk assessment process.

7.2.2 Standard controls

The standard controls identified in **Table 6 6** were drawn from:

+ Santos' DPD Project NT EPA Referral (BAA-201 0002; Santos, 2021)
+ Santos' environmental plans and procedures for similar activities
+ Regulator approved management plans developed by other proponents.

Additional controls were provided by ENVID workshop attendees based on their relevant experience.

7.2.3 Impact and risk assessment

All hazards identified were assigned a consequence level following the six levels and criteria outlined in Santos' Risk Matrix Procedure (SMS-LRG-OS01-TP02). More detailed criteria were developed to assist in addressing NT EPA Key Environmental Factors. These are the NT EPA consequence descriptors shown in **Table 7-1**.

The consequence is defined as the resulting impact from an event occurring. Consequence level for this assessment was based on the credible worst-case scenario and assumed no management actions were in place. Categories of environmental consequence and detailed definitions of each severity level are outlined in **Table 7-2**.

The likelihood can be described as the probability that that the described consequence will occur. When determining the likelihood of consequences, proposed prevention and mitigation controls identified to mitigate potential impacts were considered. A detailed description of likelihood levels is outlined in **Table 7-3**.

A likelihood level was only assigned to unplanned events as per the Santos Risk Matrix Procedures (SMS-LRG-OS01-TP02), shown in **Table 7-4**. The consequence and likelihood for each impact was then assessed to determine the residual risk that remained after proposed standard controls were considered.

Table 7-1: NT EPA consequence descriptors

Consequence Level		I	II	III	IV	V	VI
Acceptability		Acceptable	Acceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Consequence Level Description		**Negligible** No impact of negligible impact	**Minor** Detectable but insignificant change to local population, industry or ecosystem factors Localised effect	**Moderate** Significant impact to local population industry or ecosystem factors	**Major** Major long-term effect on local population industry or ecosystem factors	**Severe** Complete loss of local population industry or ecosystem factors AND/OR extensive regional impacts with slow recovery	**Critical** Irreversible impacts to regional population industry or ecosystem factors
Environmental Receptors	**Marine Ecosystems** Fauna, habitat, conservation significant areas and ecological function, processes and integrity	Short term behavioural impacts only to small proportion of local population and not during critical lifecycle activity. No decrease in local population size / area of occupancy of species / loss or disruption of habitat critical / disruption to the breeding cycle/ vales of a protected area. No introduction of disease and no reduction in habitat area/function.	Detectable but insignificant decrease in local population size and threat to local population viability. Insignificant disruption to the breeding cycle of local population / area of occupancy of species / loss of habitat critical to survival of a species/ values of a protected area. Detectable but insignificant loss of area/function of habitat with rapid recovery within 2 years.	Moderate. Significant decrease in local population size but no threat to overall population viability. Significant behavioural disruption or disruption to the breeding cycle of local population / Significant reduction in area of occupancy of species / loss of habitat critical to survival of a species. Modify, destroy, remove or decrease availability of quality habitat to the extent that a long-term decline in local population or function of habitat is likely with recovery over medium term (2-10 years) Introduction of disease likely to cause significant population decline	Long term decrease in local population size and threat to local population viability. Major disruption to the breeding cycle of local population / area of occupancy of species / loss of habitat critical to survival of a species/ values of a protected area Fragmentation of existing population / Loss or change of habitat to the extent that a long-term decline in local population and function of habitat is likely with slow recovery over decades Introduction of disease likely to cause long term population decline	Complete loss of local population, habitat critical to survival of local population or protected area/conservation significant area Widespread (regional) decline in population size or habitat critical to regional population Extensive destruction of local habitat with no recovery or long term (decades) or widespread loss of area or function of primary producers on a regional scale	Complete loss of regional population Complete loss of habitat critical to survival of regional population
	Marine Environmental Quality Water quality, sediment quality, ecosystem health and parameters that support fishing, aquaculture, recreation, aesthetics and cultural/spiritual values	Negligible. No or negligible reduction in physical environment nor decrease in ecosystem function/health. No or negligible loss of value to socio-economic activities	Detectable but localised, short term and insignificant impact to physical environment or ecosystem function/health or value to socio-economic activities. Rapid recovery evident within ~ 2 years.	Significant wide-scale medium term impact to physical environment, decrease in ecosystem function/health or value to socio-economic activities. Recovery over medium term (2-10 years).	Wide-scale, long term impact to physical environment, long term decrease in ecosystem function/health or value to socio-economic activities. Slow recovery over decades.	Extensive impact to/destruction of physical environment with no recovery or shutdown of socio-economic activities Long term (decades) and widespread loss of ecosystem function/health on a regional scale that damages value to socio-economic activities.	Complete destruction of regional physical environment / habitat with no recovery Complete loss of area or function of primary producers on a regional scale

Consequence Level		I	II	III	IV	V	VI
	Coastal Processes Geophysical processes, primary productivity/ nutrient cycling, conservation significant areas/coastal landforms and cultural, aesthetic or recreation values	Short term changes to local geophysical/hydrological processes, widespread loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale	Detectable but insignificant loss or change to local geophysical/hydrological processes, area or function of primary producers/nutrient cycling or conservation significant areas with rapid recovery within 2 years.	Moderate. Significant modification, destruction, removal or change of local geophysical/hydrological processes, wide-scale loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale with recovery over medium term (2-10 years).	Long term loss or change of local geophysical/hydrological processes, widespread loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale with slow recovery over decades	Extensive destruction of local geophysical/hydrological processes, widespread loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale with no recovery or long term (decades)	Complete loss or change of geophysical/hydrological processes. Complete loss of area or function of primary producers/nutrient cycling or conservation significant areas on a regional scale.
	Community and Economy Includes: fisheries (commercial and recreational); tourism; oil and gas; defence; commercial shipping	No or negligible loss of value of the local industry. No or negligible reduction in key natural features or populations supporting the activity.	Detectable but insignificant short-term loss of value of the local industry. Detectable but insignificant reduction in key natural features or population supporting the local activity.	Significant loss of value of the local industry. Significant medium-term reduction of key natural features or populations supporting the local activity.	Major long-term loss of value of the local industry and threat to viability. Major reduction of key natural features or populations supporting the local activity.	Shutdown of local industry or widespread major damage to regional industry. Permanent loss of key natural features or populations supporting the local industry.	Permanent shutdown of local or regional industry Permanent loss of key natural features or populations supporting the local or regional industry
	Culture and heritage Includes: Indigenous heritage and maritime heritage (i.e. shipwrecks)	No or negligible impact on the area's cultural or heritage values. No or negligible alteration, modification, obscuring or diminishing of the area's cultural or heritage values.	Detectable but insignificant impact on one or more of the area's cultural or heritage values. Detectable but insignificant alteration, modification, obscuring or diminishing of the area's cultural or heritage values.	Significant impact on one or more of the area's cultural or heritage values. Significant alteration, modification, obscuring or diminishing of the area's cultural or heritage values.	Major long-term effect on one or more of the area's cultural or heritage values. Major alteration, modification, obscuring or diminishing of the area's cultural or heritage values.	Complete loss of one or more of the area's cultural or heritage values.	Permanent loss of one or more of the area's cultural or heritage values with no recovery.

Table 7-2: Summary environmental consequence descriptors

Consequence Level	Consequence Level Description
I	**Negligible** – No impact or negligible impact
II	**Minor** – Detectable but insignificant change to local population, industry or ecosystem factors
III	**Moderate** – Significant impact to local population, industry or ecosystem factors
IV	**Major** – Major long-term effect on local population, industry or ecosystem factors
V	**Severe** – Complete loss of local population, industry or ecosystem factors AND/OR extensive regional impacts with slow recovery
VI	**Critical** – Irreversible impact to regional population, industry or ecosystem factors

Table 7-3: Likelihood description

No.	Matrix	Description
f	Almost Certain	Occurs in almost all circumstances OR could occur *within days to weeks*
e	Likely	Occurs in most circumstances OR could occur *within weeks to months*
d	Occasional	Has occurred before in Santos OR could occur *within months to years*
c	Possible	Has occurred before in the industry OR could occur *within the next few years*
b	Unlikely	Has occurred elsewhere OR could occur *within decades*
a	Remote	Requires exceptional circumstances and is unlikely even in the long term

Table 7-4: Risk assessment matrix

		Consequence					
		I	II	II	IV	V	VI
Likelihood	f	Low	Medium	High	Very High	Very High	Very High
	e	Low	Medium	High	High	Very High	Very High
	d	Low	Low	Medium	High	High	Very High
	c	Very Low	Low	Low	Medium	High	Very High
	b	Very Low	Very Low	Low	Low	Medium	High
	a	Very Low	Very Low	Very Low	Low	Medium	Medium

7.3 Residual impacts and risks

7.3.1 Planned events

The residual consequence levels from the planned impacts following implementation of standard and additional ALARP management actions (detailed in **Section 8**) are summarised in **Table 7-5**. Given the

likelihood of a planned event occurring is 100% (in other words, it will occur), the risk ranking is not assessed. A comprehensive impact assessment for each of the planned events, and subsequent management actions proposed by Santos to reduce the impacts to ALARP are detailed in the following sections. The demonstration of ALARP and/or acceptable levels is discussed in the overarching Offshore CEMP (BAS-210 0024). Within the ENVID developed by Santos some environmental aspects had multiple residual consequence ratings since multiple environmental factors were assessed against, in these cases the residual consequence of greatest severity was chosen for this summary.

Table 7-5: Summary of the residual consequence levels associated with planned impacts

TSDMMP section	Planned event impact	Residual consequence
9.2	Seabed and benthic disturbance	II – Minor
8.3.1.1	Interactions with other marine users – construction activities and Project infrastructure	II – Minor
8.3.1.2	Noise emissions	II – Minor
8.3.1.3	Light emissions	II – Minor
8.3.1.4	Routine vessel discharges	I – Negligible
8.3.1.5	Atmospheric emissions	I – Negligible

7.3.2 Unplanned events

The residual risk levels from unplanned events following implementation of standard and additional (ALARP) management actions (detailed in **Section 8**) are summarised in **Table 7-6**. Comprehensive risk assessments for each of the unplanned events, and subsequent management actions proposed to reduce the risk to ALARP and acceptable levels are detailed in the following sections. The demonstration of ALARP is discussed in the overarching Offshore CEMP (BAS-210 0024). Within the ENVID some unplanned events had multiple residual risk ratings; in these cases the residual risk of greatest severity was chosen for this summary.

Table 7-6: Summary of the residual risk level associated with unplanned risks

TSDMMP section	Unplanned event risk	Residual risk level
8.3.2.1	Dropped objects (including accidental release of non-hazardous waste)	Low
8.3.2.2	Introduction of invasive marine species	Low
8.3.2.3	Unplanned marine fauna interaction	Low
8.3.2.4	Release of hazardous liquids	Low
8.3.2.5	Release of hydrocarbon (offshore vessel bunkering or vessel tank rupture	Low
8.3.2.6	Release of dry natural gas from Bayu-Undan to Darwin pipeline	Very Low

7.4 Demonstration of ALARP

Demonstration of ALARP for each planned and unplanned event is outlined within the Environmental Management Strategies (EMS') in Section 7 of the Santos DPD Project Offshore CEMP (BAS 210-0024; Santos, 2022).

7.5 Impact/risk assessment summary

The outcomes of the impact / risk assessment are presented in **Table 7-7**, and where relevant includes reference to the relevant management strategy within this TSDMMP proposed to manage individual environmental aspects.

Table 7-7: Summary of risk assessment outcomes

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
Planned events							
Interaction with other marine users – construction activities and Project infrastructure	Trenching and spoil disposal with + Cutter Suction Dredger (CSD) + Trailer Suction Hopper Dredger (TSHD) + Backhoe Dredger (BHD) + Split Hopper Barges (SHBs) disposal	The movement of vessels in the operational area has the potential to result in interactions with other marine users or exclude other marine users (i.e., through implementation of exclusion zones) from some areas of Darwin Harbour and the spoil disposal grounds during trenching and spoil disposal operations. The marine spread for trenching includes: + TSHD and CSD (nominal duration will be approximately 6 weeks) + Split Hopper Barges/BHD + Support vessels – Approx. 11 vessels in total for trenching activities.	**Spatial** Localised around the Project vessels (and vessel exclusion zones as applicable) pipeline route and shore crossing activities including temporary causeway structures. Vessel exclusion zones are typically 500 m and will apply to Project vessels, including pipelay vessel, construction vessels and dredging vessels. **Temporal** Temporary and intermittent interaction with presence of project vessels within the Project Area over the trenching and spoil disposal campaign (indicatively 2 – 3 months).	+ Interactions with other marine users including displacement from commercial, recreation and tourism areas + Turbidity generated from trenching activities may dissuade other users from the area while it is present	+ **Community and economy** (commercial fishers, traditional fishing, tourism and recreational activities, shipping traffic and oil and gas activities)	II-Minor	**Section 8.3.1.1**
Seabed and benthic habitat disturbance	Trenching and spoil disposal with: + Cutter Suction Dredger (CSD) + Trailer Suction Hopper Dredger (TSHD) + Backhoe Dredger (BHD) Trenching at intertidal/shore crossing with excavators up to the shore pull termination point Spoil Disposal at: + Spoil ground + In situ intertidal disposal to manage	**Trenching and spoil disposal** Direct impact to seabed in trenching locations (**Figure 2-8**) Spoil from trenching areas will be transported to and disposed of in the DPD spoil disposal area in offshore NT waters, which will result in disturbance from smothering due to sedimentation. Spoil from trenching activities at the shore crossing in the intertidal area will be side cast to the lower intertidal area to provide a mitigation to potential acid sulfate soil risk (i.e., to keep wet under most tidal conditions). Dependent upon access by BHD this build-up of spoil will be subsequently removed (if not already dispersed) for offshore spoil disposal to the DPD spoil disposal	**Spatial** There will be direct disturbance within the ZoHI around trenching areas (131 Ha) and spoil disposal area (649.8 Ha**)** with areas of substrate removal and smothering occurring. There will additionally be indirect disturbance to benthic habitats from sedimentation within the ZoMI and ZoI. The spatial extent of the predicted ZoI and ZoMI from segmentation is within the trenching footprint or immediately adjacent to the trenching footprint. Sensitive benthic habitats such as seagrasses and hard corals are not predicted to occur within these areas. Refer to **Section 6.5.3.** **Temporal** Within the trenching ZoHI, impacts will be permanent and non-recoverable.	+ Change to seabed topography and potential changes to water currents and associated changes to erosion/deposition of sediments + Increase in sedimentation and reduction in water quality and visual amenity + Trenching nearshore in intertidal muds may expose acid sulfate soils resulting in oxidation and leaching of acidic by-products + Direct and indirect impact to benthic habitats, including removal, smothering of and light reduction to benthic habitats + Reduction in available food for marine species utilising affected benthic habitats + Potential to impact fish health and other fauna	+ **Marine environmental quality** (water quality, physical parameters that support fishing, aquaculture, recreation and aesthetics, sediment quality) + **Marine ecosystem** (Potential loss of the following habitats: macroalgae, sandy sediment with filter feeders and sponges, infauna, epifauna and biota quality, benthic habitats and primary	II-Minor	**Section 8.2**

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
	risk of acid sulfate soils	area in offshore NT waters using a BHD and SHB. Note – impacts associated with the construction and presence of potential rock causeway/s to support trenching in the intertidal area are assessed in the DPD Project Offshore CEMP. Alteration of seabed/intertidal zone bathymetry from trenching activity and spoil disposal potentially resulting in local alteration of hydrology (i.e., seabed currents).	Sedimentation and turbidity effects outside the ZoHI are expected to be temporary only. The combined duration of trenching activities across areas is expected to be in the order of 2 – 3 months.	+ Potential disturbance to maritime heritage and sacred sites	producer habitat, including mangroves) + **Coastal processes** (Bathymetry and seabed features) + **Community and economy** (Impacts to demersal fish habitats) + **Culture and heritage** (Heritage areas, Shipwrecks, Maritime archaeology and sacred sites)		
Noise emissions	Trenching and spoil disposal noise emissions from: + Cutter suction dredge (CSD) + Trailer suction hopper dredge (TSHD) + Backhoe Dredge (BHD) for excavating with potential used of hydraulic tools (Xcentric Ripper, hydraulic hammer) for fracturing rock + Excavators Support operations noise emissions including: + General vessel operations during all DPD Project activities + Vessel and subsea positioning equipment e.g.	Vessel noise is considered non-impulsive (continuous) and broadband and includes vessel thrusters, engines and propellers, as well as noise emitted onboard which is converted to underwater noise through the hull. The main source of vessel noise will be from propellers or dynamic positioning (DP) thrusters (deeper water pipelay only). Project vessels (excluding trenching vessels) may emit noise up to ~180 dB re 1 µPa at 1 m. Trenching will be completed using different trenching vessels, including a BHD, a TSHD and a CSD. Noise includes operation of vessel engines for propulsion (as applicable), onboard equipment, pumps and interaction of trenching equipment with the seabed. The following source levels are considered representative of trenching vessel non-impulsive noise: + TSHD: 184 dB re 1µPa @1m + CSD: 182 dB re 1µPa @1m + BHD: 175 dB re 1µPa @1m BHD rock breaking tools will be either non-impulsive from Xcentric Ripper tool or impulsive from	**Spatial** For TSHD, CSD and BHD trenching and Xcentric Ripper tool use, permanent threshold shift (PTS) SEL24 hour ranges for dolphins, dugongs and turtles modelled at <50 m. Equivalent threshold range for hydraulic hammer modelled at 100 – 160 m. For TSHD, CSD and BHD trenching and Xcentric Ripper tool use, temporary threshold shift (TTS) SEL24 hour ranges for dolphins, dugongs and turtles modelled at 40 – 350 m. Equivalent threshold range for hydraulic hammer modelled at 950 – 2,500 m. The PTS and TTS ranges were shown to decrease with reduced hammering time (per 24 hours) for the hydraulic hammer. For behavioural response thresholds, ranges for marine mammals (dolphins and dugongs) varied from 100s of metres to 10s of kilometres for scenarios modelled at MSL. Spatial scales for other activities are as follows: + Localised: A support vessel using main engines and bow thrusters to maintain position will become inaudible above	Project activities including trenching additional vessel operations and will add to the existing underwater noise profile inside and outside Darwin Harbour during construction. The use of sound in the underwater environment is important for marine animals, particularly cetaceans, to navigate, communicate and forage effectively, along with reptiles, sharks/rays and other fish, for a range of functions such as social interaction, foraging and orientation. Underwater noise could result in: + Acoustic masking: – Disruption to underwater acoustic cues – Masking of vocalisations and signals from predators and prey + Behavioural response: – Modification of fauna behaviour (avoidance, attraction and disruption of normal behaviour) – Disturbance, leading to behavioural changes or displacement from areas – Indirectly by inducing behavioural and physiological	+ **Marine ecosystem** (marine mammals particularly cetaceans, marine reptiles, sharks, rays, pelagic and demersal fish) + **Marine environmental quality** (impact to parameters that support fishing, aquaculture, recreation, aesthetics and cultural/ spiritual values) + **Community and economy** (commercial and recreational fisheries) and tourism).	II-Minor	**Section 8.3.1.2**

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
	MBES, SSS, LBL) / USBL) + Helicopter operations	hydraulic hammer (contingency only). Representative source levels are: + Xcentric Ripper: 184.8 dB re 1 µPa2 s m^2 + Hydraulic hammer: 192 dB 1 µPa2s m^2	background noise within thousands of metres. + Localised: A conservative estimate is that survey equipment (MBES/SSS) will be inaudible within thousands of metres, depending on the activity characteristics. Localised: Helicopter noise will be highly localised and most of the noise will not transfer into the water. **Temporal** Trenching vessel noise expected over indicative period of 2-3 months.	changes in predator or prey species. + Physiological impacts: – Increased stress levels – Physical injury to fauna from exposure to excessive noise (barotrauma, hearing loss including TTS and PTS – Onshore construction activities are not expected to have an impact as they will not occur in water.			
Light emissions	Trenching and spoil disposal light emissions from: + Cutter Suction Dredger (CSD) + Trailer Suction Hopper Dredger (TSHD) + Backhoe Dredger (BHD) + Split Hopper Barges (SHBs) Support operations light emissions including: + General vessel operations during all DPD Project activities	Potential impacts from light emissions may occur from: + Operational, safety and navigational lighting + Spot lighting that may also be used as needed, such as equipment deployment and retrieval. Lighting will typically consist of bright white (e.g., metal halide, halogen, fluorescent) lights typical of existing commercial vessels using Darwin Harbour.	**Spatial** Localised: Limited light 'spill' or 'glow' on surface waters surrounding a vessel. Light spill modelling conducted for an offshore pipelay vessel and an offshore construction vessel, considered ''worst-case'' in terms of vessel lighting for the DPD Project, indicates that vessel light spill intensity is around 10 times that of a full moon at 150-200m from these vessels (either individually or side by side) and drops to the intensity of a full moon at 500-1000m (Pendoley, 2022). At a distance of 2.5-4.5km, light spill was modelled to have dropped to 0.1 (10%) of a full moon. At this level, lighting is considered unlikely to have any impacts on marine turtle hatchlings (which are considered particularly sensitive to lighting impacts) (Pendoley Environmental, 2022). **Temporal** Navigational and task lighting is required 24 hours a day for the duration of the trenching activities (indicatively 2 – 3 months).	Change in fauna behaviour due to light emissions from vessels could potentially include: + Disorientating turtle hatchlings emerging from nests + Increased predation of turtle hatchlings at sea within vessel light spill zones + Attraction of seabirds and shorebirds to light + Attraction and increased predation of fish within vessel light spill zone	+ **Marine ecosystem** (marine turtles, seabirds and shorebirds, fish) + **Marine environmental quality** (Impact to parameters that support fishing, aquaculture, recreation, aesthetics and cultural/spiritual values) + **Community and economy** (Fisheries and Tourism)	II-Minor	**Section 8.3.1.3**
Routine vessel discharges	All vessel activities	Only those discharges allowable under maritime regulations will be permitted as would apply to other	**Spatial** Localised: The environment that may be affected by operational discharges within permissible discharge areas will likely be	The small volumes discharged may cause localised nutrient enrichment, organic and particulate loading, thermal impacts and increased salinity.	+ **Marine environmental quality** (Water quality)	I-Negligible	**Section 8.3.1.4**

