View of an underwater pipeline.

Desktop First Nations Archaeological Assessment Summary Report

Darwin Pipeline Duplication Project, KP0–31

September 2024

Report prepared by

OzArk Environment & Heritage

for Santos

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OzArk acknowledge the Larrakia people of the area on which this assessment took place and pay respect to their beliefs, cultural heritage, and continuing connection with the land. We also acknowledge and pay respect to the post-contact experiences of Aboriginal people with attachment to the area and to the Elders, past and present, as the next generation of role models and vessels for memories, traditions, culture and hopes of local Aboriginal people.

GLOSSARY AND ABBREVIATIONS

AAPA	Aboriginal Areas Protection Authority
Aboriginal object	A physical manifestation of past Aboriginal activity. Typical examples include stone artefacts, grinding grooves, evidence of the occupation of Aboriginal rock shelters, midden shell, hearths, stone arrangements and other landscape features which derive from past Aboriginal activity.
Aboriginal site	The location where a person in the present day can observe one or more Aboriginal objects. The boundaries of a site are limited to the extent of the observed evidence. A 'site' does not include the inferred extent of unobserved Aboriginal objects (such as archaeological deposit). Different archaeologists can have varying definitions of a 'site' and may use the term to reflect the assumed extent of past Aboriginal activity beyond visible Aboriginal objects. Such use of the term risks defining all of Australia as a single 'site'.
BGP	Barossa Gas Project (BGP)
CEMP	Construction Environmental Management Plan
CHMP	Cultural Heritage Management Plan. Describes this document which is a requirement of the Environment Approval (EP2022/022-001) for the DPD Project. A CHMP both manages impacts to Aboriginal cultural and maritime heritage within approved disturbance areas.
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DFNAA	Desktop First Nations Archaeological Assessment
DLNG	Darwin Liquefied Natural Gas
DPD	Darwin Pipeline Duplication
Environmental Approval	For the DPD Project, this refers to Environmental Approval EP2022/022-001 under the EP Act or Environmental Approval (EPBC2022/09372) under the EPBC Act
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FNUFP	First Nations Unexpected Finds Protocol
GEP	Barossa Gas Export Pipeline
Heritage Act	*Northern Territory Heritage Act 2011*
KP	Kilometres along the pipeline corridor
LGM	Last Glacial Maximum (20,000 YBP)
NOPSEMA	National Offshore Petroleum Safety and Environment Management Authority
Northern Territory	NT
NTA Act	*Native Title Act 1993*

NT EPA	Northern Territory Environment Protection Authority
NT EP Act	*Environment Protection Act 2019* (NT)
NT coastal waters	NT waters between the TSB and the boundary of NT and Commonwealth waters 3 km offshore from the TSB
Pipeline corridor	The corridor within which seabed disturbance from the laying of the pipeline and supporting infrastructure may occur (nominally a ~50 m wide corridor)
PPUCH	Protocol for Protecting Underwater Cultural Heritage
Project Area	An area including approximately 2 km either side of the pipeline corridor
Santos	Santos Australia Pty Ltd
the Guidelines	Assessing and Managing Impacts to Underwater Cultural Heritage in Australian Waters. Guidelines on the application of the *Underwater Cultural Heritage Act 2018*, DCCEEW 2024.
TSB	Territorial sea baseline
UCH Act	*Underwater Cultural Heritage Act 2018*
UFP	Unexpected Finds Protocol
YBP	Years Before Present