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
		commercial vessel using Darwin Harbour and NT waters. Planned discharges from vessels to the marine environment may include: + Deck drainage/run off including residual chemicals + Sewage and grey water – disposed in accordance with Marine Order 96. + Food wastes – disposed in accordance with AMSA and Marine Order 95, and MARPOL Annex V. + Cooling water + Bilge water – disposed in accordance with MARPOL Annex 1/Marine Order 91. + Brine (if a reverse osmosis unit is used for water treatment).	localised on a scale of metres to 10s of metres in the upper 5 m of the water column. **Temporal** Any permissible discharges will be intermittent over the period of trenching and spoil disposal (indicatively 2 – 3 months) and effects will be very short-term.		+ **Marine Ecosystem** (Ecosystem health) + **Community and economy** (Fisheries (commercial and recreational) and tourism)		
Atmospheric emissions	Atmospheric emissions from vessels combustion engines impacting on air quality	Potential impacts from atmospheric emissions may occur in the Project Area from the following sources: + Operation of trenching and support vessel engines, helicopters, and excavators. These emissions will include greenhouse gas (GHG) emissions, such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), and non-GHG emissions, such as sulphur oxides (SOX) and nitrogen oxides (NOX). + Operation of incinerators on vessels. Although the vessels may use ozone-depleting substances (ODS), this will be in a closed rechargeable refrigeration system and there is no	**Spatial** Localised: The quantities of gaseous emissions are relatively small and will, under normal circumstances, quickly dissipate into the surrounding atmosphere. **Temporal** Intermittent for the duration of the trenching activities.	Atmospheric emissions from activity vessels can result in deterioration of local air quality. Emissions of GHG can cause an incremental increase in global GHG concentrations. Given the nature and scale of DPD Project construction activities (low frequency and relatively short duration), both risks are considered to have a negligible impact on air quality.	+ **Marine environmental** quality (Local air quality) + **Community and economy** (Tourism)	I-Negligible	**Section 8.3.1.5**

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
		plan to release ODS to the atmosphere.					
Unplanned events							
Dropped objects (including accidental release of non-hazardous waste)	Trenching and spoil disposal with + Cutter Suction Dredger (CSD) + Trailer Suction Hopper Dredger (TSHD) + Backhoe Dredger (BHD) + Split Hopper Barges (SHBs) disposal Support operations including: + General vessel operations during all DPD Project activities	Solid objects such as those listed below can be accidentally released to the marine environment: + non-hazardous solid wastes, such as paper, plastics and packaging, PPE, small tools, vessel anchors and unsecured deck equipment + hazardous solid wastes, such as batteries, fluorescent tubes, medical wastes, and aerosol cans; and + equipment and materials, such as hard hats, tools or infrastructure parts (e.g., pipe joints, mattresses and frames).	**Spatial** The event would only occur within the Project Area, and all non-buoyant waste material or dropped objects are expected to remain within the Project Area. Buoyant objects could potentially move beyond the Project Area. **Temporal** Disturbance is expected to be temporary only with unplanned release of solids only occurring during construction activities	If an object is dropped overboard, potential impacts would be limited to minor and localised disturbance of the seabed and benthic habitats near the dropped object. Benthic habitat loss. Potential damage to subsea infrastructure or cultural heritage sites. Potential damage to cultural heritage objects and sites.	+ **Marine environmental quality** (Water quality and Sediment quality). + **Marine ecosystem** (Benthic habitats, infauna and epifauna and protected areas (Charles Point RPA)) + **Community and economy** (Oil and gas operations, other users, e.g. fisheries, tourism and recreational fishers and other industries e.g. telecommunications)	Low	**Section 8.3.2.1**
Introduction of invasive marine species	The mobilisation of trenching and spoil disposal vessels to the Project area.	Introduction of IMS may occur due to: + Biofouling on vessels and external/internal niches (such as sea chests, seawater systems) + Biofouling on equipment that is routinely submerged in water (such as survey equipment) + Discharge of high-risk ballast water + Cross-contamination between vessels. Once established, IMS have the potential to out-compete indigenous species and affect overall native ecosystem function.	**Spatial** Localised (seabed and water column within the Project Area) to widespread if successfully translocated to new areas via ocean currents or project equipment transit. **Temporal** Temporary to long-term (in the event of successful translocation).	Potential establishment of IMS in the marine environment as a result of the project requires IMS to: + Be present on a vector (biofouling on activity vessels and ballast water are considered credible vectors) + Be released from the vector + Establish in the receiving environment. If established, impact could include localised (seabed and water column near the Project Area) to widespread impacts, if successfully establishes to new areas. IMS could displace and outcompete local species	+ **Marine environmental quality** (Ecosystem health) + **Marine ecosystem** (Benthic habitats, benthic communities and Ecological function and processes) + **Coastal processes** (Ecological processes) + **Community and economy** (Other users e.g. commercial and recreational users and ports and shipping)	Low	**Section 8.3.2.2**

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
Unplanned marine fauna interactions	Trenching and spoil disposal with + Cutter Suction Dredger (CSD) + Trailer Suction Hopper Dredger (TSHD) + Backhoe Dredger (BHD) + Split Hopper Barges (SHBs) disposal Support operations including: + General vessel operations during all DPD Project activities	There is the potential for vessels or equipment (for example, associated with the TSHD, CSD and ROV) involved in trenching activities to interact with marine fauna, including potential strike or collision, potentially resulting in severe injury or mortality.	**Spatial** Within the Project Area, in the immediate vicinity of the vessels or subsea equipment. **Temporal** The risk is present during trenching and spoil disposal activities. Interactions with individual would be temporary.	Collisions may result in behavioural impacts, physical injury to, or the death of the fauna involved. Marine fauna may be entrained into or entangled by trenching equipment.	+ **Marine ecosystem** (Marine fauna – marine mammals, reptiles, fish and sharks)	Low	**Section 8.3.2.3**
Release of hazardous liquids	Trenching and spoil disposal with + Cutter Suction Dredger (CSD) + Trailer Suction Hopper Dredger (TSHD) + Backhoe Dredger (BHD) + Split Hopper Barges (SHBs) disposal Support operations including: + General vessel operations during all DPD Project activities	Hazardous liquids used on the DPD Project include fuels and oils for equipment and machinery and other task-specific chemicals required for trenching activities. Resulting in the accidental liquid releases (other than marine diesel oil or marine gas oil) include: + hydraulic fluids, lubricant oils and stored waste oils + stern tube oil (non-hydrocarbon-based lube oil) from the vessel thruster/propeller stern tube (approximately less than 1 m^3) + Chemicals, including corrosion inhibitor, cleaning and cooling agents, recovered solvents, stored or spent chemicals, leftover paint materials and used greases + Causes of hazardous liquid releases include: – Vessel pipework failure or rupture, hydraulic hose	**Spatial** Volumes are likely to be small and limited to the volume of individual containers (such as IBCs, 44 gallon drums) stored on the deck of supply vessels or limited to tank/hose volumes within equipment/machinery. The worst-case credible spill for this scenario is considered to be the loss of an intermediate bulk container (1 m^3). Concentrations below toxic or harmful thresholds are expected to occur at short distances from the release point. Should a spill occur, potential impacts beyond the Project area are not expected in the event of a worst-case spill. **Temporal** Potentially toxic or harmful threshold concentrations limited to a very short period immediately following an instantaneous release.	Decreases to water quality Decreases in sediment quality, and impacts to fauna from contact or ingestion. Given the nature and scale of the source of risk, the potential impacts to water and sediment quality are expected to be localised and temporary given the types of hazardous liquids that may credibly be lost overboard. Impacts to fauna may result in injury or mortality through contact and/or ingestion, however while this would reasonably be expected to impact upon individual animals; no population-scale impacts would credibly occur.	+ **Marine environmental quality** (Water quality and sediment quality) + **Marine ecosystem** (Marine fauna – marine mammals, reptiles, fish, sharks, seabirds and shorebirds)	Low	**Section 8.3.2.4**

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
		failure and inadequate and bunding – Spills or leaking machinery accidentally discharged overboard in deck drainage water – Overflow of the open and closed drainage systems – Loss of primary containment (drums, tanks, IBCs) due to handling, storage and dropped objects (such as swinging load during lifting activities). – Oily water from vessels includes bilge water and deck drainage water. The relative low volumes are expected to rapidly disperse into the marine environment					
Release of hydrocarbon (offshore vessel bunkering or vessel tank rupture	Trenching and spoil disposal with: + Cutter Suction Dredger (CSD) + Trailer Suction Hopper Dredger (TSHD) + Backhoe Dredger (BHD) + Split Hopper Barges (SHBs) disposal Support operations including: + General vessel operations during all DPD Project activities	A minor spill (up to approximately 10 m^3) of marine gas oil (MGO) or marine diesel oil (MDO) could occur during vessel to vessel refuelling resulting in a loss of hydrocarbons to the marine environment at sea surface. This scenario has been modelled within Darwin Harbour to inform the risk assessment (BAS-210 0030; RPS, 2022). Spills during refuelling can occur through several pathways, including fuel hose breaks, coupling failure or tank overfilling. It is considered credible that a release of diesel to the marine environment could occur from a vessel fuel tank rupture. For the purpose of risk assessment, discharges of 700 m^3, 300 m^3 and 87.5 m^3 have been modelled to represent a range of spill scenarios considered worst case for different	**Spatial** MDO spill trajectory modelling (BAS-210 0030; RPS, 2022) at KP 91.5 (just outside Darwin Harbour) indicated that there was some probability of a 700 m^3 marine diesel oil (MDO) spill, extending as follows (using the moderate exposure thresholds): + Shoreline loading was predicted to occur at Cox-Finniss, Outer Harbour West and West Arm in the dry season and Cox-Finniss, East Arm, Outer Harbour East and Outer Harbour West in the wet season. + Surface oil was predicted to occur within approximately 19.9 km (Dry season) and 19.3 (Wet season) of the release location. + Total submerged oil was predicted to occur within approximately 36.9 km (Dry season) and 51.3 km (Wet season) of the release location	A spill of MDO could result in a reduction in: + water quality + sediment quality + ecosystem health and impact to parameters supporting commercial and recreational uses Behavioural/ physiological impact to marine fauna (particularly those associated with the surface such as cetaceans and marine turtles) and plankton within the upper water column only. Impact to other users due to spill response activities Impacts to benthic habitats, including intertidal habitats and primary producers Impact to culture and heritage areas	+ **Marine environmental quality** (Water quality, physical parameters that support socio-economic activities) + **Marine ecosystem** (Marine fauna, benthic habitats, intertidal habitats, protected areas (Charles Point RPA)) + **Coastal processes** (primary productivity e.g. mangroves) + **Community and economy** (Community and economy e.g. commercial and recreational users)	Low	**Section8.3.2.5**

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
		vessel sizes used on the DPD Project, including trenching and spoil disposal vessels.	+ Dissolved hydrocarbons were predicted to occur with approximately 10 km (Dry season) and 13.7 km (Wet season) of the release location. MDO spill trajectory modelling for vessel fuel tank rupture (RPS, 2022) at KP 114 (in the middle of Darwin Harbour) indicated that there was some probability of a 300 m^3 marine diesel oil (MDO) spill respectively, extending as follows (using the moderate exposure thresholds): + Shoreline loading was predicted to occur at East Arm, Middle Arm, West Arm and Wickham Point in both wet and dry seasons. During the wet season shoreline loading is also expected at outer harbour east and outer harbour west + Surface oil was predicted to occur within approximately 19.6 km (Dry season) and 18.9 km (Wet season) of the release location. + Total submerged oil was predicted to occur within approximately 30.3 km (Dry season) and 32.4 km (Wet season) of the release location + Dissolved hydrocarbons were predicted to occur with approximately 0.6 km (Dry season) and 7.3 km (Wet season) of the release location. The extent of shoreline loading, and distance travelled of MDO from smaller spills of 87.5 m^3 and 10 m^3 modelled at KP 114 will be lower than that described for the 300 m^3 scenario **Temporal** The duration of a hydrocarbon spill would depend upon the specifics and severity of the incident. For the purpose of hydrocarbon spill modelling, the vessel tank rupture scenarios were modelled as 6-hour releases and the refuelling incident modelled as an instantaneous release. Once released, MDO disperses rapidly		+ **Culture and heritage** (Impacts to sacred sites or important cultural heritage significance)		

Aspect	Activity	Description of Hazard	Spatial and temporal scale	Potential Impacts	Sensitive receptors	Residual risk	Management strategy
			within the marine environment (on a scale of hours to several days) through entrainment, dissolution and evaporation leaving a smaller residual component (approximately 5%) to break down over a longer period through biodegradation (BAS-210 0030; RPS, 2022).				
Release of dry natural gas from Bayu-Undan to Darwin pipeline	Trenching activities resulting in impact to the Bayu-Undan to Darwin pipeline.	Damage to the Bayu-Undan to Darwin pipeline (located approximately 50 – 100 m from the proposed DPD pipeline route) due to objects/equipment dropped or dragged onto the pipeline from vessels associated with trenching activities.	**Spatial** The scale of a pipeline leak is dependent on the nature of the damage. Small 'pinhole' leaks will result in a stream of bubbles which may dissolve before reaching the surface. A major rupture (e.g. catastrophic failure) would result in the discharge of a large of dry gas forming a large plume in the water column and dispersing into the atmosphere. A catastrophic failure is considered to be the worst-case credible release from the Pipeline. **Temporal** The duration of the release would be dependent upon the scale of damage with smaller leaks releasing more slowly than larger leaks. Once released the gas would disperse rapidly to the atmosphere.	The gas cloud may result in impacts to air-breathing fauna, such as marine mammals, marine reptiles and birds. Animals breathing in the immediate vicinity of the release may be asphyxiated, potentially resulting in mortality. Given the dispersion of gas into the atmosphere, this potential effect would be highly localised to the release location. Toxic impacts from entrained/dissolved gas (predominantly methane) within the water column is considered unlikely given it is a dry gas. The gas cloud poses a risk to the health and safety of other marine users. A gas cloud could potentially form an explosive mix which, if ignited, result in injury/death and damage to property. However, all other marine users will be excluded from the exclusion zone and therefore will not expected to be within 500 m of an event, if it occurs	+ **Marine environmental quality** (Water quality, ecosystem health and physical parameters that support socio-economic activities) + **Marine ecosystem** (Marine fauna and protected areas (Charles Point RPA) + **Community and economy** (Other users e.g. commercial and recreational activities)	Low	**Section 8.3.2.6**

7.6 Assessment of potential for cumulative impacts

7.6.1 Marine Environmental Quality

This TSDMMP's activities have the potential to elevate turbidity levels within Darwin Harbor due to sediment suspension. Sediment dispersion modelling completed for the DPD Project (BAS-210 0036; RPS, 2020) predicted that there will be no exceedance of suspended sediment concentration (SSC) zone of impact or influence thresholds where influence or impact to sensitive benthic habitats (hard corals and seagrass) could occur, and with modelling showing that sedimentation threshold exceedance would be restricted to within or immediately adjacent to the trenching footprint (refer to **Section 6.5.3**).

While these impacts are not predicted to be significant, if multiple dredging programs were to occur concurrently, or if nearby dredging programs were to occur in close succession to one another, there is an increased risk that the cumulative impacts may be greater than from any one activity. There are numerous variables which influence the potential magnitude of these impacts including proximity, duration and dredging methodology, as well as the volumes and type of dredged material. The type, sensitivity and resilience of the different receptors present are also factors that influence the potential for cumulative impacts. External factors such as weather and seasons can also influence the potential for cumulative impacts, as well as the availability of the appropriate dredging vessels and equipment which can limit a proponent's ability to schedule activities at a practical level to reduce or avoid concurrent activities.

The potential for cumulative impacts from marine dredging from proposed dredge programs in Darwin Harbour determined to have high or medium risk of cumulative impacts with the DPD project (refer to the SER for further details; BAS-210 0020) is shown in Figure 7-1and summarised in

Table 7-8**.**

This TSDMMP outlines the management strategies for trenching and disposal activities (refer to **Section 8**). The implementation of these strategies will assist in reducing the risk of adverse impacts that may result from the DPD Project and its interaction with other projects that may occur at the same timeframes or location.

Santos will liaise with relevant proponents and authorities on timeframes and locations and will work with these stakeholders to minimise the potential for adverse cumulative impacts where possible through their stakeholder engagement process (refer to **Section 11**)

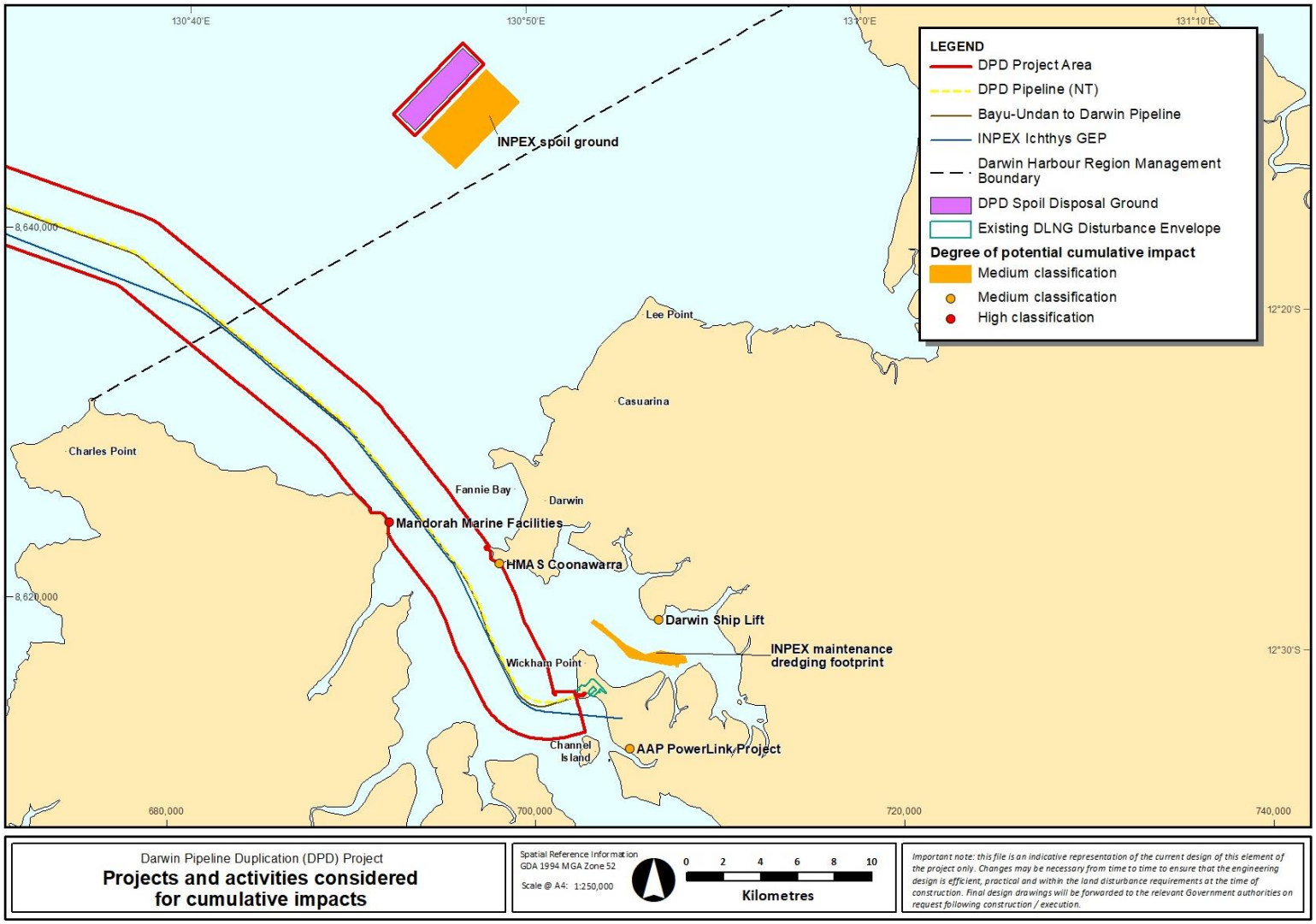


Figure 7-1: Projects and activities considered for cumulative impacts

Table 7-8: Potential for cumulative impacts from marine dredging from proposed dredge programs in Darwin Harbour

Proposed Project	Description
Mandorah Marine Facilities	The proposed Mandorah marine facilities (Mandorah project) covers an area of approximately 6 ha and involves dredging of an access channel, turning basin and berthing areas. The dredging footprint is approximately 1.5 km from the DPD Project pipeline route at its closest point (**Figure 7-1**). The draft dredging and spoil disposal management plan for the project states that 15,000 m^3 of unconsolidated marine sediments in Stage 1 and 70,000 m^3 of rock materials will be dredged for the project. Onshore disposal will occur for the rock and offshore for the unconsolidated sediments (Cardno, 2022c). Dredging of the unconsolidated marine sediments will be undertaken with a CSD and spoil will be disposed of by piping it offshore to a disposal site located approximately 600 m from the DPD Project pipeline route at its closest point and approximately the same distance from the nearest DPD Project trenching area (Trenching zones C1A and Pre-sweep Area 3, labelled as Trench Extent 6 and 10 respectively in **Figure 2-8**). The next closest trenching zone for the DPD Project is approximately 3 km south-east of the Mandorah project dredging footprint. To determine the potential for influence and impact to Marine Environmental Quality, sediment transport modelling (Cardno, 2022b) was undertaken using a similar approach to that used by Santos for the DPD Project. The modelling was used to identify potential impact zones including a Zone of High Impact (ZoHI), a Zone of Moderate Impact (ZoMI) and a Zone of Influence (ZoI) using thresholds for SSC and sedimentation for both dry and wet seasons, that were informed by INPEX Ichthys baseline water quality data (Cardno, 2022b; Cardno, 2022c). To evaluate the potential for cumulative impacts if both activities were to occur concurrently, the spatial extents of the worst case Zones of Influence (e.g. both wet and dry) from the spoil disposal site of the Mandorah project and the worst case Zone of Influence for the closest DPD Project trenching activities (CSD and TSHD trenching zones C1A and Pre-sweep Zone 3, labelled Trench Extent 6 and 10 respectively on **Figure 2-8**) were compared. This revealed that these Zones of Influence do not overlap and are separated by more than 400 m. Given this separation, the fact that the ZoI does not indicate impact, and the lack of sensitive receptor habitat (i.e. hard corals or seagrasses) between these areas, it is unlikely that there will be (or have any potential for) cumulative impact on water quality to the extent where this would influence benthic habitat. In a temporal context, dredging for the Mandorah project is currently scheduled for 2023 into 2024, and may occur concurrently with the overall DPD trenching program. The likelihood of concurrent and proximal trenching shall be established and temporal separation of the two capital dredging programs will be explored in collaboration with the Mandorah project to further minimise the potential for any cumulative impacts occurring.

Proposed Project	Description
	While there is predicted to be no overlap in zones of influence between Mandorah and DPD Project dredging/trenching activities, there could be interaction of turbidity plumes at very low concentrations, i.e. below the ZoI thresholds. It is considered that the greatest risk for interaction of turbidity between the Mandorah project and DPD Project activities is if the offshore disposal of sediments for the Mandorah project occurs concurrently with DPD Project trenching at the closest trenching and pre-sweep zones. Through consultation with DIPL, Santos understands the discharge is expected to be 3 – 6 weeks duration. Therefore, there is a reduced likelihood of this discharge and DPD trenching to be occurring at the same time and same place. Through continued consultation, opportunities to avoid spoil disposal/trenching operations at the same time in the same area will be explored.
INPEX – Ichthys Maintenance Dredging	INPEX is proposing to undertake maintenance dredging in East Arm, adjacent to the onshore Ichthys LNG facility and East Arm Wharf. The footprints of the proposed maintenance dredging and DPD trenching zones are > 5 km apart at their closest point near Wickham Point, and the spoil disposal area for each program are adjacent, with INPEX disposal grounds abutting the DPD disposal grounds to the southeast. Maintenance dredging proposed for INPEX shall occur in 2024 following completion of trenching for the DPD Project. The INPEX Maintenance Dredging and Spoil Disposal Management Plan (2023 – 2027) (INPEX, 2022) contemplates a scenario where the INPEX maintenance dredging and the DPD Project trenching operations could occur concurrently. The INPEX dredging area is over 4.5 km from the DPD Project pipeline route at its closest point and based on sediment transport modelling for both projects, there is no overlap of the ZoIs from these activities. When considering the INPEX spoil disposal activities at its offshore disposal site located over 15 km north-east of the closest DPD Project trenching zone (trenching zone C1A), there is no overlap of the ZoIs, however there is potential for excess suspended sediment (below ZoI threshold concentrations) to overlap. However, the concentration of the overlapping plume associated with trenching and spoil disposal is negligible (e.g. ≤1 mg/L) and over areas of soft bottom benthos/sediment so the potential for cumulative impact is not likely. The only exception are small, localised areas off Wagait Beach and the DLNG facility where modelling predicts small, localised areas of excess suspended sediment concentration plumes up to 2.5 mg/L. There is a small area of potential overlap of these modelled outputs, in particular the 3 – 5 mg/L contour in both the wet and dry season off Wagait Beach and 5 – 10 mg/L contour in both the wet and dry season adjacent to the DLNG facility. Based on this overlap, there is potential for cumulative 95th percentile excess suspended sediment plumes for the Project's maintenance dredging and DPD trenching to reach 7.5 mg/L off Wagait Beach and 12.5 mg/L adjacent to the DLNG facility for short periods of time. This is on the basis that the most intensive dredging for both campaigns is undertaken simultaneously, which is unlikely. Even if were to occur, the area that the suspended sediment concentration overlap occurs over is soft bottom benthos/sediment, with no overlap with coral or seagrass habitat.

Proposed Project	Description
HMAS Coonawarra - Dredging and Dredged Material Management	Department of Defence proposes to carry out two capital dredging campaigns of approximately 100,000 m^3 – 120,000 m^3 as part of upgrades to the Royal Australian Navy wharf facilities and basin navigation area at HMAS Coonawarra, which is approximately 1.8 km from the closest part of the DPD Project pipeline route (**Figure 7-1**). The first of those campaigns is referred to as NCIS-5 and is expected to occur in 2023, prior to commencement of DPD Project construction. The proposed action includes ongoing maintenance dredging at HMAS Coonawarra in the order of 10,000 m^3 to 15,000 m^3 every 5 – 7 years (NT EPA, 2022). Dredged spoil from operation of a CSD will be pumped via a pipeline to a location approximately 300 m southwest of HMAS Coonawarra breakwater for disposal into the channel. This location is approximately 1.5 km away from the nearest part of the DPD Project pipeline route and approximately the same distance away from the nearest pre-sweep area (labelled Trench Extent 5 in **Figure 2-8**). A small amount of hard pegmatite rock may need to be removed by BHD if the CSD cannot remove, if this is the case, associated BHD spoil will be disposed onshore. The NCIS-5 - HMAS Coonawarra Draft Dredging and Disposal Management Plan (KBR, 2022) presents modelled ZoIs and ZoMIs informed by sediment dispersion modelling. Comparing the worst-case extent for a Zone of Influence from the NCIS-5 dredging with a worst-case ZoI for the DPD Project (i.e. associated with pre-sweep in Trench Extent 5) reveals that these zones do not overlap and are approximately 900 m separated at the closest point which is west of the disposal site. Given this separation and the lack of sensitive receptor habitat (i.e., hard corals or seagrasses) between these areas, it is unlikely that there will be a cumulative water quality (turbidity/sedimentation influence on either water quality or benthic habitat from these projects, noting also they are not expected to be occurring at the same time. It is expected that Coonawarra dredging will be separated in time with DPD Project dredging, with NCIS-5 dredging expected to occur during 2023 and over a period of 2 months while DPD Project trenching will not occur until 2024. Given this, and also the spatial separation of zones of influence between these projects there is considered to be a low likelihood of impacts to benthic habitats from cumulative effects on water quality from these dredging/trenching campaigns. Santos will consult with the Department of Defence on the timing of dredging programs and management of any potential cumulative impacts.
Darwin Ship Lift and Marine Industries Project	The NT Government is proposing to deliver the Darwin Ship Lift and Marine Industries Project, which includes the construction of northern Australia's largest common user ship lift and adjacent maintenance facility in East Arm (AECOM, 2021). Construction requires the dredging of approximately 500,000 m^3 to create an access channel, manoeuvring/turning basin and berth pockets. All dredged material will be placed onshore, and where possible utilised for land reclamation. At its closest point, Ship Lift facilities are >5 km (closest straight line distance) from the DPD Project shore crossing, although Middle Arm lies between these two points. The

Proposed Project	Description
	original construction schedule indicates dredging operations will occur between Q4 2022 and Q2 2024 inclusive (AECOM 2021), however the main construction contractor, Clough, went into voluntary administration in December 2022 and was acquired by Webuild in February 2023. This may the Project. This small overlap on proximal projects modelled in a worst-case credible scenario suggest that the potential for cumulative impact with the DPD Project, which is at its closes point 5.5 km to the southwest, is unlikely. As per the Draft Dredging and Spoil Disposal Monitoring and Management Plan (AECOM, 2022) the modelled distribution of dredging and tailing disposal turbidity and sedimentation are very localised to the Ship Lift construction footprint and the closest ZoI from dredging is >5 km away from the closest ZoI from DPD Project trenching. Therefore there is no overlap in areas where water quality could potentially influence benthic habitat.
Australia-Asia Powerlink Project	The Australia-Asia PowerLink (AAPowerLink) by Sun Cable proposes to install three subsea cable systems extending from a cable transition facility near Gunn Point, to Singapore (Sun Cable, 2022). There are currently two proposed cable routes, both run west from Gunn Point and either pass to the approximately 3 km south or 1 km north of the dredge spoil disposal areas of the DPD project and INPEX. The AAPowerLink alignments cross the DPD alignment approximately 16 km and 30 km offshore respectively. Installation requires open trenches (one for each cable) to be excavated through the intertidal zone using conventual excavators (shore or barge based), which will be back filled with excavated material once cable pull is complete. Subtidal cable once laid, will be buried using high-pressure water injection or jet trenching, with the latter suited to intertidal and shallow water sections. The jetting system works by fluidising the seabed sediment causing the cable to sink under its own weight through the fluidised sediment, with sediment returning to their pre-jetted condition once jetting ceases. Jetting and subsequent fluidisation causes sediment to enter the water column where it can be transported to the far-field and potential impact sensitive receptors similar to dredging and spoil disposal. Modelling of jetting was completed assuming simultaneous burial of all three cables starting at the Gunn Point shore crossing moving along the cable route for 50 km over a seven-day period and repeated three times (i.e. three passes of jet trencher) to achieve modelled burial depth (Sun Cable, 2022). The modelling used predicted turbidity levels to identify High, Medium and Low risk zones (for impact), but none of these zones overlap the DPD Project Zone of Influence for the spoil disposal site. While there is no overlap in the ZoIs predicted, if the activities were to occur concurrently, there could be interaction of turbidity plumes at very low concentrations, i.e. below the ZoI thresholds. However, even if this were to occur, the lack of sensitive habitats in the area means there is a very low likelihood of potential for cumulative impacts.

Proposed Project	Description
	Given the recent decision for Sun Cable to enter into voluntary administration, the likelihood of concurrent dredging in areas in proximity to the capital dredging program and spoil disposal area is low. Nonetheless Santos will remain in consultation with Sun Cable to determine likelihood of any potential conflicting or concurrent dredging programs with a view to minimising the potential for any cumulative impacts where possible.

7.6.2 Marine Ecosystems

Impacts to Marine Ecosystems have been presented in the SER (BAS-210 0020) and summarised in **Section 7.5** and the residual impacts from the DPD planned activities were assessed to be Minor or Negligible. Consequently, it is unlikely that the Project activities could contribute towards a significant impact. However, the potential for cumulative impact from direct and indirect seabed disturbance and from noise and unplanned vessel interactions has been assessed in the following sections.

7.6.2.1 Cumulative direct habitat disturbance

Direct impacts to seabed habitats from planned events will be restricted to the DPD Project infrastructure footprints, including the spoil disposal ground which do not overlap with other current, or proposed project activities. The benthic habitats under the DPD Project infrastructure footprints comprise predominately filter feeders which are widely represented elsewhere in Darwin Harbour and the wider region. No sensitive hard coral or seagrass habitats are at risk from direct impact. Consequently, direct impact is not expected to have a significant impact to the function of the ecosystem and while other current and proposed activities will also have direct impacts to benthic habitats, overall spatial overlap is minor and indicates cumulative impacts are unlikely to be significant.

Based on the calculations presented in (BAS-210 0020), the direct and indirect impact to benthic habitats from the Project make up > 0.2% of the bare ground, <0.2% of the macroalgae and <0.3% of the sponge or sponges/filterers/octocoral habitat in Darwin Harbour. The habitat loss predicted by the Mandorah Marine Facilities (Cardno, 2022a) is <0.001% of coral, 0.04% of sponge and 0.02% of seagrass along the east side of Darwin Harbour (Note, as the percentage loss is given as a proportion of the habitat along the east side of Darwin Harbour, the loss as a percentage of habitats across Darwin Harbour would be considerably smaller). In the Ichthys EIS supplement (INPEX Browse Ltd, 2011) predicted the loss of 0.9% of coral and filter-feeder habitat, 0.8% loss of macroalgae, and <5% of sand, mud and gravel. While no data for the Bayu-Undan to Darwin pipeline were available, a conservative approach would be to base habitat loss on the current Project given its parallel alignment and similar installation methods.

When the benthic loss from each of these projects is combined (conservatively), less than 5% of the bare ground, <1% of hard coral, seagrass macroalgae and sponges or sponge/filterer/octocoral habitat found across Darwin Harbour has or will be lost from these developments. Other projects that are proposed, such as the INPEX maintenance dredging, the Ship Lift and Marine Industries Project and the HMAS Coonawarra dredging programme all predict no impact to seagrass, coral or macroalgae, suggesting any cumulative impact to benthic habitats would be the loss of bare sediment or to be very conservative, loss of filter feeder habitat which is the most abundant habitat type found across Darwin Harbour.

However, while there has been/would be loss of particular benthic habitats, these habitats have been/will be replaced by additional hard substrate in the form of pipelines and other infrastructure. Recent studies investigating habitats and fish associated with oil and gas infrastructure, including the existing Bayu-Undan to Darwin pipeline (McLean *et al.*, 2021) documented that the sessile biota growing on the pipeline, which included potential prey for marine turtles such as soft corals and sponges, had much higher densities compared to the habitats surrounding the pipeline where such biota were wither absent, or present at much lower densities. Furthermore, the fish assemblages observed on and around subsea pipelines, are of higher diversity than those found off the pipelines (McLean *et al.*, 2020) and there is evidence in the literature that the presence of such subsea infrastructure can promote biodiversity and abundance through an increase in habitat complexity and crevices (McLean *et al.*, 2022).

7.6.2.2 Cumulative indirect habitat disturbance

Indirect impacts to marine ecosystem, e.g., from increased SSC and sedimentation from the DPD Project will be temporary and have been predicted to be low. As the spatial extent of potential indirect impacts have also been predicted to be restricted to footprints where direct impacts will occur, and similarly ZoIs are within or very localised around footprints, it is unlikely that the DPD Project could contribute to significant cumulative indirect impacts. While other current and proposed activities will also have indirect impacts to benthic habitats, as there is no overlap in ZoIs form other dredging project and the DPD Project (refer to **Section 7.6.1**) and the habitats that may be impacted from other dredging projects are well represented across Darwin Harbour, there is a low likelihood that cumulative impacts could become significant.

This argument extends into the assessment as to whether cumulative impact (direct and indirect) of benthic habitats could indirectly impact marine fauna. While some of the habitats that will be impacted by current and proposed activities provide foraging material and habitat for a range of marine fauna including reptiles and fish, the proportionately small loss of habitat as a percentage of that available in Darwin Harbour (quantified above) is unlikely to have an indirect impact on those fauna or the wider ecosystem function, especially where habitat is being replaced with infrastructure which can improve diversity and provide hard substrate that can be exploited by sessile biota which in turn can become a source of food for marine fauna.

8 Environmental Management Strategies

This section outlines the environmental management strategies (EMSs) that will be implemented for trenching and spoil disposal activities to reduce and mitigate impacts and risks to the environment.

The EMSs to be implemented as part of this TSDMMP comprise of the following:

+ Management of trenching related water quality and benthic habitat impacts (**Section 8.2**)
+ Management of other trenching-related impacts (**Section 8.3**)

These EMSs outline environmental performance objectives (EPOs), measurable targets and the management actions (MA) in place to ensure that the EPOs and targets are met. Performance Indicators and monitoring activities (where applicable) are used to quantify success in meeting targets and identify the need for corrective actions. This provides a mechanism for improving the effectiveness of the Project's EMSs. The EMSs define the reporting requirements, terms, and responsibilities.

All EMSs are structured to align with the template presented in **Table 8-1**.

Table 8-1: Environmental management strategy template derived from the NT EPA Draft Guideline for the Preparation of an Environmental Plan (NT EPA, 2022)

Item	Content
Environmental Performance Objectives (EPO)	Environmental management goal(s) tailored to each aspect per NT EPA requirements.
Target	Aspect specific measurable performance necessary to successfully achieve objective. Part 1 of NT EPA required performance criteria.
Performance Indicator	Quantitative or qualitative measures representing the performance related to Target(s). Part 2 of NT EPA required performance criteria.
Management actions	Measures or actions that will be used to achieve objective/s. For example, trained and competent anchor handling operators will be used

8.1 NT EPA environmental management hierarchy

In the development of the management strategies outlined within this TSDMMP Santos applied the Environmental Decision-Making Hierarchy outlined within the EP Act. This hierarchy being:

a. To ensure that actions are designed to avoid adverse impacts on the environment
b. To identify management options to mitigate adverse impacts on the environment to the greatest extent practicable
c. And if appropriate, provide for environmental offsets in accordance with the EP Act for residual adverse impacts on the environment that cannot be avoided or mitigated[3]

[3] No offsets were deemed appropriate for this project.

8.2 Management of trenching-related water quality and benthic habitat impacts

This EMS does not cover management measures associated with potential acid sulfate soils within the shore crossing area. This is outlined specifically within the ASSDMP (BAS-210 0049).

Management of sediment related impacts has been informed by the sediment related management framework developed in INPEX Ichthys Project: Dredging and Spoil Disposal Management Plan and INPEX Ichthys Project: Maintenance Dredging and Spoil Disposal Management Plan (INPEX, 2014; INPEX, 2018; INPEX, 2022).

8.2.1 Environmental performance objectives, performance criteria and management actions

The EPOs and performance criteria relevant to this impact are described in **Table 8-2**.

Table 8-2: Seabed and benthic habitat disturbance EPOs and associated performance criteria

EPO	Performance criteria	
	Target/s	**Performance Indicator/s**
Minimise direct impacts to sensitive marine habitat, cultural and socio-economic sensitivities	Pipeline alignment and trench areas designed to minimise trenching requirements and direct footprint of seabed disturbance	+ Quantitative risk assessment (BAS-201 0925) + Nearshore pipeline route selection report- Darwin Harbour (BAS-200 0642)
	No trenching outside the boundaries of the trench areas	+ Nearshore pipeline trench and trench backfill alignment details 34in northern route (BAS-200 0523 001) + Trenching out-survey reports
	No anchoring on sensitive seabed areas	Incident reports of anchoring inside anchoring exclusion zone
	No damage to known heritage sites of significance or existing submerged infrastructure	Incident reports of damage to heritage sites/ artefacts of significance, or existing infrastructure
	All unexpected finds managed as per Unexpected Finds Protocol (BAS-201-0051)	Records indicating unexpected finds are managed per the Offshore Development Unexpected Finds Protocol (BAS-210 0051)

EPO	Performance criteria	
	Target/s	Performance Indicator/s
Avoid sediment dispersion and sedimentation related impacts on seagrass and hard coral habitats from trenching and spoil disposal activities	No DPD Project related impact to seagrass or hard coral from trenching or spoil disposal turbidity	+ Water quality and benthic habitat monitoring data (refer to **Section 9**) + Attributability assessments
Minimise impacts from spoil disposal	No spoil disposal outside of DPD spoil disposal ground	+ During and post spoil disposal Hydrographic surveys + Spoil disposal logs

The EPOs detailed in this TSDMMP are in line with the following objectives for the relevant NT EPA factors (NT EPA, 2021):

+ Coastal processes – Protect the geophysical and hydrological processes that shape coastal morphology so that the environmental values of the coast are maintained.
+ Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.
+ Culture and heritage – Protect culture and heritage.

The management actions for this impact are detailed in **Table 8-3**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-3: Management action for trenching related seabed and benthic habitat disturbance

MA reference	Management actions
Standard management actions	
Avoidance	
DPD-MA12	Pipeline route was surveyed (geophysical and geotechnical) to evaluate the seabed and designed to avoid seabed features, known heritage sites and to minimise trenching/rock protection as far as possible while maintaining safety requirements Trenching will only be undertaken at identified areas (using standard positional accuracy measures used in the industry)
Mitigation	
DPD-MA13	Overflow from the TSHD will be undertaken through the adaptive management processes (if triggered) There will be 'environmental valve', 'green valve' where available (attached to O/F to reduce air entrained, to reduce billowing and facilitates sediment sinking) as standard which will be used as a first step
DPD-MA14	Standard operating procedure for spoil disposal will be used.
DPD-MA15	Spoil will not be disposed of in a single location, to avoid developing a single large mound.
DPD-MA16	Spoil will only be placed *in situ* within a short section of trenching within intertidal zones and will be removed subsequently where accessible by BHD and SHB for offshore disposal
DPD-MA18	Anchor management plans will be developed to allow safe anchoring of vessels undertaking pipelay, trenching and other support activities in the vicinity of sensitive habitats and nearshore heritage or sacred sites
DPD-MA29	Trained and competent anchor handling operators will be used
DPD-MA20	Anchors exclusion areas will be implemented to avoid sensitive habitats and heritage sites
DPD-MA21	Independent cultural heritage and habitat assessment have been undertaken to identify potential important heritage sites and habitat along the pipeline route and to avoid sensitive benthic habitats and cultural objects where practicable. Maritime cultural heritage objects that cannot be avoided will be managed as per NT Heritage Branch requirements
Monitoring	
DPD-MA28	Adaptive management process as defined in Section 8.6.2.4 which includes environmental monitoring of water quality with management measures applied if water quality exceeds trigger levels

Table 8-4: Additional management action not adopted for trenching related seabed and benthic habitat disturbance

Additional management actions not adopted		Reasoning for rejection
1	No trenching using CSD	It is not technically feasible to stabilise and protect pipeline without trenching. The use of CSD is a mitigation for dredging consolidated material and variations from design in realised conditions. Not utilizing the CSD may pose substantial schedule and cost impacts if harder soil types are encountered on the operating limits of the TSHD and BHD.
2	No trenching using TSHD	It is not technically feasible to stabilise the pipeline without trenching.
3	No trenching using BHD	It is not technically feasible to stabilise the pipeline without trenching.
4	Restrict timing of activities to operate outside of known sensitive periods only. Flatback turtle peak nesting period is May to October and Dolphin peak calving is October to April.	The beaches closest to the Project Area (Casuarina Beach, Cox Peninsula) are not considered regionally significant turtle nesting beaches. It is also not considered ALARP to prevent trenching in peak dolphin calving period due to cost and schedule implications. Monitoring programs have been unable to determine spatial and temporal patterns in occurrence and abundance of dolphins in Darwin Harbour or any links to anthropogenic activities and behavioural disruption. Trenching areas are adjacent high use areas for vessels and the effects of turbidity are expected to be minor in the context of natural variability.
5	No offshore spoil disposal	The only alternative is for onshore disposal of spoil, however the additional time in the field that would be required, would be prohibitive and greatly prolong impact to other users of Darwin Harbour. Given the minor impacts predicted from the offshore disposal of spoil, this control is rejected. There are currently no viable options for the re-use of spoil available.
6	Spoil to be disposed of in a manner to create a uniform thickness of spoil	Spoil will not be disposed in one area only however it cannot be guaranteed to be uniformly spread. The additional time and effort to ensure uniform thickness of spoil is not reasonably practicable in comparison to any potential benefits. Sediment modelling has not identified re-suspension and ongoing transportation of sediments to be significant.

8.2.2 Adaptive monitoring/management strategy

The adaptive monitoring/management strategy for trenching related water quality and benthic habitat impacts has been developed to adapt management actions if associated triggers are exceeded to ensure EPOs are met. The strategy includes a tiered pressure-response strategy (in accordance with the NT EPA Draft Guidelines for the Environmental Assessment of Marine Dredging in the Northern Territory; NT EPA, 2013) based on turbidity monitoring, with management response escalation proportionate to the risks to sensitive receptor communities. The environmental monitoring program (**Section 9**) is therefore based on turbidity data as the lead indicator for environmental quality deterioration resulting from trenching activities. This allows trenching operations to be managed appropriately to prevent or mitigate the potential ecological impacts to an agreed level and remove the requirement for immediate/intensive sensitive receptor monitoring. A three-tiered approach to trigger levels, consistent with that included in INPEX Ichthys dredge management plans, has been applied as follows (refer to **Figure 8-1**, **Table 8-6** for adaptive management decision tree and adaptive management actions):

1. **Level 1 triggers** are early warning indicators. They indicate when environmental quality conditions are nearing the limits of the background conditions that receptors are naturally exposed to. Exceedance of Level 1 triggers does not require any alterations to the trenching operation but does necessitate an attributability assessment to determine if the exceedance is related to the DPD Project trenching activity and investigation into potential improvements to optimise trenching work method.
2. **Level 2 triggers** are the limits of the background conditions that receptors are naturally exposed to. Exceedance of Level 2 triggers (if attributable to dredging) result in the implementation of responsive management actions to reduce turbidity measurements to within Level 1 triggers. Once implemented adaptive management can only cease and normal operations recommence once turbidity measurements have returned below Level 1 trigger values.
3. The **Level 3 trigger** is an exceedance of an allowable duration. If a Level 2 trigger has been reached, and found to be attributable to dredging, and turbidity does not return to below the Level 1 trigger within seven days after the implementation of Level 2 responsive management, contingency management actions must be implemented until turbidity has returned below Level 1 trigger values. Normal operations cannot recommence until turbidity has returned below Level 1 trigger values.

To reduce the potential impacts resulting from the cumulative impact of increased SSC and increased water temperatures on coral communities' trigger values for water temperature will be implemented. If the 21-day rolling average for water temperature exceeds the trigger value outlined of 31°C at the reactive sites, then appropriate responsive management actions will be implemented (**Table 8-6**).

A habitat trigger will not be adopted as part of the adaptive management for trenching. The time lag between surveys and data analysis means is too long for reactive management given the total proposed duration of trenching, i.e., trenching in any specific area would have been completed before results are returned. Instead, the proposed WQ monitoring would report any exceedance of triggers within 24hrs of occurrence. Additionally, WQ is a leading indicator and the triggers defined are conservative and will therefore effectively mitigate any potential impacts to benthic habitats.