CONTENTS

Figures

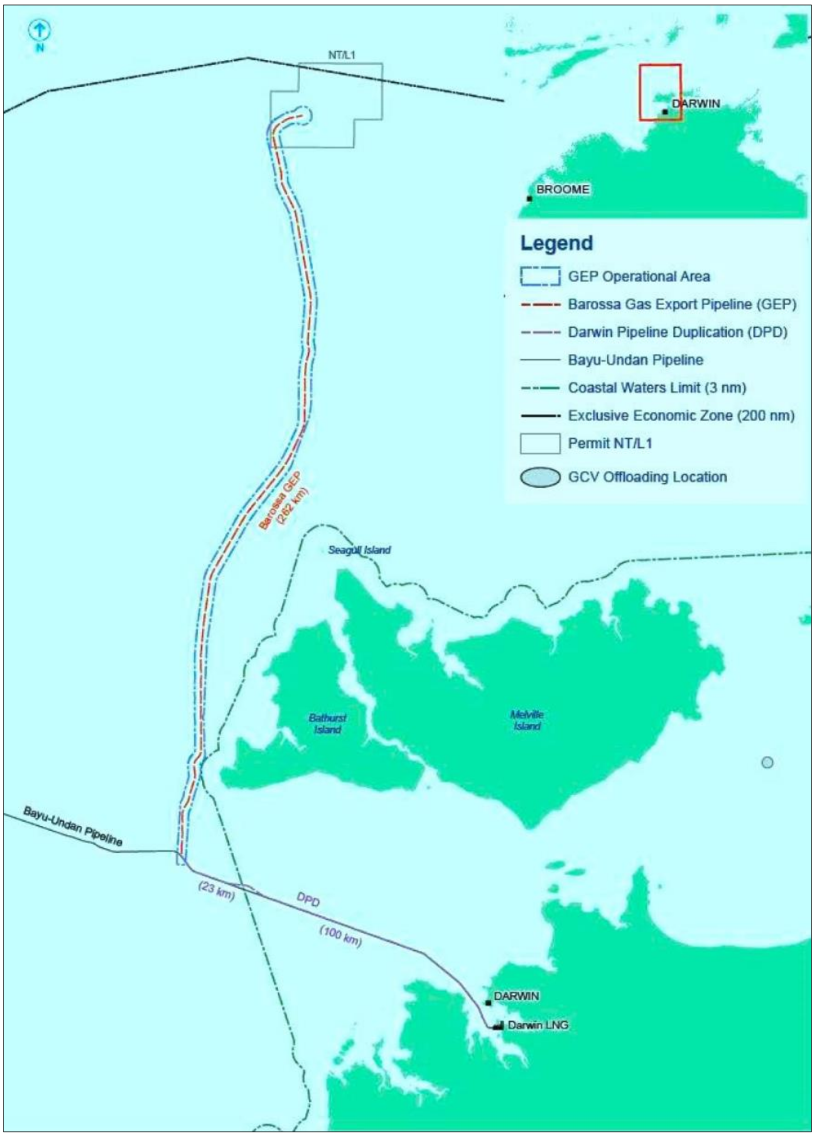
Tables

1 INTRODUCTION

OzArk Environment & Heritage (OzArk) has been engaged by Santos (the proponent) to prepare a summary of the Desktop First Nations Archaeological Assessment report (DFNAA, OzArk 2024) which was prepared to inform the *Cultural Heritage Management Plan* (CHMP) and the *Protocol for Protecting Underwater Cultural Heritage* (PPUCH) for the Darwin Pipeline Duplication (DPD; the Project). This summary of the DFNAA has been requested to ensure a high-level understanding of the findings can be provided to government agencies without the need to redact sensitive First Nations heritage information. This summary is also specific to the northern section of the Project Area in Commonwealth and Northern Territory (NT) coastal waters.