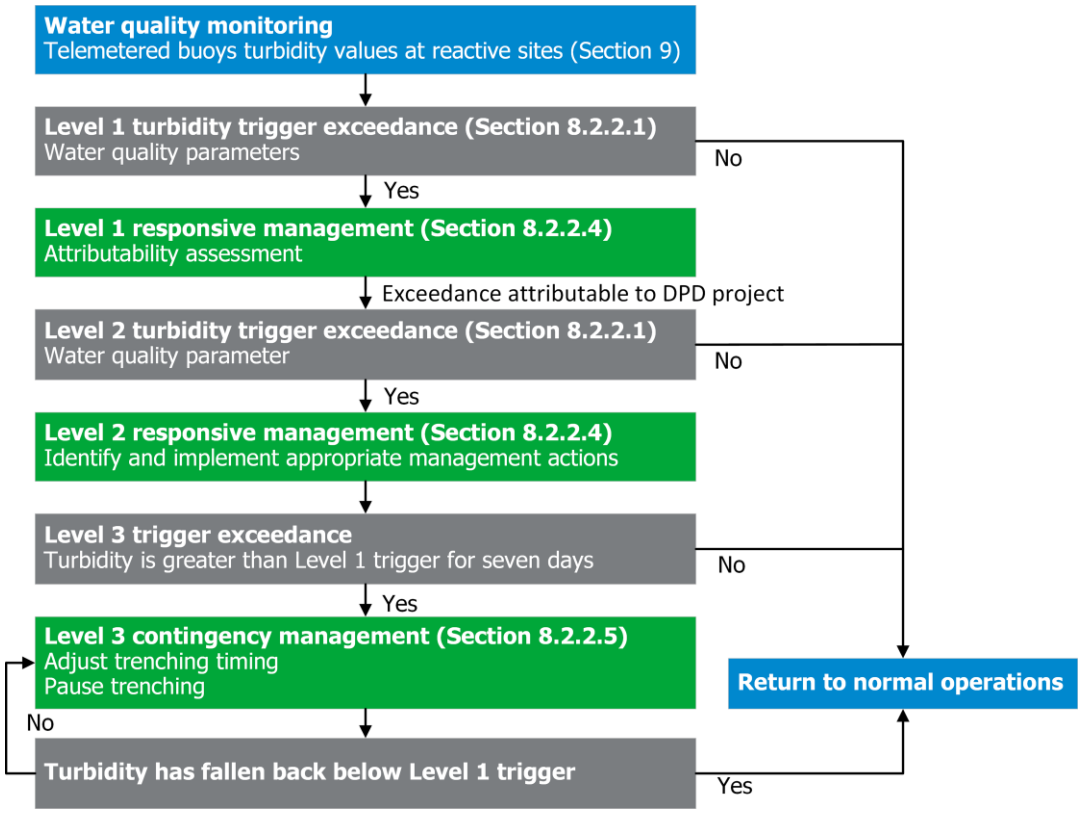


Figure 8-1: Decision tree outlining practise for turbidity triggers

8.2.2.1 Management triggers values

Management trigger values for this TSDMMP are based upon the methods used to develop triggers for INPEX's Maintenance Dredging and Spoil Disposal Management Plan (INPEX, 2018; INPEX, 2022). As there were no recorded declines in sensitive receptors (seagrass and coral) health attributed to dredging activity detected during INPEX's capital dredging campaign, triggers could not be derived based on dredging-related turbidity and impacts to sensitive receptors. Therefore, the following conservative method of establishing turbidity triggers has been implemented for this TSDMMP.

A habitat trigger will not be adopted as part of the adaptive management for trenching. The time lag between surveys and data analysis means is too long for reactive management given the total proposed duration of trenching, i.e., trenching in any specific area would have been completed before results either do or do not indicate an impact. Instead, the proposed water quality monitoring (**Section 9**) would report any exceedance of triggers within 24hrs of occurrence. Additionally, water quality is a leading indicator and the triggers defined are conservative and will therefore effectively mitigate any potential impacts to benthic habitats.

The method used by INPEX was based on McArthur *et al.* (2002) and Jones *et al.* (2015), and summarised as follows:

+ The use of local data within which water quality is to be maintained.
+ Recognition that impacts to sensitive receptors are not solely caused by increased turbidity, but also the duration and frequency of exposure events, relevant to natural ranges.
+ Management triggers to be developed for both acute and chronic events.

In line with INPEX's DSDMP, only acute triggers are deemed relevant due to the relatively short duration of Santos' trenching campaign.

The management triggers were derived for this TSDMMP are site-specific and based on long-term baseline turbidity data collected at sites relevant to the DPD Project from January 2010 to January 2011 and August 2012 to January 2015, excluding periods of dredging activity (INPEX, 2018). Data recorded during extreme rainfall events were also excluded from the dataset used to develop triggers as it was noted that these events led to the calculated trigger being much greater at certain sites. Therefore the exclusion of these data has resulted in more conservative trigger values. Extreme rainfall events were defined as exceedances of the 95th percentile for wet season mean daily rainfall events and were developed from the rainfall data collected at the Bureau of Meteorology Channel Island weather station between 1991 – 2018. Refer to **Section 9.3.1** for details of the sites selected for the derivation of management triggers and therefore trigger exceedance monitoring (termed reactive sites).

Level 1 and Level 2 turbidity triggers were developed from daily average turbidity and are comprised of a turbidity value and allowable duration that both need to be exceeded for an exceedance to occur.

Level 1 trigger turbidity values are the 95th percentile of the daily average turbidity data recorded. The allowable duration was then developed by reviewing the dataset to determine the number of consecutive days the turbidity values were exceeded, collectively known as individual event. The 95th percentile for individual events was then identified as the allowable duration. Therefore, providing the allowable number of consecutive days the turbidity value can be exceeded.

Level 2 trigger turbidity and allowable duration values were developed using the same method as Level 1 triggers, except the turbidity values are represented by the 99th percentile of daily average turbidity data. Allowable duration trigger was then developed by reviewing the dataset to determine the number of consecutive days the 99th percentile turbidity value was exceeded (i.e., individual events). The 95th percentile for individual events was then identified as the allowable duration.

Table 8-5: Level 1 and 2 turbidity management trigger criteria for trenching related seabed and benthic habitat disturbance

Monitoring site	Season	Level 1 trigger (daily average) >intensity value & >duration or > frequency			Level 2 trigger (daily average) >intensity value & >duration or > frequency		
		Intensity (95th %ile)	Duration (consecutive days)	Frequency (days per 7 day rolling period)	Intensity (99th %ile)	Duration (consecutive days)	Frequency (days per 7 day rolling period)
Channel Island	Wet season	24 mg/L	7	6	49 mg/L	3	3
	Dry season	15 mg/L	4	4	19 mg/L	3	3
Weed Reef	Wet season	31 mg/L	7	6	67 mg/L	2	2
	Dry season	11 mg/L	5	4	15 mg/L	3	3
Woods Inlet	Wet season	16 mg/L	2	2	20 mg/L	1	1
	Dry season	15 mg/L	4	4	20 mg/L	2	2
Charles Point	Wet season	22 mg/L	3	3	27 mg/L	1	1
	Dry season	23 mg/L	4	4	26 mg/L	2	2
Mandorah	Wet season	13 mg/L	1	1	15 mg/L	1	1
	Dry season	16 mg/L	4	4	20 mg/L	2	2

8.2.2.2 Adaptive management actions

Adaptive management actions that will be implemented following the exceedance of a trigger are detailed in **Table 8-6**.

Table 8-6: Adaptive Management Mechanism for trenching related seabed and benthic habitat disturbance following trigger exceedance

MA reference	Management Actions
Level 1 exceedance responsive management actions	
DPD-RMA01	Santos will conduct attributability assessment and liaise with other proponents with concurrent dredging operations in Darwin Harbour.
DPD-RMA02	Dredging Contractor in consultation with Santos (and other concurrent Darwin Harbour dredging operations, as applicable) will assess potential opportunities for continuous improvement
Level 2 exceedance (attributable to trenching) responsive management actions	
DPD-RMA04	Dredging Contractor in consultation with Santos (and other concurrent Darwin Harbour dredging operations, as applicable) will: + Implement applicable responsive management actions from the following: – Investigate potential changes to dredge methods to improve water quality – Changing location of trenching to another trenching zone – Reduce dredge overflow – Change disposal location within spoil disposal ground + Where applicable prepare an implementation strategy for adaptive management actions.
DPD-RMA05	Santos will inform NTEPA and DEPWS of exceedance and management actions taken
Level 3 exceedance (attributable to trenching) contingency management actions	
DPD-CMA01	Dredging contractor in consultation with Santos (and other concurrent Darwin Harbour dredging operations, as applicable) will: + Implement applicable contingency management actions (identified based on investigation of impacts): – Trenching operation timing e.g. night/day – Pause trenching activities
DPD-CMA02	Implementation of benthic habitat monitoring at exceedance site/s and control sites to determine if any trenching-related impacts to hard corals and/or seagrass condition has occurred

MA reference	Management Actions
DPD-CMA03	Santos will notify NT EPA and DEPWS within 24 hours
DPD-CMA04	Santos will demonstrate that applicable contingency management action/s are suitable for mitigation of impacts.
DPD-CMA05	Santos to review telemetered environmental quality data to ensure implemented contingency management action/s are effective.
Coral temperature trigger exceedance responsive management actions	
DPD-RMA01	Conduct attributability assessment to determine if trenching is raising turbidity at the site/s showing the coral temperature trigger exceedance. If trenching is attributable to an increase in turbidity, dredging Contractor in consultation with Santos will: + Implement applicable responsive management actions from the following: – Investigate potential changes to dredge methods to improve water quality – Changing location of trenching – Reduce dredge overflow – Change disposal location within spoil disposal ground

8.2.2.3 Attributability to trenching

If triggers are exceeded the cause of the exceedance needs to be investigated initially to define whether it is attributable to DPD Project trenching and/or spoil disposal activities. The attributability process is initially started by determining whether the data collected is reliable. If an exceedance is found to not be valid due to data quality issues (e.g. fouling on sensors), then management actions are limited to those required to reduce the likelihood of future data quality issues.

If data is considered reliable then multiple lines of evidence will be explored to investigate the cause of exceedance per the recommendations from ANZG (2018). Below is all information considered in attributability investigation:

+ Weather and oceanographic conditions prior to and during exceedance.
+ Water quality from telemetered buoy sites and from regional remote sensing imagery
+ Sediment characteristics at dredging sites
+ Location of monitoring site recording exceedance in relation to recent DPD Project trenching and spoil disposal activities
+ Relationship between the nature of recent DPD Project trenching activities and start of exceedance
+ The activities of any other concurrent dredging operations within Darwin Harbour and the potential effect on water quality from these concurrent operations.

This assessment of evidence will likely utilise published scientific literature and tools including:

+ Hydrodynamic model outputs such as predicted current speed and direction
+ Sediment dispersion modelling predictions of excess SSC occurrence related to trenching activities (RPS 2022).

If following the investigation of attributability, the exceedance is found to be attributable to trenching activities, then appropriate responsive management actions will be implemented if Level 2 triggers are exceeded (**Section 8.2.2.4**). It is important to note that an exceedance attributable to trenching activity may not always indicate adverse ecological impacts. This particularly applies to Level 1 exceedances as they are an early warning indicator, identifying that turbidity levels are approaching the limits of natural conditions. Level 2 exceedances will result in the identification and execution of responsive and if necessary, contingency management actions and will consider multiple factors that are discussed in the following sections.

Where an exceedance of the Level 2 triggers occurs but the attributability assessment has determined it is due to natural events (i.e. not attributable to dredging), the relevant NT EPA and Northern Territory Government departments will be notified and no further action will occur.

8.2.2.4 Responsive management

If a Level 2 exceedance occurs and is determined to be attributable to DPD Project trenching activities, responsive management actions will be implemented. Trenching activities return to normal operations once turbidity has returned to below Level 1 trigger values. A summary of adaptive responsive management actions considered practicable to reduce and/or mitigate turbidity have been listed in **Table 8-6**. Where there are concurrent dredging operations in Darwin Harbour, and there is evidence that concurrent dredging operations are affecting water quality at monitoring sites, responsive management will be done in consultation and coordination with other dredging operators.

8.2.2.5 Contingency management

If turbidity values do not return below Level 1 exceedance triggers within seven days of adaptive management actions being implemented, the Level 3 trigger is exceeded and contingency management actions will be implemented. Trenching activities can only return to normal operations once turbidity returns below Level 1 exceedance trigger. A summary of contingency management actions considered practicable to reduce turbidity are listed in **Table 8-6**. Additional to management measures, benthic habitat monitoring will be conducted at monitoring site/s showing a Level 3 exceedance, and at reference sites, to determine if exceedances have impacted seagrass and/or hard corals present at the sites. Monitoring results will be compared to baseline results collected prior to trenching (refer to **Section 9**)

Where there are concurrent dredging operations in Darwin Harbour, and there is evidence that concurrent dredging operations are affecting water quality at monitoring sites, contingency management will be done in consultation and coordination with other dredging operators. The NT EPA will be notified of proposed additional contingency management actions by Santos prior to their implementation. The appropriateness of contingency management actions will be interpreted, validated, and justified by dredging contractor and approved by Santos prior to notification of NT EPA.

8.3 Management of impacts and risks

8.3.1 Other planned events impacts

Santos' environment assessment identified an additional five potential sources of environmental impact associated with the planned activities to be undertaken in the Project Area. Management strategies have been adopted in the TSDMMP based on the ENVID undertaken for DPD Project trenching and spoil disposal activities in May/June 2022 (Refer to **Section 7.2**).

8.3.1.1 Interaction with other marine users – construction activities and Project infrastructure

8.3.1.1.1 Environmental performance objectives, performance criteria and management actions

The EPOs relevant to this impact including performance criteria are described in **Table 8-7**.

Table 8-7: Interaction with other marine users (including construction activities and Project infrastructure) EPOs and associated performance criteria

EPO	Performance criteria	
	Target/s	Performance Indicator/s
Avoid incidents resulting from interaction with other marine users	Zero incidents resulting from interactions.	Incident records of interactions with other marine users
Minimise impacts to other marine users	Zero impacts to other marine users on completion of DPD trenching and spoil disposal activities	Number of complaints from other marine users following completion of DPD trenching and spoil disposal activities
Stakeholders are well-informed of the DPD Project and its associated restrictions	DPD Project stakeholder list is provided activity update/s and notification of commencement of trenching and spoil disposal activities	Stakeholder notification records

The EPOs detailed in this TSDMMP are in line with the following objective for the relevant NT EPA factor (NT EPA, 2021):

+ Community and economy – Enhance communities and the economy for the welfare, amenity and benefit of current and future generations of Territorians.

The management actions for this activity are shown in **Table 8-8**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-8: Management actions for trenching vessel interaction with other marine users

MA Reference	Management Action
Standard management actions	
Mitigation	
DPD-MA04	Activity vessels equipped and crewed in accordance with Australian maritime requirements
DPD-MA05	Ongoing stakeholder consultation with relevant stakeholders and marine users (including applicable notifications) to minimise adverse impacts on other marine users
DPD-MA06	Implementation of precautionary zones around DPD Project vessel to mitigate against adverse interactions
DPD-MA07	Vessels supporting the trenching operations will act as surveillance vessels when operating adjacent to the trenching vessels

8.3.1.2 Noise emissions

8.3.1.2.1 Environmental objectives, performance criteria and management actions

The EPOs relevant to this impact including performance criteria are described in **Table 8-9**.

Table 8-9: Noise emissions EPOs and associated performance criteria

EPO	Performance criteria	
	Target/s	**Performance Indicator/s**
Avoid hearing injury impacts to protected marine species from underwater noise generated by DPD Project trenching and spoil disposal activities	Zero incidents of injury or mortality to EPBC Act listed marine fauna from noise generated during DPD trenching and spoil disposal activities	+ Incident reports of injured or dead EPBC Act listed fauna + MFO records of EPBC Act listed fauna within vessel observation/exclusion zones
	Zero incidents of dredging while protected marine fauna observed in exclusion zone	MFO records of EPBC Act listed fauna within vessel exclusion zone

The EPOs detailed in this TSDMMP are in line with the following objectives for the relevant NT EPA factors (NT EPA, 2021):

+ Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-10** and **Table 8-11**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-10: Management actions for noise emissions during routine construction including the use of an Xcentric Ripper tool

MA reference	Management actions
Standard management actions	
Avoidance	
DPD-MA46	Observation and exclusion zones for marine fauna developed based on noise modelling results and standard protocols
Mitigation	
DPD-MA49	Vessel inductions for all crew to address marine fauna risks and the required management controls
DPD-MA50	Vessel and helicopter to complete Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000, which includes controls for minimising interaction with marine fauna
DPD-MA51	Personnel trained in MFO to be present on pipelay, dredge and rock installation vessels/barges during daylight hours, including one crew member with MFO training on the bridge at all times
DPD-MA52	All marine fauna interactions and observations to be appropriately recorded and reported to DEPWS/NT EPA and DCCEEW as required
DPD-MA55	Maintenance of vessel, vehicle and equipment combustions engines and vessel incinerators as per planned maintenance system
Additional (ALARP) management actions	
Avoidance	
DPD-MA56	Observation and shut-down zones for marine fauna have been developed based on noise modelling results for trenching and standard protocols and include: + Observation (150 m) and exclusion (50 m) zones for marine mammals and turtles. + Observation zone monitored for 10 minutes prior to commencing trenching during daylight only. A Marine Megafauna Observation and Adaptive Management Protocol for routine trenching operations, including the use of Xcentric Ripper tool, is to be followed as per MMNMP (BAS-210 0045)
Mitigation	
DPD MA62	+ Soft start (ramp-up) of hydraulic tools (rock breaking) by BHD, where practicable + Soft start (ramp-up) of trenching equipment, where practicable, will apply to the CSD and TSHD

Table 8-11: Additional environmental management actions for contingency rock breaking using hydraulic hammer

MA reference	Management actions
Contingency management actions	
1	Increased Observation and Exclusion Zones for hydraulic hammering based on noise modelling results will be applied as follows: + If up to 8 hours of rock breaking is required, an increased Observation Zone of 2.5km (marine mammals) and 1km (turtle) will apply and an increased Exclusion Zone of 150m for marine mammals and turtles will apply + If up to 6 hours of rock breaking is required, an increased Observation Zone of 2 km (marine mammals) and 750 m (turtle) will apply and an increased Exclusion Zone of 100m for marine mammals and turtles will apply + If up to 4 hours of rock breaking is required, an increased Observation Zone of 1.5 km (marine mammals) and 750 m (turtle) will apply and an increased Exclusion Zone of 100 m for marine mammals and turtles will apply + If up to 2 hours of rock breaking is required, an increased Observation Zone of 1 km (marine mammals) and 500 m (turtle) will apply and an increased Exclusion Zone of 50 m for marine mammals and turtles will apply
2	Contingency hydraulic hammering protocols for managing noise impacts will be followed as per MMNMP (BAS-210 0045)
3	Hydraulic hammering for no greater than 8 hrs over a 24 hr period.
4	No hydraulic hammering at night
5	A separate vessel with MFO onboard will be required to patrol the Observation Zone prior to and during hydraulic hammering

Table 8-12: Additional (ALARP) management actions not adopted for noise emissions

Additional management actions not adopted		Reasoning for rejection
1	Schedule trenching activities outside of peak flatback turtle nesting period (May to October) or outside of peak Darwin Harbour dolphin calving period (October to April).	+ It would not be possible to avoid both peak periods. + The potential benefit of avoiding locations of higher marine megafauna sensitivity at certain times of the year, such as nesting periods for turtles and dolphin calving periods, is considered disproportionately low compared to the implications to Project scheduling and costs – While there are known flatback turtle nesting sites (Cox Peninsula and Casuarina Beach), and a known period of increased nesting activity (May to October), the densities of nesting turtles in these areas are very low and not significant on a regional scale (Chatto and Baker, 2008). Furthermore, these sites are on a scale of

Additional management actions not adopted		Reasoning for rejection
		1000s of meters away from the pipeline route and trenching areas (as they are from existing vessel traffic using navigation channels) and the relative risk of behavioural effects to turtles at this scale from vessel noise is considered low (Popper et al., 2014). For dolphins, there is evidence that there is a peak in calving within Darwin Harbour between October and April (Palmer, 2010). Important areas have not been defined however and given the high mobility of dolphin species within Darwin Harbour and the use of adjoining coastal areas (Griffiths et al., 2019) it is unlikely that behavioural disturbance around DPD Project activities, relative to the total area of Darwin Harbour and surrounding coastal waters, would have a significant impact on calving behaviour.
2	The observation period for marine megafauna prior to commencing dredging and pile driving is 20 minutes and the MFO is solely dedicated to the task of sighting and recording marine megafauna interactions prior to, and during, dredging and pile driving operations.	+ A 20-minute observation period was considered excessive for the size of the Observation Zone (150 m) and a 10-minute observation period was considered sufficient to monitor this zone for marine fauna. An additional 10 minutes would prolong dredging operations without any appreciable benefit. + A MFO for the pre-start up observation period was considered warranted however a MFO solely to the task of sighting and recording marine megafauna for the entirety of dredging operations was not considered warranted given that the dredging vessel to have multiple crew with marine fauna observation training onboard during daylight hours and the vessel bridge to be constantly manned with at least one crew with MFO training on the bridge at all times.
3	No use of DP vessels.	Not using DP vessels will cause additional seabed and benthic habitat impacts through the need to use anchoring to hold position during pipelay. The use of DP also decreases pipelay duration and reduces impact to other users through shorter timeframe.
4	Cease noise generating activities (e.g. DP) when near marine fauna.	Ceasing DP activities when near sensitive fauna may reduce the potential for impacts, however, the potential for impacts beyond behavioural disturbance are very low. Engine/DP thruster noise cannot reliably be ceased due to the safety critical role of vessel propulsion. It is also not practical to cease pipelay or other critical construction activities in a short timeframe as safely abandoning such operations can often take a number of hours (namely laying down the pipeline or disconnecting from a structure), during which time the impacted fauna will have left the area. Therefore, this control is not deemed feasible.
5	Soft start/power-up procedures for use of sonar equipment and use of fauna observation and shutdown zones.	The systems being used are at a low power or are an intermittent type such that the reduced cumulative exposure would reduce TTS or PTS impacts for marine fauna and behavioural impacts were not considered credible
6	No use of helicopters.	Use of helicopters required (e.g. vessel/crew transfers) and restriction will result in an overall longer duration construction activity and therefore noise impacts
7	Avoidance of night work for routine trenching and Xcentric Hammer use.	Avoidance will result in an overall longer duration construction activity and therefore noise impacts and also increase the safety risk profile. The cost of implementing this far exceeds the benefit gained.

8.3.1.3 Light emissions

8.3.1.3.1 Environmental objectives, performance criteria and management actions

The EPOs relevant to this impact including performance criteria are described in **Table 8-13.**

Table 8-13: Light emissions EPOs and associated performance criteria

EPO	Performance Criteria	
	Target/s	Performance Indicator/s
Minimise light disturbance to fauna and fauna habitat (including to turtle nesting beaches and turtle hatchlings)	Non-navigational lighting is shielded and/or directed away from the marine environment where practicable.	+ Vessel lighting inspection records + Records of vessel light spill on Darwin Harbour turtle nesting beaches

The EPOs detailed in this TSDMMP are in line with the following objectives for the relevant NT EPA factors (NT EPA, 2021):

+ Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-14**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-14: Management actions for trenching and spoil disposal related light emissions

MA Reference	Management actions
Standard management actions	
Mitigation	
DPD-MA57	Shielding, where practicable, and/or orienting operational lights (excluding navigational lighting) on vessels to limit light spill to the environment
DPD-MA58	Housekeeping measures will be adopted, including requiring all crew to keep shutters on windows closed at night, to limit light emissions from vessels
Additional management actions	
Mitigation	
DPD-MA59	Vessel searchlights will only be operated in an emergency situation.
Monitoring	
DPD-MA66	Santos will document vessel light spill on Darwin Harbour turtle nesting beaches as part of the DPD Project's environmental monitoring program

Table 8-15: Additional management actions not adopted for trenching and spoil disposal related light emissions

	Additional management actions not adopted	Reasoning for rejection
1	Crew transfers or loading of supplies which require direction of floodlights outside vessel will not occur during hours of darkness within 10 km of turtle nesting beaches during peak hatchling season.	Nearby beaches are not significant turtle nesting beaches. Significant turtle nesting beaches are >10 km from the Project Area.
2	Do not undertake trenching and spoil disposal activities during peak turtle nesting and hatchling emergence season.	Nearby beaches are not significant turtle nesting beaches. Significant turtle nesting beaches are >10 km from the Project Area.
3	Vessels shall be fitted with turtle friendly (low vapour sodium or LED) directional lighting (requirement applies to external lighting only).	Nearby beaches are not significant turtle nesting beaches. Significant turtle nesting beaches are >10 km from the Project Area. It is not practicable to change out vessel lights for short duration activities and also lighting must meet navigational requirements. White lights required for operational requirements will be directed onto work areas and/or shielded to limit external light spill.
4	Restrict lighting to navigation lights only	Operational lighting, including lighting of work areas and decks, is required for safe working conditions.

8.3.1.4 Routine vessel discharges

8.3.1.4.1 Environmental performance objectives and control measures

The EPOs relevant to this impact including performance criteria are described in **Table 8-16**.

Table 8-16: Routine vessel discharges EPOs and associated performance criteria

EPO	Performance Criteria	
	Target/s	Performance Indicator/s
Minimise environmental impacts from waste and liquid discharges generated during DPD construction activities	Zero recorded environmental incidents of vessel discharges not meeting regulatory requirements	Incident records of non-compliant discharges

The EPOs detailed in this TSDMMP are in line with the following objectives for the relevant NT EPA factors (NT EPA, 2021):

+ Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-17**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-17: Management actions for routine vessel discharges

MA reference	Management Action
Standard management actions	
Mitigation	
DPD-MA61	Vessels will comply with relevant Marine Orders with respect to planned discharges, including: + Marine Order 91 – Marine Pollution Prevention: Oil, which implements Annex I of the MARPOL + Marine Order 95 – Marine Pollution Prevention: Garbage + Marine Order 96 – Marine Pollution Prevention: Sewage, which implements Annex IV of the MARPOL
DPD-MA62	Santos Marine Assurance Process

Table 8-18: Additional management action not adopted for routine vessel discharges

Additional management actions not adopted		Reasoning for rejection
1	Storage and transport of sewage, putrescible and waste for disposal onshore regardless of legislative requirement.	Waste is managed in accordance with required legislative controls and discharge of sewage, greywater, and putrescible results in a negligible impact. The additional costs for transport and disposal, increased health, and safety risks (e.g., hygiene) and increased environmental impact (e.g., atmospheric emissions from vessels transporting waste) outweigh any environmental benefit gained.

8.3.1.5 Atmospheric emissions

8.3.1.5.1 Environmental performance outcomes and control measures

The EPOs relevant to this impact including performance criteria are described in **Table 8-19**.

Table 8-19: Atmospheric emissions EPOs and associated performance criteria

EPO	Performance criteria	
	Target/s	Performance Indicator/s
Minimise environmental impacts from atmospheric emissions generated during DPD construction activities	Compliance with preventative maintenance procedures for combustion engines, incinerators and ozone depleting substances (ODS) containing equipment	Planned maintenance records

The EPOs detailed in this TSDMMP are in line with the following objective for the relevant NT EPA factor (NT EPA, 2021):

+ Air quality – Protect air quality and minimise emissions and their impact so that environmental values are maintained.

The management actions for this activity are shown in **Table 8-20.** Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-20: Management actions for atmospheric emissions

MA reference	Management actions
Standard management actions	
Mitigation	
DPD-MA53	Maintenance of combustions engines and incinerators as per vessel's planned maintenance system
DPD-MA66	Atmospheric emissions from combustion, incinerators and ODS managed in accordance with standard maritime practice (MARPOL)
DPD-MA67	Monitoring and reporting of fuel consumption and calculated GHG emissions
DPD-MA68	Use of low sulphur diesel
Additional management actions	
N/A	

8.3.2 Unplanned events risks

Santo's environmental assessment identified six potential sources of environmental risks associated with the unplanned events for this activity. Management strategies have been adopted in the TSDMMP based on the ENVID undertaken for DPD Project trenching and spoil disposal activities in May/June 2022 (Refer to **Section 7.2**).

8.3.2.1 Dropped objects (including accidental release of non-hazardous waste)

8.3.2.1.1 Environmental performance outcomes and control measures

The EPOs relevant to this impact including performance criteria are described in **Table 8-21**.

Table 8-21: Dropped objects (including accidental release of non-hazardous waste) EPOs and associated performance criteria

EPO	Performance Criteria	
	Target/s	Performance Indicator/s
Avoid environmental impact resulting from accidental release of non-hazardous solid waste and dropped objects	Zero incidents of loss of equipment/cargo/waste overboard from vessels resulting in a consequence II – Minor or above	Incident records

The EPOs detailed in this TSDMMP are in line with the following objectives for the relevant NT EPA factors (NT EPA, 2021):

+ Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-22.** Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-22: Management actions for release of dropped objects

MA reference	Management Actions
Standard management actions	
Avoidance	
DPD-MA61	Vessels will comply with relevant Marine Orders, including: + Marine Order 95 – Marine Pollution Prevention: Garbage
DPD-MA75	Implementation of Santos approved standards and procedures for outboard lifts
DPD-MA76	All lifting and winching equipment will undergo inspection, testing and certification as per Applicable Laws and Applicable Codes and Standards
Mitigation	
DPD-MA77	Dropped object recovered where safe and practicable to do so
Additional management actions	
Avoidance	
DPD-MA81	Pipeline route design selected where practicable to avoid the potential for impact to habitat / cultural seabed features or assets from a dropped object

8.3.2.2 Introduction of invasive marine species

8.3.2.2.1 Environmental performance outcomes and control measures

The EPOs relevant to this impact including performance criteria are described in **Table 8-23**.

Table 8-23: Introduction of invasive marine species EPOs and associated performance criteria

EPO	Performance Criteria	
	Target/s	Performance Indicator/s
Avoid introducing invasive marine species (IMS) into NT waters	+ All DPD Project vessels assessed mobilising from outside of Darwin Harbour/Project Area assessed as low risk for IMS prior to entry into Project Area	+ Records of vessel IMS risk assessment + Ballast water records system maintained by vessels

The EPOs detailed in this TSDMMP are in line with the following objective for the relevant NT EPA factor (NT EPA, 2021):

+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-24.** Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-24: Management actions for introduction of invasive marine species

MA reference	Management Action
Standard management actions	
Avoidance	
DPD-MA82	Vessels equipped with effective anti-fouling coatings as required for class
DPD-MA83	Ballast water management will comply with MARPOL requirements (as applicable to class), Australian Ballast Water Management Requirements and *Biosecurity Act 2015*
DPD-MA84	Apply risk-based IMS management for vessels and immersible equipment – vessel and immersible equipment must be assessed as having a low risk of IMS prior to coming onto activity
DPD-MA85	Vessels having suitable anti-fouling coating (marine growth prevention system) in accordance with the *Protection of the Sea Act 2006*

Table 8-25: Additional management actions not adopted for invasive marine species

Additional management actions not adopted		Reasoning for rejection
1	Use of Australian vessels only	It is not feasible to only use Australian vessels given constraints on availability and suitability
2	All vessels to be dry docked, cleaned, and inspected for IMS	Santos requires a risk assessment to be undertaken for project vessels which considers factors that lessen the risk of IMS incursion and requires vessel to achieve a low-risk score. These factors include a vessel's history of dry-docking, cleaning and IMS inspection but these activities are not necessarily mandatory depending upon vessel history and other risk factors. The costs of applying mandatory dry-docking and cleaning is considered disproportionate given the existing risk-based approach being applied.
3	Heat or chemical treatment of ballast water to eliminate IMS	Cost and effort is considered to outweigh benefits given existing regulatory requirements for ballast exchange will be adhered to.

8.3.2.3 Unplanned marine fauna interactions

8.3.2.3.1 Environmental performance outcomes and control measures

The EPOs relevant to this impact including performance criteria are described in **Table 8-26**.

Table 8-26: Unplanned marine fauna interactions EPOs and associated performance criteria

EPO	Performance Criteria	
	Target/s	Performance Indicator/s
Avoid interactions resulting in injury to or mortality of protected marine megafauna	Zero incidents of interactions resulting in the injury or mortality of EPBC Act listed marine megafauna	+ Incident reports relating to marine fauna injury or mortality + MFO reports of sightings of live, injured or dead marine megafauna

The EPOs detailed in this TSDMMP are in line with the following objective for the relevant NT EPA factor (NT EPA, 2021):

+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-27**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-27: Management actions for marine fauna interaction

MA reference	Management Actions
Standard management actions	
Avoidance	
DPD-MA48	Vessel and helicopter movements will comply with Part 8 of the EPBC Regulations 2000
DPD-MA49	Personnel trained in marine fauna observation present on trenching and spoil disposal vessels during daylight hours, always including one crew member with MFO training on the bridge at all times.
DPD-MA86	Inductions to include observing marine fauna (e.g., dolphins and turtles)
DPD-MA87	The TSHD shall be fitted with pre-sweeping mechanisms / chain curtains to mitigate turtle ingestion (fauna strike – unplanned)
Mitigation	
DPD-MA50	All marine fauna interactions and observations will be appropriately recorded and reported to relevant authorities
Additional management actions	
Avoidance	
DPD-MA54	Observation and shut-down zones for marine fauna have been developed based on noise modelling results and standard protocols and include: + Observation (150 m) and exclusion (50 m) zones for marine mammals and turtles. A Marine Megafauna Observation and Adaptive Management Protocol will be included within the MMNMP (BAS-210 0022)

Table 8-28: Additional management actions not adopted for marine fauna interaction

Additional management actions not adopted		Reasoning for rejection
1	Restrict the timing of activities to operate outside of known sensitive periods only. Flatback turtle peak nesting period is May to October and Dolphin peak calving is October to April	Project schedule is unable to avoid sensitive periods. Beaches closest to the project area are also not considered significant turtle nesting beaches so this control is not considered relevant.
2	Activities will only occur during daylight hours	Construction works need to occur 24/7 to maintain project schedule. Increased project schedule may result in increase in vessel movements and potential for more cumulative impacts.

8.3.2.4 Release of hazardous liquids

8.3.2.4.1 Environmental performance outcomes and control measures

The EPOs relevant to this impact including performance criteria are described in **Table 8-29**.

Table 8-29: Release of hazardous liquids EPOs and associated performance criteria

EPO	Performance Criteria	
	Target/s	**Performance Indicator/s**
Avoid significant environmental impact resulting from release of hazardous materials	Zero incidents of release of hazardous liquids to the marine environment during DPD construction activities	Number of recorded incidents
	Response to incident implemented as per the relevant emergency response plans	Incident report including details of response

The EPOs detailed in this TSDMMP are in line with the following objectives for the relevant NT EPA factors (NT EPA, 2021):

+ Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-30**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-30: Management actions for hazardous liquids releases

MA reference	Management actions
Standard management actions	
Avoidance	
DPD-MA61	Vessels will comply with relevant Marine Orders, including: + Marine Order 95 – Marine Pollution Prevention: Garbage
DPD-MA88	Inspection and maintenance for all equipment using chemicals
DPD-MA90	ROV operations undertaken in accordance with good industry practise (in relation to hydraulic fluid control)
DPD-MA93	Chemicals will be managed in accordance with standard maritime practices as per vessel shipboard oil pollution emergency plan (SOPEP)
Mitigation	
DPD-MA89	Santos chemical selection procedure applied for chemicals planned to be discharged to the environment
DPD-MA92	Chemical storage areas designed to contain leaks and spills and inspected routinely
DPD-MA94	Spill clean-up kits available in high-risk areas
DPD-MA95	Bunding/secondary containment
Additional management actions	
N/A	

8.3.2.5 Release of hydrocarbon (offshore vessel bunkering or vessel tank rupture)

8.3.2.5.1 Environmental performance outcomes and control measures

The EPOs relevant to this impact including performance criteria are described in **Table 8-31**.

Table 8-31: Hydrocarbon and marine diesel release (offshore vessel bunkering or vessel tank rupture) EPOs and associated performance criteria

EPO	Performance Criteria	
	Target/s	**Performance Indicator/s**
No release of hydrocarbons to the marine environment as a result of the DPD Construction Activities	Zero incidents of unplanned discharge of hydrocarbons into the marine environment as a result of DPD construction activities	Number of recorded incidents
	Response to incident implemented as per the relevant emergency response plans	Incident report including details of response

The EPOs detailed in this TSDMMP are in line with the following objectives for the relevant NT EPA factors (NT EPA, 2021):

+ Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-32**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-32: Management actions for hydrocarbon release (offshore bunkering incident or vessel fuel tank rupture)

MA reference	Management Actions
Standard management actions	
Avoidance	
DPD-MA88	Inspection and maintenance for all equipment using hydrocarbons
DPD-MA90	ROV operations undertaken in accordance with good industry practice (in relation to hydraulic fluid control)
DPD-MA93	Hydrocarbons will be managed in accordance with standard maritime practices as per vessel (SOPEP)
DPD-MA96	Vessel-specific bunkering procedures and equipment consistent with Santos marine vessel vetting requirements including: + Use of bulk hoses that have quick connect 'dry break' couplings + Correct valve line-up + Defined roles and responsibilities, and the specific requirement for bunkering to be completed by trained personnel only + Visual inspection of hoses prior to bunkering to confirm they are in good condition + Testing of the emergency shutdown mechanism on the transfer pumps + Assessment of weather/sea state + Maintenance of radio contact with Vessel during bunkering operations + Bunkering checklist Visual monitoring during bunkering Marine Order 91 – Marine Pollution Prevention: Oil
DPD-MA97	Vessel equipped and crewed in accordance with Australian maritime requirements
DPD-MA99	Safety exclusion zone around DPD Project vessels and Notice to Mariners will be issued for offshore works advising all major shipping traffic formally.
Mitigation	
DPD-MA92	Hydrocarbon storage areas designed to contain leaks and spills and inspected routinely
DPD-MA94	Spill clean-up kits available in high-risk areas
DPD-MA95	Bunding/secondary containment around hydrocarbon storage/transfer areas
DPD-MA100	No intermediate fuel oil (IFO) or heavy fuel oil (HFO) will be used in activity vessels working inside the Project Area
DPD-MA101	Implement tiered spill response as per DPD Project specific OPEP in the event of an MDO spill
Additional management actions	
DPD-MA102	Santos to make oil spill tracking buoys available on primary project vessel/s with Santos CSR/s and/or at local supply base for immediate deployment to assist with tracking of an oil spill

Table 8-33: Additional management actions not adopted for hydrocarbon release (offshore bunkering incident or vessel fuel tank rupture)

Additional management actions not adopted		Reasoning for rejection
1	No bunkering of fuel during the trenching and spoil disposal activity	Vessels will routinely bunker when in port, as this is the safest and most cost effective means to refuel vessels. However due to the gas export pipeline installation method, the pipelay vessel cannot bunker alongside port facilities and requires bunkering within the operational area to undertake the activity. Following implementation of the selected existing controls, the risk reduction associated with eliminating bunkering at sea is considered to be negligible. The potential impacts to schedule and associated cost of implementing the control is considered to be grossly disproportionate to the reduction in risk. The control has not been adopted.
2	Bunkering only during daylight hours	Bunkering only during daylight hours increases the likelihood of detecting a leak, as surface hydrocarbon sheens are typically more visible under sunlight. Bunkering operations are typically completed during daylight hours; however, circumstances may occur where bunkering is required during darkness (e.g., large volume transfers at slow rates or when bunkering is safer to perform at night due to prevailing metocean conditions). Bunkering will only commence in daylight hours however. Following implementation of the selected existing controls, the risk reduction associated with prohibiting bunkering during darkness is considered to be low. The cost of implementing the control is considered to be grossly disproportionate to the reduction in risk. The control has not been adopted.
3	Schedule activities to avoid coinciding with sensitive periods for marine fauna present in the operational area	Project schedule is unable to avoid sensitive periods. Beaches closest to the Project Area are also not considered significant turtle nesting beaches. The cost of limiting the timing of activities would be excessive compared to the little to no reduction in risk of oil spill to significant turtle nesting beaches.
4	Require all support vessels involved in the activity to be double hulled.	Cost and availability of double hulled vessels make this control not feasible.

8.3.2.6 Release of dry natural gas from Bayu-Undan to Darwin pipeline

8.3.2.6.1 Environmental performance outcomes and control measures

The EPOs relevant to this impact including performance criteria are described in **Table 8-34**.

Table 8-34: Release of dry natural gas environmental performance objectives and associated performance criteria

EPO	Performance Criteria	
	Target/s	**Performance Indicator/s**
Avoid environmental impacts from the accidental release of dry natural gas from Bayu-Undan to Darwin pipeline	No releases of gas from the Bayu-Undan pipeline to the environment as a result of impact/drag or dropped object from the DPD construction activity	Incident records
	Response to incident implemented as per the relevant emergency response plans	Incident report including details of response

The EPOs detailed in this TSDMMP are in line with the following objectives for the relevant NT EPA factors (NT EPA, 2021):

+ Air quality – Protect air quality and minimise emissions and their impact so that environmental values are maintained.
+ Marine environmental quality – Protect the quality and productivity of water, sediment and biota so that environmental values are maintained.
+ Marine ecosystems – Protect marine habitats to maintain environmental values including biodiversity, ecological integrity and ecological functioning.

The management actions for this activity are shown in **Table 8-35**. Environmental Performance Standards for these management actions will be developed between Santos and Contractor prior to the finalisation of this TSDMMP.

Table 8-35: Management actions for release of dry natural gas

MA reference	Management actions
Standard management actions	
Avoidance	
DPD-MA08	The proposed pipeline route will be marked on marine charts, in the same way that the existing pipelines are gazetted and marked on marine charts
DPD-MA75	Implementation of Santos approved standards and procedures for lifting
DPD-MA103	Trenching will only occur within pre-programmed areas (using standard positional accuracy measures used in the industry)
DPD-MA104	Exclusion zones programmed on all primary vessels associated with the works to clearly indicate no entry zones and nearby pipelines – this will clearly identify areas for spud placement, anchor positioning and trenching activities
Additional management actions	
Avoidance	
DPD-MA78	Identification of no lift zones or additional controls, where relevant, in proximity to subsea pipelines as documented in relevant lifting and operational procedure/s

9 Environmental Monitoring

9.1 Overview

Environmental monitoring is proposed within Project Area and in surrounding areas containing key sensitive receptors (i.e., seagrass and hard coral) to ensure that the EPO for the management of water quality and benthic habitats is met. The environmental monitoring program will focus on real-time measurements of turbidity for the protection of sensitive receptors, as turbidity is the primary indirect stressor resulting from trenching activities. Turbidity measurements will allow assessment of performance indicators i.e., determination if Level 1, 2 and 3 triggers within the adaptive monitoring/management strategy (**Section 8**) have been exceeded. Other parameters including Photosynthetic Active Radiation (PAR), salinity and water temperature will also be collected to provide environmental context and evidence to trenching activity attributability assessment (**Section 8.2.2.3**) and, in the case of temperature, to determine whether a hard coral temperature trigger has been exceeded.

Baseline and responsive habitat monitoring (if triggered) will also be undertaken to assess the health of sensitive receptors. Prior to the commencement of trenching activities monitoring will be completed to develop an environmental baseline for benthic habitat condition and to verify existing baseline water quality information already collected at the monitoring sites.

Lastly, MODIS satellite images will be used to add context to data collected by telemetered buoys and habitat monitoring. This information will assist the attributability assessment and to assess the spatial distribution of the visible plume.

Note, the final decision is yet to be made as to the exact trenching methodology to be adopted and, key components of the monitoring programme such as parameters to be monitored, monitoring locations, numbers of monitoring sites, and the durations and frequency of the monitoring programme may change depending on the final trenching methodology selected. Therefore, the monitoring programme presented herein should be considered as a draft at this stage. Once the final trenching methodology is selected the monitoring programme may be adapted and finalised to reflect the final trenching methodology selected.

The following sections describe the monitoring program proposed for the main and maintenance trenching operations.

9.2 Monitoring objectives

The key objectives of the monitoring program are to:

+ Verify the already existing environmental baseline turbidity dataset at water quality monitoring sites
+ Indicate the exceedance of triggers (turbidity and temperature) for responsive and contingency monitoring and management actions
+ Assess the environmental performance of responsive and contingency management actions.
+ Provide contextual information of Photosynthetically Active Radiation (PAR) levels that can be used as a line of evidence for assessing potential trenching and spoil disposal impacts. This will in turn improve understanding of PAR fluctuation and PAR vs turbidity relationship at multiple sites within Darwin Harbour.

+ Collect baseline benthic habitat data (and reactive benthic habitat data, if triggered) to provide contextual information in the event of an exceedance of management triggers and to contribute to existing scientific knowledge of Darwin Harbour.
+ To collect information on the distribution of turbidity plumes using remote sensing.

9.3 Environmental monitoring program

The environmental monitoring program, including sites, parameters, frequency and purpose are summarised in **Table 9-1**..

Table 9-1: Overview of proposed monitoring program.

Monitoring	Sites	Methods	Purpose	Indicative schedule and frequency
Telemetry Water Quality Monitoring: + Turbidity + PAR + Temperature	Reactive sites[1] + Channel Island + Weed Reef + Woods Inlet + Charles Point + Mandorah Reference sites[2] + Channel Island + Fannie Bay + East Point + Wickham Point + Casuarina	Telemetered water quality monitoring buoys	+ Trigger monitoring + Environmental context + Development of turbidity vs PAR relationship + Reference sites used as a part of attributability assessment	Validation window of a few weeks to a month prior to trenching. Data collected in-situ and recorded x minutes during trenching activities.
Water Quality Profiling: + Salinity + Temperature + Depth	Reactive sites[1] + Channel Island + Weed Reef + Woods Inlet + Charles Point + Mandorah Reference sites[2] + Channel Island + Fannie Bay + East Point	Seabird CTD profiler	+ Environmental context + Inform attributability assessment + Reference sites used as a part of attributability assessment	During visits to telemetered water quality sites.

Monitoring	Sites	Methods	Purpose	Indicative schedule and frequency
	+ Wickham Point + Casuarina			
Seagrass Monitoring	+ Wood Inlet + Charles Point + Fannie Bay + Casuarina + East Point	ROV captured images/videos	+ Environmental context + Assessment of impact following an exceedance	Baseline – prior to trenching campaign during dry season Responsive – if Level 3 trigger exceeded
Coral Monitoring	+ Channel Island + Weed Reef + Mandorah + Charles Point	ROV captured images/videos	+ Environmental context + Assessment of impact following an exceedance	Baseline – prior to trenching campaign during dry season Responsive – if Level 3 trigger exceeded
Dredge plume monitoring	+ Location of trenching and spoil disposal	Aerial imagery via drone flight or satellite capture	+ Environmental context + Inform attributability assessment	Responsive – if Level 1 trigger exceeded as part of attributability assessment

Notes:

1. Reactive sites are not sites where an impact from dredging is expected, rather these are sites where sensitive receptors are located in closest proximity to the trenching zones.
2. Locations of reference sites may need to be adjusted based on other works in Darwin Harbour that may be undertaken concurrently by other proponents to ensure sites are not being impacted by other anthropogenic stresses.
3. The number and location of monitoring sites may be subject to change based on final route alignment and trenching methods.
4. Metal concentrations will be measured in water and sediment samples at selected sites.

9.3.1 Monitoring site selection

The sites for this proposed monitoring program and their designation are identified in **Figure 9-1** and **Table 9-1**. The number and location of monitoring sites may be subject to change based on final route alignment and trenching methods.

Reactive sites are not sites where an impact from dredging is expected (i.e., none of the sites are within a zone of impact or influence as detailed in **Section 6.5.3**), rather the sites represent locations of sensitive receptors (seagrass and hard coral) in closest proximity to the proposed trenching activities, therefore have the potential to be influenced by trenching works. These reactive sites are existing INPEX monitoring sites that have historical baseline data associated and water quality is therefore well understood, resulting in high confidence in being able to detect exceedances outside of normal tolerance limits. They additionally have associated reactive trigger values that if exceeded and found to be attributable to trenching activity will trigger actions outlined in **Section 8.2**. Reference sites have been identified in areas of sensitive receptors further from trenching activities, within equivalent sections of Darwin Harbour, i.e., nearshore, mid-harbour and offshore. Data from these sites will be used to assess if trigger exceedances identified at the impact sites is attributable to Santos' trenching activities and to provide contextual information on the natural variability in water quality.

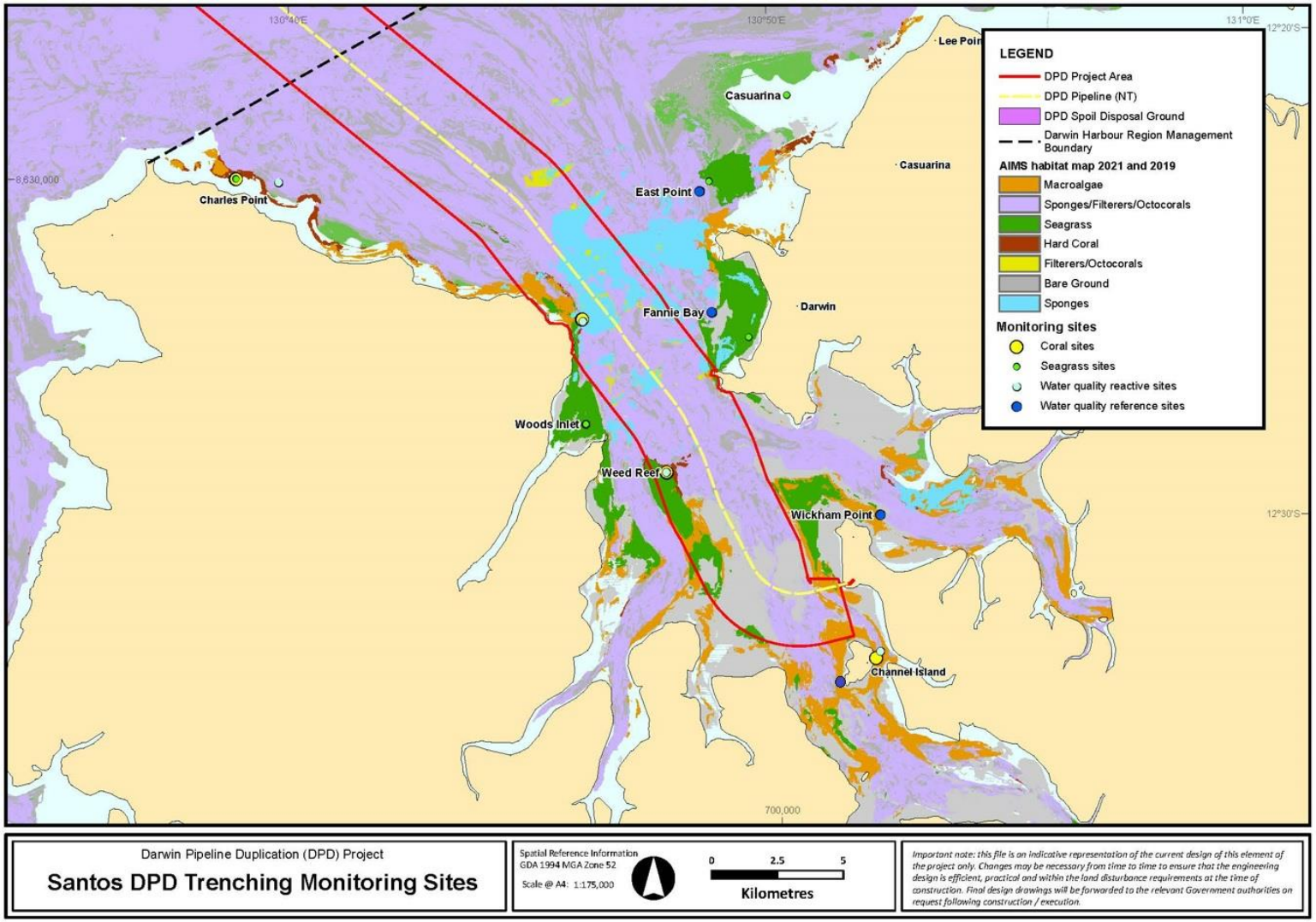


Figure 9-1: DPD Trench Monitoring sites

9.3.2 Methods and QAQC

The environmental monitoring program developed for this TSDMMP is based on INPEX's Maintenance DSDMPs water quality monitoring (INPEX, 2018).

This environmental quality monitoring program will be undertaken by qualified personnel.

9.3.2.1 Water quality monitoring

Telemetered water quality buoys will be used to record water quality with data being logged at regular intervals and uploaded to an online database for analysis.

The telemetered water quality buoys will be fixed moorings and recording instruments, where possible will be approximately 1 m above the seabed to create a standardised method, per INPEX's nearshore environmental monitoring program (Cardno, 2014). In line with INPEX's capital and maintenance dredging programs telemetered water quality buoys and water profiling equipment will be deployed adjacent to sensitive receptor habitat rather than directly within them to prevent damage upon deployment and retrieval. Water profiling equipment will be deployed on scheduled maintenance trips for telemetered buoys and will be used to collect water quality parameters throughout the water column providing further context to environmental data.

Water quality profile data will be collected using by lowering a calibrated conductivity, temperature and depth (CTD) profiler between the surface and seabed at monitoring site.

Water quality and sediment quality samples will also be collected at selected sites for laboratory analysis.

In line with INPEX's Maintenance DSDMP no sedimentation monitoring has been proposed, as there is not currently suitable methodology for acceptable resolution.

9.3.2.1.1 Water quality parameters

This environmental water quality monitoring program is based upon INPEX's Maintenance DSDMP (INPEX, 2018) and similarly focuses on real-time measures of turbidity (NTU) as a suitable early warning sign for potential impacts to coral and seagrass habitat. PAR, salinity, temperature and depth will also be measured (salinity and depth will not be telemetered) as informative measures to provide further context to changes in water quality. Temperature will additionally be monitored in real-time to indicate the presence of increased pressure upon hard coral communities. In addition, metal concentrations will be measured in water and sediment samples at selected sites. Parameters are listed in **Table 9-2**.

Turbidity is the main basis of environmental assessment as trenching activities will elevate turbidity and turbidity can negatively impact sensitive receptor habitats. Turbidity additionally provides a proxy of light available to sensitive receptor habitats. Furthermore, this monitoring program will operate on the assumption outlined in INPEX's Maintenance Dredging Spoil Disposal Management plan (INPEX, 2018; INPEX, 2022) that there is a relationship between turbidity and sedimentation rates, with turbidity measurements potentially providing an indication of sedimentation levels settling on the seabed. INPEX have previously established a 1:1 relationship between TSS and NTU which will be assumed for this monitoring program. However, this relationship will be verified by data collected by Santos.

PAR will measure the quantity of light potentially available to sensitive receptors (i.e., corals and seagrasses), which could be impacted by increased turbidity attributable to DPD Project trenching. This parameter will be used alongside turbidity data to identify whether trenching activities are responsible

for changes in light availability. Telemetered water quality buoys and water sample analysis will be used during monitoring to determine the TSS vs PAR and NTU vs TSS relationship for specific sites.

Salinity was not found to be significantly impacted by INPEXs capital dredging activities (Cardno, 2015) Although conductivity measures could provide a good indication of natural changes to environmental conditions.

Trenching and spoil disposal activities will not have a significant effect on water temperature, although this parameter will be recorded in real-time at all sites as natural increases in water temperature alongside increased turbidity could result in coral bleaching events. Water temperature data will additionally be assessed against a temperature-based trigger value.

Table 9-2: Proposed water quality parameters and units

Parameters	Units
Turbidity	NTU
PAR	µE $m^{-2}s^{-1}$
Conductivity (as a proxy for salinity)	S/m
Temperature	°C
Depth	m
Total suspended sediments	mg/L
Metals in water	mg/L
Metals in sediment	mg/kg

9.3.2.2 Habitat monitoring

Habitat monitoring will be undertaken prior to trenching by way of Remote Operated Vehicle's (ROV) or towed video to collect video transects at designated seagrass and hard coral monitoring sites (**Figure 9-1** and **Table 9-1**). Images derived from footage will then be analysed by qualified personnel using a quantitative analysis technique (e.g., point counts) to assess parameters such as community composition, density, and health of biota at seagrass and hard coral sites.

A review of previous benthic habitat monitoring programs within Darwin Harbour will be undertaken to refine methodology and metrics used to assess condition of benthic habitats (hard coral and seagrass). At a minimum, the pre-trenching baseline state of benthic habitat (coral and seagrass) at monitoring sites will be determined. Additional monitoring to assess potential impacts will be undertaken if triggered by water quality monitoring (exceedance of Level 3 water quality monitoring trigger; **Section 8.2.2**).

9.3.2.3 Remote sensing

MODIS Satellite images (250 m pixel resolution) will be obtained to supplement data collected by telemetered buoys to provide greater spatial coverage (Kutser *et al.*, 2007; Evans *et al.*, 2012). Images will be used to add context to site-specific data where it is believed to add value to the analysis of attributability of exceedances and, where required, to assess the spatial distribution of the visible sediment plume (where images are cloud free). Where possible, satellite imagery with a finer pixel resolution (although infrequent passes) may also be utilised.

Aerial imagery of the visual plume will potentially also be captured by drone from shoreline or vessel as appropriate to supplement MODIS imagery. Automated sampling transects using flight planning software are to be flown in parallel lines with minimal image overlaps between each transect. Flight paths will maintain approximately the same height for each transect for image consistency. Where possible, drone sampling is to coincide in time and location with in-situ (e.g., water monitoring) sampling undertaken during dredging operations. Drone pilots will be required to have the appropriate commercial drone operating licencing (ReOC or RePL) for the type and weight category of drone in use.

9.3.2.4 Quality assurance and quality control

All water quality instruments will be calibrated and maintained per the suppliers and manufacturer's instructions. Telemetered water quality monitoring buoys will be implemented and will upload data to an online database; therefore, any malfunctions, losses/damage or fouling will be quickly identified. If malfunction, loss/damage, or fouling is identified, a system can be retrieved and replaced within five business days. Additionally, maintenance will be scheduled per supplier/manufacturer recommendations, with telemetered buoys systematically retrieved and replaced with clean systems maintaining the quality of data collected.

Other supporting parameters such as salinity temperature and depth will be collected in situ using water profiling equipment and therefore data loss is unlikely to be a significant issue.

All data collected will undergo quality assurance and quality control (QA/QC) procedures.

9.3.2.5 Data analysis

Water quality analysis will meet requirements outlines in the NT EPA Guideline for Reporting on Environmental Monitoring (NT EPA, 2016). Where applicable, best practise statistical and analysis techniques will be implemented based on the WAMSI dredging node studies (Jones *et al.*, 2015).

Following best practice, preliminary data checks will be undertaken prior to analysis to assess the integrity of data and as part of data QA/QC anomalous data will be removed using an objective function. Then QA/QC trigger assessment will be completed to assess measured turbidity data (NTU) against management triggers at each reactive site during the dredging phase, the following steps will be followed (based on methods outlined in INPEX's Maintenance DSDMP).

- Daily average turbidity will be calculated using turbidity data recorded by telemetered buoys between 0:01am to midnight at each reactive site.
- If there is a data loss and the period is less than 12 hours, then the daily average will be calculated based on remaining data as one tidal period should have been captured.
- If there is a data loss and the period is greater than12 hours, then the daily average may be derived in one of the following ways:
  - Where data loss is greater than 12 hours but less than 24 hours:
    - Daily average turbidity will be calculated on the available data provided that the expected maximum turbidity period based on review of previous water trends is captures. If the expected maximum turbidity period is not captured, then if practicable a nearby monitoring site will act as surrogate.
  - Where data loss is greater than 24 hours:
    - Where practicable a nearby monitoring site will act as surrogate until equipment repair or replacement can occur.

  - Note if telemetry function of buoys ceases to work the data in most instances will be recorded on the buoys for download and analysis post repair.

+ Once daily average turbidity values are calculated for reactive sites, they will be compared against the trigger values in **Table 8-5**.
+ Where a trigger value is exceeded for more than the allowable number of consecutive days (durations detailed in **Table 8-5**) then an exceedance event has occurred.
+ If an exceedance trigger event has occurred, Santos, in consultation with the Monitoring Consultant and Dredging Contractor (as appropriate), will complete an attributability assessment (**Section 8.2.2.3**).

10 Implementation Strategy

This section presents the processes and procedures that will be implemented to ensure the environmental requirements within this TSDMMP will be met, including:

+ Specific systems, practices and procedures that ensure both environmental impacts and risks are reduced to ALARP and Environmental Performance Objectives (EPOs), Performance Criteria and Performance Standards of this TSDMMP are being met;
+ A clear chain of command, outlining roles and responsibilities of personnel involved in the implementation, management and review of this TSDMMP;
+ Measures to ensure that employees and/or contractors working in relation to this activity are aware of their responsibilities regarding the environment and have the appropriate skill and training;
+ Auditing, review and revision processes;
+ Incident recording and reporting in line with Santos and regulatory requirements;
+ Maintenance of quantitative records of discharges and emissions; and
+ Details of emergency response and oil spill arrangements.

This implementation strategy is consistent with the Barossa Health, Safety & Environment Management Plan for Execute (BAA-200 0003).

Stakeholder engagement is assessed separately for the requirements of the activity. Ongoing stakeholder management strategies are discussed in **Section 11**.

10.1 Leadership, accountability and responsibility

To enable the DPD Project to succeed in meeting environmental objectives as outlined within this TSDMMP, the following measures apply:

+ Appropriately skilled and qualified DPD Project team is established with HSE accountabilities, responsibilities, and resources clearly defined;
+ Setting of EPOs and Performance Criteria (incl. Targets and Performance Indicators) and establishment of the practices and tools used to measure performance and drive continual improvement (**Section 8**); and
+ Implementing HSE Leadership Teams with key contractors to discuss HSE performance and improvement

The Barossa Project Director is responsible for delivery of the Barossa Development, including the DPD Project, and has responsibilities for:

+ Accountability for project HSE performance
+ Demonstrating strong and visible HSE leadership
+ Endorsing HSE performance indicators and targets
+ Communicating HSE performance and events to the Chief Operating Officer, Upstream Oil & Gas
+ and Group Executive Committee.
+ Providing HSE resources.

+ Engaging with senior regulatory managers.

The Barossa Project Director is supported by the Barossa Project Management Team. The effective implementation of this TSDMMP requires collaboration and cooperation among Santos Barossa Team personnel and contractors. The accountabilities of key Santos and contractor personnel in relation to the implementation, management and review of the TSDMMP is outlined in **Table 10-1**.

Table 10-1: Chain of command, key leadership roles and responsibilities

Title (role)	Environmental responsibilities
Office-based personnel	
Santos Barossa Subsea and Pipelines Manager	+ Confirm that the campaign is undertaken in accordance with this TSDMMP. + Provide sufficient resources to implement the management controls in this TSDMMP. + Confirm Contractor personnel attend an environmental induction upon commencing work on the campaign (Section 10.2). + Action the management actions, as detailed in the Environmental performance standards (EPS) in this TSDMMP (Section 8), as required, prior to the commencement of the activity. + Confirm the Contractor meets the requirements of the Santos management system and relevant standards/procedures.
Santos Barossa HSE Manager	+ Provide assurance that adequate resources are provided to support all environmental activities associated with this TSDMMP. + Develop a program to implement and monitor TSDMMP commitments. + Liaise with NT EPA, DITT, DCCEEW and other regulators. + Ensure incident notification process is in place and investigations completed to identify root causes. + Review and submit environmental performance reports and external environmental incident notification reports.
Santos Barossa GEP Package Lead	+ Confirm the campaign is undertaken in accordance with this TSDMMP. + Communicate any changes to the activity that may affect the risk and impacts assessment, EPOs, EPSs and MAs detailed in this TSDMMP to the Santos HSE team. + Coordinate resources required to enable the commitments in this TSDMMP to be maintained. + Confirm the reporting of environmental incidents meets both external and Santos' incident reporting requirements. + Liaise with Santos Environmental Advisor on environmental incidents and what constitutes a reportable incident. + Track and close out of any corrective actions raised from environmental audits as required by this TSDMMP.

Title (role)	Environmental responsibilities
Santos Marine Manager	+ Confirm vessel vetting as per the Santos Offshore Marine Assurance Procedure (SO 91 ZH 10001). + Ensure relevant inspections are undertaken to confirm vessels comply with relevant Marine Orders and Santos marine standards/procedures and on boarding requirements to meet safety, navigation and emergency response requirements.
Santos Barossa Crisis and Emergency Management Specialist	+ Develop Santos Crisis Management and Emergency Response Plans and procedures. + Ensure emergency response drills are undertaken as per Santos Crisis Management and Emergency Response plans and procedures.
Santos Emergency Response Coordinator	+ Undertake Santos Incident Management Team (IMT) drills and exercises in accordance with the Crisis and Incident Management Exercise Schedule. + Undertake assurance activities on oil spill response arrangements + Review Santos Emergency Response Plans and procedures.
Santos Barossa Environmental Advisor/s	+ Develop offshore environmental approval documents, including DPD Project EMPs and OPEP, for submission and acceptance by DITT. + Provide environmental inductions to contractor personnel. + Ensure environmental inspections and audits are undertaken against TSDMMP commitments as per the Barossa Project Environmental Compliance Assurance Plan (BAA-200 0635). + Review and approve chemical products that will be discharged to the marine environment and require assessment. + Review biofouling risk assessments undertaken by Contractors. + Prepare environmental performance reports. + Advise on environmental incident reporting requirements, including what constitutes a reportable incident
Santos Barossa External Relations Advisor	+ Prepare and implement the relevant and interested persons consultation program for the DPD activity. + Manage and report on any relevant and interested persons consultation received in relation to the activity. + Undertake ongoing engagement with relevant and interested persons, for the duration of the activity, as required.

Title (role)	Environmental responsibilities
Contractor Project Manager	+ Undertake the pipelay installation in accordance with this TSDMMP. + Provide the resources required to enable the commitments in this TSDMMP to be maintained. + Confirm vessel management system and procedures are implemented and comply with the requirements detailed in this TSDMMP. + Confirm personnel receive an environmental induction that meets the requirements outlined in this TSDMMP + Ensure invasive marine species and pests are risk assessment on all vessels mobilised to the operational area. + Ensure that all crew attend HSE inductions and that attendance records saved. + Ensure incidents are reported and investigated, as required.
Site and offshore based personnel	
Santos Senior Client Site Representative	+ Confirm contractors undertake the activity in a manner consistent with the EPOs and environmental management procedures detailed in this TSDMMP. + Confirm the management measures detailed in this TSDMMP are implemented. + Communicate any changes to the activity to the Santos Environmental Advisor. + Confirm all subsea chemical components and other fluids that may be discharged to the marine environment are approved for use. + Confirm that the Vessel Master and all crew adhere to the requirements of this TSDMMP. + Advise the Santos GEP Package Lead of any changes in activities that may lead to nonconformance with the EPOs in this TSDMMP. + Report environmental incidents to Santos GEP Package Lead.

Title (role)	Environmental responsibilities
Vessel Master (contractor personnel)	+ Confirm vessel management system and procedures are implemented and comply with the requirements detailed in this TSDMMP. + Confirm personnel receive an environmental induction that meets the requirements outlined in this TSDMMP on commencing work on the vessel. + Confirm crew personnel are competent to undertake the assigned work tasks. + Confirm SOPEP drills are undertaken in accordance with the vessel's schedule. + Comply with vessel entry and movement requirements within exclusion zones. + Maintain ballast water management plan, valid ballast water management certificate, ballast water management records, and Antifouling System Certificate specific to the vessel. + Maintain records of fuel use and vessel discharges/ transfers (including waste, sewage and oily water) as per MARPOL and Santos requirements + Confirm vessel crew are provided with sufficient training to implement the SOPEP/SMPEP (as appropriate to vessel class). + Ensure supervision of all bunkering/transfer operations to the vessel. + Report any environmental incidents or non-conformance with the EPOs, EPSs or MA in this TSDMMP in accordance with Santos and statutory requirements.
Offshore Construction Superintendent (Contractor Personnel)	+ Responsible for ensuring that pipeline construction activities are performed in accordance with this TSDMMP.

Title (role)	Environmental responsibilities
Offshore HSE Advisors (Santos and/or Contractor)	+ Support the Santos Senior Client Site Representative to ensure that the controls detailed in this TSDMMP relevant to offshore activities are implemented and assist in collection and recording of evidence of implementation (other controls are implemented and evidence collected onshore). + Support the Santos Senior Client Site Representative to ensure environmental incidents or breaches of objectives and/ or standards outlined in this TSDMMP, are reported, and corrective actions for incidents and breaches are developed, tracked and closed out in a timely manner. + Ensure periodic environmental inspections/reviews are completed and corrective actions from inspections are developed, tracked and closed out in a timely manner. + Review Contractors procedures, input into Toolbox talks and JSAs. + Provide day to day environmental support for activities in consultation with the Santos Environmental Advisor.
All Project personnel	+ Act in an environmentally responsible manner. + Undertake work in accordance with accepted HSE systems and procedures. + Comply with this TSDMMP and all regulatory requirements as applicable to assigned role. + Report any unsafe conditions, near misses or environmental incidents immediately to supervisors. + Attend environmental inductions and HSE meetings, and complete training as required. + Report marine megafauna sightings as applicable to role in accordance with Project requirements

10.2 Workforce training and competency

This section describes the mechanisms that will be in place, so all Project personnel (including employee and contractor roles) are aware of his or her responsibilities in relation to the TSDMMP and has appropriate training and competencies.

10.2.1 Inductions

Santos and its contractors will develop a mandatory project induction, which will detail TSDMMP requirements. Project induction attendance will be logged and held with the Project Administration Assistant. Santos personnel will be required to complete required contractor site and facility inductions, including DLNG facility inductions, including permitting requirements, as applicable for working in and around the DLNG facility.

All Project site roles will complete an induction that will include a component addressing their TSDMMP responsibilities. Induction attendance records for all personnel will be maintained. Inductions will include information about:

+ Environment, Health and Safety Policy
+ Regulatory regime
+ Operating environment (for example, nearby marine protected areas)
+ Activities with highest risk
+ TSDMMP EPOs, Performance Indicators and management commitments (**Section 8**)
+ Incident reporting and notifications
+ Regulatory compliance reporting
+ Importance of marine communications regarding any potential interactions with other marine users
+ Process for assessing changes to TSDMMP activities
+ Oil pollution emergency response.

10.2.2 Training and competency

The implementation of training requirements will ensure project personnel have the skills, knowledge and competencies to conduct work in a safe manner without harm to their health or the environment.

All members of the workforce will complete relevant training and/or hold relevant qualifications and certificates for their roles.

Santos and its contractors are individually responsible for ensuring that their personnel are qualified and trained. The systems, procedures and responsible persons will vary and will be managed using online databases, staff on-boarding process and training departments, etc.

Personnel qualification and training records will be sampled before and/or during an activity. Such checks may be performed during the procurement process, inductions, crew change, and operational inspections and audits.

Crew trained in marine fauna observation will ensure marine megafauna can be reliably identified to species during observation periods.

10.2.3 Workforce involvement and communication

Daily operational meetings will be held at which HSE will be a standing agenda item. It is a requirement that supervisors attend daily operational meetings and that all personnel attend daily toolbox or pre-shift meetings. Toolbox or pre-shift meetings will be held to plan jobs and discuss work tasks, including HSE risks and their controls.

HSE performance will be monitored and reported during the activity, and performance metrics (including environmental performance indicators and the number of environmental incidents) will be regularly communicated to the workforce. Workforce involvement and environmental awareness will also be promoted by encouraging offshore personnel to report marine fauna sightings and marine pollution (for example, oil on water, dropped objects). Findings, learnings and corrective actions identified from assurance activities and incident investigations will be communicated to project personnel to drive continuous improvement (e.g., through HSE Alerts, pre-shift / toolbox meetings).

10.3 Audits and inspections

Environmental Audits and Inspections undertaken to provide assurance of requirements within this TSDMMP are being met may include:

+ Vessel pre-mobilisation inspections
+ Routine vessel environmental inspections (weekly / monthly during Project execution)
+ Contractor Environmental Audits
+ Regulator Inspections and Audits (as required by Regulator)

For this TSDMMP the environmental audit and inspection processes are described in the Barossa Project Environmental Compliance Assurance Plan (BAA-200 0635).

An Environmental Assurance Activities Schedule (EAAS) will be developed and maintained by the Barossa HSE Team which will align with the Barossa Project Integrated Audit Schedule. The EAAS will provide an overview and schedule of assurance (verification) activities required to meet compliance for each activity (e.g., inspections, audits, assessments, and reviews). Additionally, it will allow Santos and the Barossa HSE Team to plan and resource appropriately to ensure all environmental assurance requirements can be met.

Audit criteria, as included within a terms of reference (ToR), will typically include a selection of management actions and environmental performance standards and outcomes; however, may also include parts of the activity description, stakeholder consultation and implementation strategies.

Audit findings may include opportunities for improvement and non-conformances (requirements not met). Audit non-conformances are managed as described in below.

10.3.1 Environmental Incident Reporting Internal incident reporting

All personnel will be informed through inductions and daily operational meetings of their duty to report HSE incidents and hazards. Reported HSE incidents and hazards will be shared during daily operational meetings and will be documented in the incident management systems as appropriate. HSE incidents will be investigated and reported in accordance with the Santos Incident Reporting and Investigation Procedure (SMS-HSS-OS07-PD01) and contractor procedures.

The incident reporting requirements will be provided to all crew on-board the facilities and support vessels with special attention to the reporting time frames to provide for accurate and timely reporting.

10.3.2 External incident reporting

Certain incidents will require notification to external Regulatory authorities under NT and Commonwealth legislation. This includes requirements below; additional requirements may apply as conditions of approval of the DPD Project.

10.3.2.1 Reportable incident – Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 (Cth)

While the NT P*etroleum (Submerged Lands) Act 1981* and subordinate Commonwealth Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 do not technically apply to the activity area of this TSDMMP, for consistency with other DPD activities that do fall within the jurisdiction of this legislation Santos intends on following the reportable incident definition and reporting requirements described below for this TSDMMP.

Reportable Incidents, defined as "*…an incident arising out of operations for the activity that is not within the parameters of the environmental performance standards in the environment plan in force for the activity*", will be reported to DITT in accordance with Part 3 of the Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 which requires the following:

+ The operator of an activity must give notice of a reportable incident (either oral or written), with all material details of the incident that are reasonably available to the operator, to the Designated Authority as soon as possible after the first occurrence of the incident.
+ The operator must give a written report of the incident to the Designated Authority:
  - if the Designated Authority specifies a reasonable period for giving the report — within that period; or
  - in any other case — as soon as practicable after the first occurrence of the incident.
+ The report must set out fully:
  - all the material facts and circumstances of the incident that the operator knows or is able, by reasonable search and inquiry, to find out; and
  - the action (if any) taken to avoid or mitigate any adverse effects of the incident on the environment; and
  - the corrective action that has been taken, or is proposed to be taken, to prevent another incident of that kind.
+ The operator must keep a record of reports of each reportable incident, and of the details, in each case, of any corrective action taken.

10.3.2.2 Reportable incident – Waste Management and Pollution Control Act 1998 (NT)

As per Part 3 Section 14 of the Waste Management and Pollution Control Act 1998 (WMCA Act 1998), incidents causing, or that may threaten to cause, pollution resulting in material environmental harm or serious environmental harm, will be reported to the NT EPA as soon as practicable after (and in any case within 24 hours after) becoming aware of the incident. An incident includes "*an accident, emergency or malfunction and a deliberate action, whether or not that action was taken by the person conducting the activity in the course of which the incident occurred*".

A notification to the NT EPA of an incident as per Part 3 Section 14 of the WMCA Act 1998 will specify:

+ the incident causing or threatening to cause pollution;
+ the place where the incident occurred;
+ the date and time of the incident;
+ how the pollution has occurred, is occurring or may occur;
+ the attempts made to prevent, reduce, control, rectify or clean up the pollution or resultant environmental harm caused or threatening to be caused by the incident; and
+ the identity of the person notifying.

10.3.2.3 Wildlife incident reporting

Any incident resulting in a significant impact to a species listed as threatened or migratory under the *Environmental Protection and Biodiversity Protection Act 1999* (EPBC Act 1999) is to be reported to DCCEEW as soon as practicable (and in any case within 24 hours) of becoming aware of the event

occurring. For the Project Area, marine species listed as threatened or migratory under the EPBC Act include marine turtles (all species), dolphins, dugongs and crocodiles.

The report will contain:

+ time, location and description of the incident
+ a summary of the response being undertaken
+ details of the relevant contact person.

Any occurrences of stranded, injured or entangled marine megafauna are also to be reported to NT Marine Wild Watch (1800 453 941) (DEPWS) as soon as practicable after observing.

10.3.2.4 Hydrocarbon/ hazardous substance spill reporting

External reporting requirements will include reporting to Darwin Port (for incidents within Darwin Port limits), NT EPA (as above) and the Australian Maritime Safety Authority (AMSA), including completion of a marine pollution notification (POLREP). Oil spill reporting is to follow any additional reporting requirements outlined within the DPD Project Oil Pollution Emergency Plan (BAS-210 0026).

10.3.3 Corrective actions

Corrective actions identified from environmental assurance activities and incident investigations will be derived in collaboration with contractors. For this TSDMMP, corrective actions and contingency processes are described as per the Barossa Project Environmental Compliance Assurance Plan (BAA-200 0635) and Barossa Health, Safety & Environment Management Plan for Execute (BAA-200 0003).

TSDMMP non-conformances will be addressed and resolved by a systematic corrective action process as outlined in Santos' Management System. Santos' incident and action tracking management system (HSE Toolbox) will be used to track corrective actions in the following instances:

+ Where there has been or potentially been a reportable incident
+ Where there has been a non-compliance in accordance with a statutory plan
+ Where any corrective action requires notification to an external regulatory or statutory body
+ Where there are corrective actions from formal audits (Contractor Pre-Start Audit, external regulator audit etc.).

Once entered, corrective actions, time frames and responsible persons (including action owners and event validators) will be assigned. Corrective action 'close out' will be monitored using a management escalation process.

Environmental corrective actions identified through compliance assurance activities are to be promptly managed to ensure timeframes for external reporting are met and that decision making is made visible.

10.3.4 Continuous improvement

For this TSDMMP, continuous improvement will be driven by the list below and may result in a review of the TSDMMP, with changes applied in accordance with **Section 10.6**.

+ Improvements identified from the review of business-level HSE key performance indicators
+ Actions arising from Santos and departmental HSE improvement plans
+ Corrective actions and feedback from HSE audits and inspections, incident investigations and after-action reviews

+ Opportunities for improvement and changes identified during pre-activity reviews and MoC documents
+ Actions taken to address concerns and issues raised during the ongoing stakeholder management process (**Section 11**).

Identified continuous improvement opportunities will be assessed in accordance with the MoC process (**Section 10.6**) to ensure any potential changes to this TSDMMP are managed in a controlled manner.

10.4 Emergency preparedness and response

Emergency preparedness and response arrangements, applicable to activities covered by this TSDMMP, including for oil spill response, will be included in Santos and Contractor procedures.

10.4.1 Contractor emergency and oil spill response plans

DPD Project contractors are responsible for having comprehensive Emergency Response Plans (ERPs) that address emergency response actions associated with all credible incidents for the activity. These will describe the interface arrangements between Contractor and Santos Incident Management structures and cover all aspects of emergency response including technical, logistical and medical support.

Contractor ERPs will outline roles and responsibilities of contractor personnel for emergency events. The ERPs are accepted by Santos and reviewed on an annual basis by the contractor or if a significant change has occurred to the incident management or emergency response arrangements.

Scenario-based drills are performed to test the emergency response arrangements and updates are made to improve the ERPs, if required.

Contractor vessels undertaking activities covered by this TSDMMP are required, where applicable to vessel class, to have Shipboard Oil Pollution Emergency Plans (SOPEP) and/or Shipboard Marine Pollution Emergency Plans (SMPEPs) outlining hydrocarbon/ hazardous substance spill response arrangements, including response actions and equipment requirements. Vessels are required to conduct regular spill response drills as per arrangements detailed in these plans.

10.4.2 Santos incident management and oil spill response arrangements

Santos maintains Incident and Crisis Management Teams (IMT and CMT) and support arrangements to respond to all-hazard incidents, including oil spill incidents, at its sites and for activities under its control or influence, including activities covered under this TSDMMP. Santos' crisis and incident management arrangement are outlined within the Crisis, Incident Management & Emergency Response Procedure (SMS-HSS-OS05-PD01) and Incident Management Plan – Upstream Offshore (SO-00-ZF-00025). IMT and CMT training and exercise requirements, including OPEP exercises, are included within an annual training and exercise plan and schedule.

Specific oil spill response support strategies and arrangements for hydrocarbon spill scenarios covered in this TSDMMP will be outlined within the DPD Project Oil Pollution Emergency Plan (BAS-210 0026). This will include roles and responsibilities and response strategies / resources applicable for responding to worst case spill scenarios for DPD activities covered by this TSDMMP. The arrangements within the OPEP will provide support to, and interface with, response activities undertaken by onsite personnel (e.g., vessel oil spill response activities), as well as response activities coordinated by designated NT Control Agencies.

10.5 Reporting and notifications

Environmental reporting for the DPD Project construction activities will include reports between Subcontractors and Contractors, Contractors and Santos, and Santos and Stakeholders, including Regulatory authorities. Reports will be delivered within agreed upon timeframes. **Table 10-3** outlines an initial assessment of reporting requirements relevant to this TSDMMP.

External reporting requirements may be dictated by approval conditions associated with the DPD Project and finalisation of this TSDMMP will include all relevant external regulatory reporting requirements.

A detailed schedule of reporting requirements and submission dates for the DPD Project will be developed as per the Barossa Project Environmental Compliance Plan (BAA-200 0635).

10.5.1 Internal reporting

10.5.1.1 Routine reporting

Internal reporting will occur between trenching and environmental consulting contractors and Santos. This reporting will be undertaken on a daily and weekly basis and will include trenching operation and environmental performance reports.

Daily reports will be provided by contractors to Santos, this will include:

+ Dredge log
+ Telemetered turbidity data recorded at monitoring sites for 24-hr period prior to reporting, including the daily rolling average turbidity value (**Section 9**)
+ Turbidity data trigger exceedance (**Section 9**)
+ Telemetered water temperature data recorded at coral monitoring sites for 24-hr period prior to reporting, including the 21-day rolling water temperature average (**Section 9**)
+ Coral water temperature trigger exceedance
+ Marine megafauna interactions
+ Changes to weekly trenching plan

Weekly reports will be provided by the contractors to Santos, this will include:

+ Weekly dredge report
+ Telemetered turbidity data recorded at monitoring sites for the week prior to reporting, including daily rolling average turbidity value (**Section 9**)
+ Responses to turbidity and coral water temperature trigger exceedances
+ Responses to marine megafauna interactions
+ Changes to overall dredge plans
+ Summary of environmental events
+ Inspection and/or audit outcomes and status of actions/findings

10.5.1.2 Environmental event reporting and investigation

Environmental incidents, hazards, non-compliances and near misses are deemed by Santos as environmental events. All seas will report all environmental events related to trenching and spoil

disposal activities in accordance with contractual requirements. Environmental events will be documented and investigated as appropriate. Actions taken to prevent and or mitigate environmental events will be documented and tracked by the contractor until close-out.

10.5.2 External reporting

10.5.2.1 Exceedance reporting

In the event that Level 2 trigger values (detailed in **Section 8.2.2.1)** are exceeded during trenching and spoil disposal activities, and exceedance is attributable to trenching activity, Santos will notify DITT and NT EPA/DEPWS as soon as practicable (within 24 hours after becoming aware of exceedance).

Indicative notification and reporting timeframes (in business days) for each step is summarised in **Table 10-2.**

Table 10-2: Trigger exceedance notification and reporting summary

Communication	Trigger Level	Time	Content
Initial exceedance notification	Level 2	Within 24 hours following identification of exceedance	Notify stakeholders of exceeded triggers.
Attributability notification	Level 2	Within 5 days of exceedance	Notify stakeholder attributability
Exceedance is attributable to dredging			
Exceedance report	Level 2	Weekly	Report including management actions implemented and their effectiveness (where practicable)
Lessons learnt report	Level 2	15 days after return to below Level 1 trigger level	Report on exceedance management, including lessons learnt.

10.5.2.2 Monitoring reporting

DITT and NT EPA/DEPWS will be provided with a comprehensive and interpretive water quality report following the conclusion of monitoring, unless otherwise agreed upon with regulator.

This water quality report will be formatted following the National Water Quality Management Strategy, Australian Guidelines for Water Quality Monitoring and Reporting, no. 7 (ANZECC and ARMCANZ, 2000) and will include assessment of likely impacts to sensitive receptors from the release of fine material.

10.5.3 Summary of reporting

Reporting required in association with Santos' DPD Project, including that detailed above, is summarised in **Table 10-3**.

Table 10-3: Summary of reporting requirements.

Report/ Notification	Responsibility	Content	Frequency	Recipient
Pre-start				
OVID inspection reports	Santos Marine Assurance Team	Provides a summary of the findings of the support vessel inspection which assesses compliance with relevant international (e.g. MARPOL 73/78), Australian and Santos requirements.	Prior to commencement of the activity	Santos
Pre-start contractor audit	Santos Barossa Team	Confirmation of compliance with TSDMMP commitments relating to operational procedures and processes that Santos require to be in place prior to the commencement of the activity.	Prior to commencement of the activity	Santos
Pre-start notifications	Santos Barossa Team / Contractors	Details on DPD Project commencement to meet requirements of stakeholders (including Regulatory authorities)	Prior to commencement of the activity	Various stakeholders
Execution and completion				
Regular Stakeholder updates	Santos Barossa Team	Regular updates on DPD Project during planning and execution as per Stakeholder Management Plan (refer **Section 11**)	Throughout planning and execution	Various stakeholders
Contractor environmental execution audit	Santos Barossa Team	Confirmation of compliance with TSDMMP commitments relevant to execution of the activity.	Prior to completion of the activity	Santos
Vessel Daily Reports	Contractor Vessel Master	Update on day's activities, including any identified non-conformance against this TSDMMP, and any issues that may need addressing.	Daily	Santos

Report/ Notification	Responsibility	Content	Frequency	Recipient
Vessel Environmental Reports/Checklists	Contractor Vessel Master	Compliance against key regulatory and contractual commitments (including TSDMMP commitments). Reporting of fuel usage, vessel discharges and emissions etc.	Weekly/ Monthly[1]	Santos
HSE Meetings Records	Contractor and Santos Barossa Team	Monthly, dedicated HSE meetings are held with the offshore and Perth-based management (including contractor management) and advisors to address targeted health, safety and environment incidents and initiatives. Minutes of these meetings are produced and distributed as appropriate.	Monthly	Santos
Completion notifications	Santos Barossa Team / Contractors	Details on DPD Project completion to meet requirements of stakeholders (including Regulatory authorities)	Following completion of the activity	Various stakeholders
Unexpected Finds Notification	Contractor and Santos Barossa Team	Notification by Contractor of potential unexpected find of heritage value. Further notification to Maritime Archaeologist and NT Heritage Branch, as required, following Unexpected Finds Protocol.	Dependent upon occurrence of unexpected find of cultural value	NT Heritage Branch
Environmental Monitoring Reports	Santos Contractor and Santos Barossa Team / Environmental Monitoring Contractor	Reporting on the outcomes of environmental monitoring activities (including water quality and benthic habitat monitoring) associated with the DPD Project construction activities.	Various dependent upon program	Santos DEPWS DITT NT EPA DCCEEW (if required)

Report/ Notification	Responsibility	Content	Frequency	Recipient
Environmental Performance/ Compliance Assurance Report	Santos Barossa Team	Provides a summary of compliance performance, including the environmental performance objectives, standards and measurement criteria within this TSDMMP and any other conditions of approval on the DPD Project.	At completion of the activity and not less than annually	DITT NTEPA (DEPWS) DCCEEW (if required)
Incident reporting				
Incident Report – Internal	Contractor and Santos Barossa Team	Provides framework for Internal notification of incidents including spills. The first report contains tools for assessing the severity of the incident and escalating as per the incident notification procedure. Incident reporting will also be undertaken through Santos' online EHS Toolbox system.	Incident specific	Santos
Incident Report – Reportable Environmental Incident (P(SL)(MoE) Regs 1999)	Santos Barossa Team	Reporting of Reportable Incidents as per Part 3 of the Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 (P(SL)(MoE) Regs 1999) (Refer **Section 10.3.2.1**)	Incident specific	DITT
Incident Report – Reportable Environmental Incident (WMPC Act 1998)	Santos Barossa Team	Reporting of Reportable Incidents as per Part 3 of the Waste Management and Pollution Control Act 1998 (WMPC Act 1998) (**Section 10.3.2.2**)	Incident specific	NT EPA
Incident Report – Wildlife Incidents	Santos Barossa Team	Reporting of incidents involving EPBC Act species and reports of stranded, injured or entangled marine megafauna (**Section 10.3.2.3**)	Incident specific	DCCEEW DEPWS

Report/ Notification	Responsibility	Content	Frequency	Recipient
Incident Report – Hydrocarbon/ hazardous substance spill	Contractor and Santos Barossa Team	Reporting of NT oil spill incidents to Darwin Port (within port limits), AMSA and NT EPA. Additional oil spill reporting requirements as stated within the DPD Project Oil Pollution Emergency Plan (BAS-210 0026)	Incident specific	Darwin Ports AMSA NT EPA
Incident Report – Egress into wreck exclusion zone	Santos Barossa Team	Reporting of any egress into or disturbance of the exclusion zones of the Booya and Catalina 6 wrecks	Incident specific	Darwin Ports Harbour Master
Environmental reporting specific to the TSDMMP				
Initial exceedance notification	Santos Barossa Team	Notify stakeholders of exceeded triggers.	Incident specific Within 24 hours following identification of exceedance	Santos DEPWS DITT NT EP
Attributability notification	Santos Barossa Team	Notify stakeholder attributability	Incident specific Within 5 days of exceedance	Santos DEPWS DITT NT EPA Relevant other proponents

Report/ Notification	Responsibility	Content	Frequency	Recipient
Exceedance report	Santos Barossa Team	Report including management actions implemented and their effectiveness (where practicable)	Weekly	Santos DEPWS DITT NT EPA
Lessons learnt report	Santos Barossa Team	Report on exceedance management, including lessons learnt.	15 days after return to below Level 1 trigger level	Santos DEPWS DITT NT EPA

Notes:

1. As per the Barossa compliance assurance plan

10.6 Document management

This TSDMMP will be revised based on conditions of environmental approvals and/or licences and submitted to the appropriate regulator, for review and approval as required, prior to DPD Project implementation (i.e., commencement of construction activities).

10.6.1 Information management and document control

This TSDMMP, as well as any approved management of change (MoC) documents, are controlled documents and current versions will be available on Santos' document control system and made available to Project contractors.

As per the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 (Cth)* the TSDMMP and all records associated with monitoring and reporting against TSDMMP commitments will be maintained for a period of five years. This includes revisions of the TSDMMP, and subordinate EMPs, written reports relating to environmental performance (monitoring, audit and review), records of emissions and discharges, records of calibration and maintenance of monitoring devices and records of reportable incidents.

The management and transfer of environmental assurance evidence between Santos and the primary construction contractor will be undertaken as per the Barossa Project Gas Export Pipeline (GEP) Environmental Compliance Assurance Plan (ECAP) Evidence Management and Transfer Procedure (BAS-210 0050).

10.6.2 Management of change

Following regulatory review and approval of this TSDMMP any changes to Project activities as described in this document, which have the potential to materially increase environmental impacts and risks, will be evaluated and controlled following the impact and risk assessment process followed in **Section 7**. The documentation and approval of management of change (MoC) assessments will follow the process outlined within the Santos Management of Change Procedure (SMS-LRG-OS01-PD04). MoC records will be retained and details of MoCs outlined within Regulatory compliance/performance reports.

As per the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 (Cth)*, if a significant new environmental effect or risk is identified, or a significant increase in environmental effect of risk identified, which is not already provided for in the TSDMMP, a revision of the plan will be submitted to DITT as soon as practicable after the occurrence or identification of the significant effect or risk.

If there is a change in the petroleum instrument holder, or operator for the activity, a revision of the TSDMMP will be submitted to DITT as soon as practicable after the change.

10.6.3 Reviews

This TSDMMP addresses a temporary construction activity. The TSDMMP will be reviewed annually, or as required in response to regulatory requirements and any changes to impacts, risks or management actions raised in Santos' assurance processes, incident response, stakeholder engagement or contractor engagement. These changes will be evaluated through the MoC process, and any updates communicated to regulators for review and approval as required.

11 Stakeholder Engagement and Communications

Stakeholder engagement is an open dialogue that continues through the full project lifecycle. It is an essential process supporting environmental impact assessment as it provides affected and interested stakeholders with information about the Project's potential impacts and benefits.

Stakeholder engagement supports the early identification of issues, addresses community concerns and expectations on decisions that may affect them and leads to better decision-making and outcomes.

The objectives of the engagement strategy used for the DPD Project are to:

+ Maintain an ongoing dialogue, keeping stakeholders informed of the Project details and potential impacts.
+ Update stakeholders on changes to the Project during each stage of engagement.
+ Notify stakeholders of commitments made by Santos as part of the Project approval process.
+ Encourage stakeholders to provide comments and raise issues or concerns about the Project.
+ Respond to those comments as part of documentation required through the assessment process and directly to stakeholders as required.
+ Continue to build on existing stakeholder relationships and trust to inform Santos' longer term-activities and community involvement.

11.1 Key Stakeholders

Key stakeholder groups were identified based on them having activities within the Project's footprint area, likely to have an interest in the Project, or the potential to be positively or negatively impacted by the Project. This list may change and be updated as the Project progresses, with the SEP being a live document throughout the life of the Project. Key stakeholders identified at this point are listed in **Table 11-1**.

Table 11-1 Key stakeholders consulted

Sector	Stakeholder
Commonwealth Government	Department of Climate Change, Energy, the Environment and Water (formerly Department of Agriculture, Water and the Environment) Department of Defence
NT Government Regulators / Agencies	Aboriginal Areas Protection Authority (AAPA) Department of Environment, Parks and Water Security Department of Chief Minister and Cabinet Department of Industry, Tourism and Trade (Fisheries) Department of Industry, Tourism and Trade (Energy) Department of Industry, Tourism and Trade (Tenure) Department of Industry, Tourism and Trade (Tourism) Department of Infrastructure, Planning & Logistics

Sector	Stakeholder
	Department of Infrastructure, Planning & Logistics (Middle Arm Sustainable Development Precinct Project) Department of Infrastructure, Planning & Logistics (Darwin Shiplift Project; Mandorah Ferry Project) Department of Infrastructure, Planning & Logistics (Roads) Department of Territory Families, Housing and Communities (Heritage) Environmental Protection Authority NT Power and Water
Indigenous Groups / Representative Bodies	+ Aboriginal Areas Protection Authority (also noted as agency above) + Darwin Harbour Advisory Committee + Larrakia Nation (including Larrakia Sea Rangers) + Northern Land Council + Tiwi Land Council + Wickham Point Deed Reference Group
Environmental Group Representatives	+ Australian Marine Science Association + Australian National University (individual) + Environment Centre NT + Sea Turtle Foundation
Fishing Representative Bodies	+ Amateur Fishermans' Association of the NT (recreational) + NT Seafood Council (commercial)
Other Industry / Operators	+ Darwin Port + DLNG Pty Ltd + Eni Australia + INPEX + NT Guided Fishing Industry Association + Paspaley Pearling + Sea Darwin + Sun Cable + Telstra + Top End Tourism + Tourism NT

11.2 Stakeholder engagement process

The first stage of the engagement process was undertaken prior to the submission of a Project Referral to the NT-EPA and occurred from 8 October to 20 December 2021.

A total of 33 meetings was conducted during this period with identified stakeholders. Feedback was used to inform the Referral and identify key issues and concerns to be considered by Santos as part of the management framework and subsequent preparation of approvals documentation.

Following submission of the Referral in early-January 2022, Santos continued to proactively engage with key stakeholders to discuss their issues and concerns. On 18 January 2022, the NT EPA published the Referral and invited public comment until 15 February 2022. On 3 March 2022, the EPA provided Santos with the submissions on the Referral that had been received from the public by the EPA's closing date of 15 February 2022, with submissions from other NT Governments provided on 7 April 2022.

In preparing the SER, Santos has considered and assessed each submission individually and taken into consideration the issues raised when engaging with stakeholders to assess potential impacts and proposed management measures.

Prior to the start of consultation formally commencing in late 2021, Santos identified the need to engage with other organisations proposing to undertake future trenching activities on an ongoing basis throughout the planning and assessment periods. The aim of this specific engagement was to share information and seek collaboration across a range of aspects including the undertaking of environmental studies, data sharing, spoil disposal and re-use, contracting of vessels and equipment and project schedule. The organisations are the NT Department of Infrastructure, Planning and Logistics (covering three projects), INPEX and the Commonwealth Department of Defence.

The SER provides a summary of the issues raised relevant to the Project and Santos' assessment and response to these issues. A full register with all submissions and responses is provided in the SER (BAS-210 0020). Specifically, the register includes submissions and responses related to both the impacts and risks associated with trenching activities and collaboration with other proponents of projects involving trenching activities in Darwin Harbour.

11.3 Ongoing and future engagement

Santos is committed to continuing with the engagement process throughout the ongoing assessment process and through the life of the Project. Ongoing engagement will focus on issues raised by stakeholders. Prior to the commencement of construction Santos will conduct a series of meetings with external stakeholders to explain the activities and schedule and how marine users will be kept informed while the activities are occurring. The Larrakia Sea Rangers will also be specifically consulted with regards to the monitoring components of this plan.

The NT Department of Infrastructure, Planning and Logistics is developing a reference group that will provide information and advice on its preparation of a future dredge management plan for Darwin Harbour. Santos has indicated its willingness to be part of these efforts in addition to the other ongoing engagement activities specifically for the Darwin Pipeline Duplication project. Further details of the planned engagement following the assessment period, including the construction and operation periods, is provided as part of the SEP (Appendix 3 of the SER; BAS-210 0020). Sections of the SEP specific to the lead-up to and execution of trenching activities are shown in **Table 11-2**.

Table 11-2 Sections of the SEP specific to the lead-up to and execution of trenching activities

Stage	Aims and Activities	Deliverables
Public Comment Period on SER and ongoing engagement awaiting final NT EPA decision	Aims: Ensure all issues/concerns raised by stakeholders during the assessment process have been addressed; as many additional stakeholders as possible have been identified; all stakeholders are aware of the final decision and opportunities to further engage with Santos. Key activities: + Engage with DEPWS and stakeholders on additional issues/concerns raised during public comment period. + Continued engagement with NT Government agencies and private organisations on technical issues, secondary project approvals and/or collaborative opportunities. + Notification to all stakeholders re assessment outcome and conditions placed on Project; progress on approved activities and required associated approvals; stakeholder communication and consultation process going forward. + Continued engagement with NT Government agencies and other relevant stakeholders for all secondary project approvals that are required prior to activities commencing + Engage with indigenous organisations on outcomes from AAPA investigation and Clearance Certificate conditions + Continued engagement with community and indigenous organisations on opportunities to support/collaborate associated directly with project activities (e.g. Larrakia Rangers) or community-based activities + Engage with key contractors to be undertaking activities on Santos' behalf and owners of land upon which activities will occur (e.g. Darwin Port, DIPL- East Arm, DLNG, Wickham Point Deed Reference Group, Mount Bundy) + Ongoing engagement with potential suppliers via ICN NT + Ongoing engagement with the following stakeholders on specific issues raised:	+ Stakeholder meetings + Presentations at stakeholder events (see potential list below) + Email, phone communication + Distribution of project update via email + Publication of SER documentation on NT EPA website + Notification via email of SER public comment period + Information posted to Santos website + Project page on ICN Gateway website + Santos ASX and media statements

Stage	Aims and Activities	Deliverables
	– Opportunities for collaboration on dredging-related activities – NT DIPL, INPEX, Department of Defence – Pipelay activities within Reef Fish Protection Area – NT DITT – Fisheries, AFANT, NTSC – Indigenous consultation resulting from AAPA Clearance Certification – AAPA, NLC, Wickham Point Deed Reference Group, other identified Larrakia stakeholders – Opportunities for collaboration on environmental studies and modelling – NT DPEWS, INPEX, Darwin Harbour Advisory Group, Larrakia Rangers – Road traffic management – NT DIPL – Darwin Harbour impacts management – NT DIPL, Darwin Port, DHAC, Tourism NT, Top End Tourism, AFANT, NTGFIA	
Lead-up to execution of activities	Aims: Ensure all identified stakeholders are aware of pending activities, timeframes, how issues/concerns have been mitigated/are being managed, how complaints will be handled and ongoing communications process and contact points. Key activities: + Continued engagement with NT Government agencies and private organisations on technical issues and/or collaborative opportunities. + Continued engagement with NT Government agencies and other relevant stakeholders for all secondary approvals associated with the Project and required prior to activities commencing + Notification to all stakeholders re proposed activities, schedule stakeholder communication and consultation process going forward. + Ongoing engagement with potential suppliers via ICN NT + Engage with key contractors who will be undertaking activities on Santos' behalf and the owners of land upon which activities will occur (e.g. Darwin Port, DIPL- East Arm, DLNG Management, Wickham Point Deed Reference Group)	+ Stakeholder meetings + Presentations at stakeholder events (e.g. Darwin Port Users Group, Darwin Harbour Advisory Committee, Top End Tourism, Tourism NT, NT Chamber of Commerce, NT Energy Club) + Email, phone communication + Distribution of project update via email + Distribution of project fact sheets via email and stakeholder meetings + Distribution of project information via third parties

Stage	Aims and Activities	Deliverables
	+ Ongoing engagement with the following stakeholders on specific issues raised: – Opportunities for collaboration on dredging-related activities – NT DIPL, INPEX, Department of Defence – Pipelay activities within Reef Fish Protection Area – NT DITT – Fisheries, AFANT, NTSC – Indigenous consultation resulting from AAPA Clearance Certification – AAPA, NLC, Wickham Point Deed Reference Group, other identified Larrakia stakeholders – Opportunities for collaboration on environmental studies and modelling – NT DPEWS, INPEX, Darwin Harbour Advisory Group, Larrakia Rangers – Road traffic management – NT DIPL, other stakeholders identified – Darwin Harbour impacts management – NT DIPL, Darwin Port, DHAC, Tourism NT, Top End Tourism, AFANT, NTGFIA	(e.g. Darwin Port, Tourism NT) to their membership + Distribution of project information via paid advertorial in NT News + Information posted to Santos website + Project page on ICN Gateway website + Santos ASX and media statements
Execution of activities in NT Waters	Aims: To help ensure safe use by all users of locations where project activities are occurring. Ensure all identified stakeholders are kept regularly informed of aware of progress on current activities, pending activities, timeframes, how issues/concerns have been mitigated/are being managed, how complaints are being handled and ongoing communications process and contact points. Key activities: + Continued engagement with NT Government agencies and private organisations on technical issues and/or collaborative activities. + Continued engagement with NT Government agencies and other relevant stakeholders for the safe and efficient compliance of all secondary approvals (e.g. road traffic management, waste discharges, licence conditions) associated with the Project + Notification to all stakeholders re proposed activities, schedule stakeholder communication and consultation process going forward. + Ongoing engagement with potential suppliers via ICN NT	+ Stakeholder meetings + Presentations at stakeholder events (e.g. Darwin Port, Top End Tourism, Tourism NT, Chamber of Commerce, Energy Club) + Email, phone communication + Distribution of project update via email + Distribution of project fact sheets via email and stakeholder meetings + Project fact sheets posted to Santos external website

Stage	Aims and Activities	Deliverables
	+ Ongoing engagement with key contractors undertaking activities on Santos' behalf and the owners of land upon which activities will occur (e.g. Darwin Port, DIPL- East Arm, DLNG Management, Wickham Point Deed Reference Group) to ensure efficient communications and help maintain safe operations. + Ongoing engagement with the following stakeholders on specific issues raised: – Opportunities for collaboration on dredging-related activities – NT DIPL, INPEX, Department of Defence – Pipelay activities within Reef Fish Protection Area – NT DITT – Fisheries, AFANT, NTSC – Indigenous consultation resulting from AAPA Clearance Certification – AAPA, NLC, Wickham Point Deed Reference Group, other identified Larrakia stakeholders – Opportunities for collaboration on environmental studies and modelling – NT DPEWS, INPEX, Darwin Harbour Advisory Group, Larrakia Rangers – Road traffic management – NT DIPL – Darwin Harbour impacts management – NT DIPL, Darwin Port, DHAC, Tourism NT, Top End Tourism, AFANT, NTGFIA	+ Distribution of project information via third parties (e.g. Darwin Port, Tourism NT) to their membership + Distribution of project information via paid advertorial in NT News + Physical location on Darwin Harbour for distribution of project information and discussion of issues/concerns + Santos ASX and media statements

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Appendix 1: Santos Environment, Health and Safety Policies

Environment, Health & Safety

SMS Santos

Policy

Our Commitment

Santos is committed to being the safest gas company wherever we have a presence and preventing harm to people and the environment

Our Actions

We will:

1. Integrate environment, health and safety management requirements into the way we work
2. Comply with all relevant environmental, health and safety laws and continuously improve our management systems
3. Include environmental, health and safety considerations in business planning, decision making and asset management processes
4. Identify, control and monitor risks that have the potential for harm to people and the environment, so far as is reasonably practicable
5. Report, investigate and learn from our incidents
6. Consult and communicate with, and promote the participation of all workers to maintain a strong environment, health and safety culture
7. Empower our people, regardless of position, to "Stop the Job" when they feel it necessary to prevent harm to themselves, others or the environment
8. Work proactively and collaboratively with our stakeholders and the communities in which we operate
9. Set, measure, review and monitor objectives and targets to demonstrate proactive processes are in place to reduce the risk of harm to people and the environment
10. Report publicly on our environmental, health and safety performance

Governance

The Environment Health Safety and Sustainability Committee is responsible for reviewing the effectiveness of this policy.

This policy will be reviewed at appropriate intervals and revised when necessary to keep it current.

Kevin Gallagher

Managing Director & CEO

Status: APPROVED

Document Owner:	Jodie Hatherly, General Counsel and VP Legal, Risk and Governance		
Approved by:	The Board	Version:	3

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Appendix 2: Summary of Management Actions

MA reference	Management Action
DPD-MA04	Activity vessels equipped and crewed in accordance with Australian maritime requirements
DPD-MA05	Ongoing stakeholder consultation with relevant stakeholders (including applicable notifications) to minimise adverse impacts on other marine users
DPD-MA06	Implementation of precautionary zones around DPD Project vessel to mitigate against adverse interactions
DPD-MA07	Vessels supporting the trenching operations will act as surveillance vessels when operating adjacent to the trenching vessels
DPD-MA08	The proposed pipeline route will be marked on marine charts, in the same way that the existing pipelines are gazetted and marked on marine charts
DPD-MA12	Pipeline route was surveyed (geophysical and geotechnical) to evaluate seabed, trenching, stabilisation and freespan correction/ prevention will only be undertaken at identified areas (using standard positional accuracy measures used in the industry)
DPD-MA13	Overflow from the TSHD will be undertaken through the adaptive management processes. There will be 'environmental valve', 'green valve' where available (attached to O/F to reduce air entrained, to reduce billowing and facilitates sediment sinking) as standard which will be used as a first step.
DPD-MA14	Standard operating procedure for spoil disposal will be used.
DPD-MA15	Spoil will not be disposed of in a single location, to avoid developing a single large mound.
DPD-MA16	Spoil will only be placed *in situ* within a short section of trenching within intertidal zones and will be removed subsequently where accessible by BHD and SHB for offshore disposal
DPD-MA18	Anchor management plans will be developed to allow safe anchoring of vessels undertaking pipelay, trenching and other support activities in the vicinity of sensitive habitats and nearshore heritage or sacred sites
DPD-MA19	Trained and competent anchor handling operators will be used
DPD-MA20	Anchors exclusion areas will be implemented to avoid sensitive habitats and heritage sites
DPD-MA21	Independent cultural heritage and habitat assessment have been undertaken to identify potential important heritage sites and habitat along the pipeline route and to avoid sensitive benthic habitats and cultural objects where practicable. Maritime cultural heritage objects that cannot be avoided will be managed as per NT Heritage Branch requirements
DPD-MA28	Adaptive management process as defined in Section 8.6.2.4 which includes environmental monitoring of water quality with management measures applied if water quality exceeds trigger levels
DPD-MA49	Observation and shut-down zones for marine fauna have been developed based on noise modelling results and standard protocols
DPD-MA50	Vessel inductions for all crew will address marine fauna risks and the required management controls
DPD-MA51	Vessel and helicopter contractor procedures will comply with Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000, which includes controls for minimising interaction with marine fauna
DPD-MA52	Personnel trained in marine fauna observation (MFO) will be present on trenching and spoil disposal vessels during daylight hours, including one crew member with MFO training on the bridge at all times
DPD-MA53	All marine fauna interactions and observations will be appropriately recorded and reported to DEPWS/NT EPA and DCCEEW
DPD-MA55	Vessels will adhere to Port of Darwin vessel speed limits
DPD-MA56	Maintenance of vessel, vehicle and equipment combustions engines and vessel incinerators as per planned maintenance system
DPD-MA57	Observation and shut-down zones for marine fauna have been developed based on noise modelling results for trenching and standard protocols and include: + Observation (150 m) and exclusion (50 m) zones for marine mammals and turtles. + Observation zone monitored for 10 minutes prior to commencing trenching and sheet piling. A Marine Megafauna Observation and Adaptive Management Protocol will be included within the MMNMP (BAS-210 0022)

MA reference	Management Action
DPD-MA58	+ Soft start (ramp-up) of hydraulic tools (rock breaking) by BHD + Soft start (ramp-up) of trenching equipment, where practicable, will apply to the CSD and TSHD
DPD-MA60	Shielding, where practicable, and/or orienting operational lights (excluding navigational lighting) on vessels to limit light spill to the environment
DPD-MA61	Housekeeping measures will be adopted, including requiring all crew to keep shutters on windows closed at night, to limit light emissions from vessels
DPD-MA62	Vessel searchlights will only be operated in an emergency situation.
DPD-MA63	Santos will document vessel light spill on Darwin Harbour turtle nesting beaches as part of the DPD Project's environmental monitoring program
DPD-MA64	Vessels will comply with relevant Marine Orders with respect to planned discharges, including: + Marine Order 91 – Marine Pollution Prevention: Oil, which implements Annex I of the MARPOL + Marine Order 95 – Marine Pollution Prevention: Garbage + Marine Order 96 – Marine Pollution Prevention: Sewage, which implements Annex IV of the MARPOL
DPD-MA65	Santos Marine Assurance Process
DPD-MA69	Atmospheric emissions from combustion, incinerators and ODS managed in accordance with standard maritime practice (MARPOL)
DPD-MA70	Monitoring and reporting of fuel consumption and calculated GHG emissions
DPD-MA71	Use of low sulphur diesel
DPD-MA78	Implementation of Santos approved standards and procedures for outboard lifts
DPD-MA79	All lifting and winching equipment will undergo inspection, testing and certification as per Applicable Laws and Applicable Codes and Standards
DPD-MA80	Dropped object recovered where safe and practicable to do so
DPD-MA81	Identification of no lift zones or additional controls, where relevant, in proximity to subsea pipelines as documented in relevant lifting and operational procedure/s
DPD-MA84	Pipeline route design selected where practicable to avoid the potential for impact to habitat / cultural seabed features or assets from a dropped object
DPD-MA85	Vessels equipped with effective anti-fouling coatings as required for class
DPD-MA86	Ballast water management will comply with MARPOL requirements (as applicable to class), Australian Ballast Water Management Requirements and *Biosecurity Act 2015*
DPD-MA87	Apply risk-based IMS management for vessels and immersible equipment – vessel and immersible equipment must be assessed as having a low risk of IMS prior to coming onto activity
DPD-MA88	Vessels having suitable anti-fouling coating (marine growth prevention system) in accordance with the *Protection of the Sea Act 2006*
DPD-MA89	Inductions to include observing marine fauna (e.g., dolphins and turtles)
DPD-MA90	The TSHD shall be fitted with pre-sweeping mechanisms / chain curtains to mitigate turtle entrapment (fauna strike – unplanned)
DPD-MA91	Inspection and maintenance for all equipment using chemicals
DPD-MA92	Santos chemical selection procedure applied for chemicals planned to be discharged to the environment
DPD-MA93	ROV operations undertaken in accordance with good industry practise (in relation to hydraulic fluid control)
DPD-MA96	Chemical storage areas designed to contain leaks and spills and inspected routinely
DPD-MA97	Chemicals will be managed in accordance with standard maritime practices as per vessel shipboard oil pollution emergency plan (SOPEP)
DPD-MA98	Spill clean-up kits available in high-risk areas
DPD-MA99	Bunding/secondary containment

MA reference	Management Action
DPD-MA100	Vessel-specific bunkering procedures and equipment consistent with Santos marine vessel vetting requirements including: + Use of bulk hoses that have quick connect 'dry break' couplings + Correct valve line-up + Defined roles and responsibilities, and the specific requirement for bunkering to be completed by trained personnel only + Visual inspection of hoses prior to bunkering to confirm they are in good condition + Testing of the emergency shutdown mechanism on the transfer pumps + Assessment of weather/sea state + Maintenance of radio contact with Vessel during bunkering operations + Bunkering checklist Visual monitoring during bunkering Marine Order 91 – Marine Pollution Prevention: Oil
DPD-MA101	Vessel equipped and crewed in accordance with Australian maritime requirements
DPD-MA102	Safety exclusion zone around DPD Project vessels and Notice to Mariners will be issued for offshore works advising all major shipping traffic formally.
DPD-MA103	No intermediate fuel oil (IFO) or heavy fuel oil (HFO) will be used in activity vessels working inside the Project Area
DPD-MA104	Implement tiered spill response as per DPD Project specific OPEP in the event of an MDO spill
DPD-MA105	Santos to make oil spill tracking buoys available on primary project vessel/s with Santos CSR/s and/or at local supply base for immediate deployment to assist with tracking of an oil spill
DPD-MA106	Trenching will only occur within pre-programmed areas (using standard positional accuracy measures used in the industry)
DPD-MA107	Exclusion zones programmed on all primary vessels associated with the works to clearly indicate no entry zones and nearby pipelines – this will clearly identify areas for spud placement, anchor positioning and trenching activities