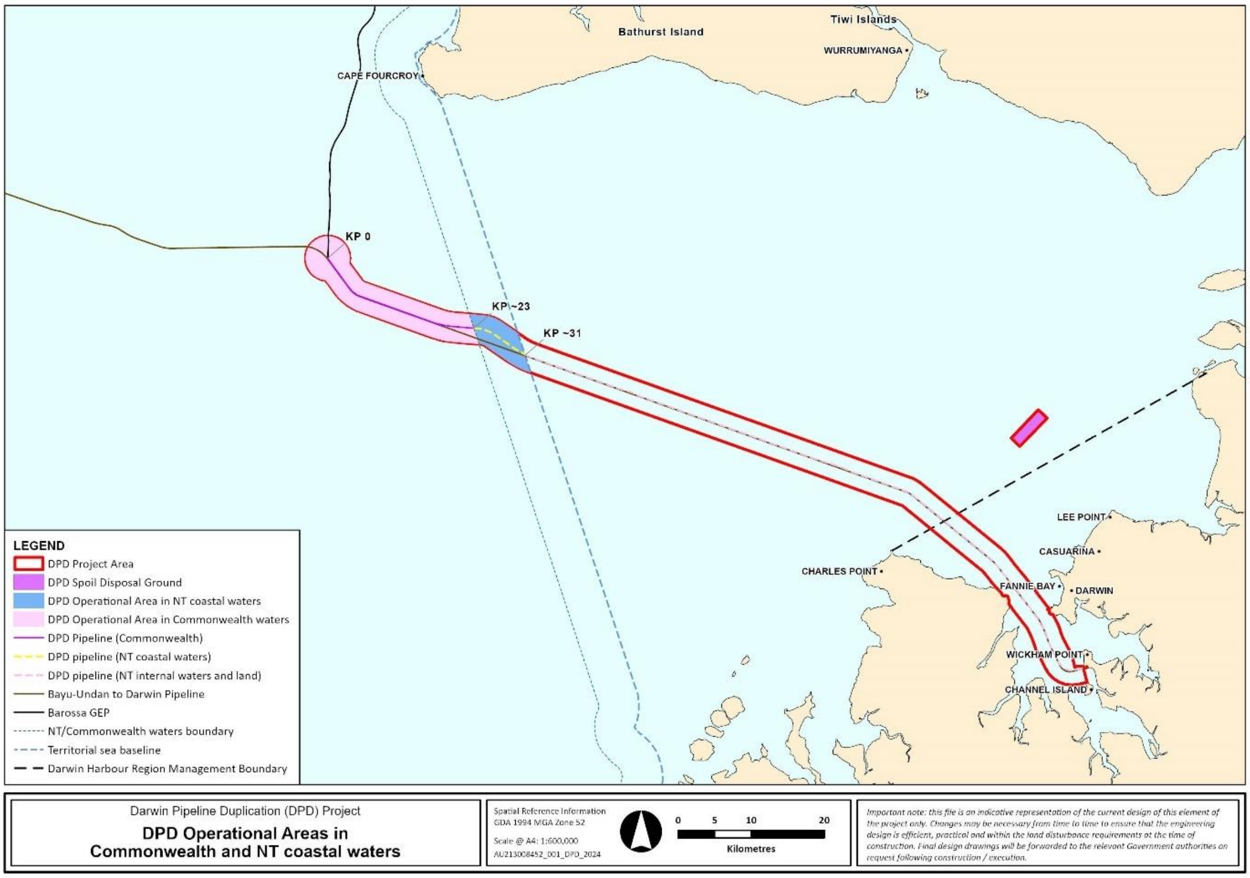
The DPD Project includes the installation of the DPD pipeline extending from the southern extent of the Barossa Gas Export Pipeline (GEP) to the Darwin Liquified Natural Gas (DLNG) facility at Wickham Point in Darwin Harbour (**Figure 1-1**), with greater detail shown on (**Figure 1-2**).

Figure 1-1: Regional context of the DPD Project.



This summary report has been prepared to specifically cover the pipeline corridor between kilometre point (KP)0 and KP31, in Commonwealth waters operational area and NT coastal waters operational area (**Figure 1-2**).

Figure 1-2: Map showing the Project Area, and specially the Commonwealth and NT coastal waters operational areas covered in this summary report.



1.1 PROJECT OVERVIEW

The DPD Project comprises construction, commissioning, operation, and decommissioning of the DPD pipeline. The DPD pipeline extends from the end of the GEP to the existing DLNG facility (**Figure 1-2**) inclusive of approximately 23 kilometres (km) in Commonwealth waters and approximately 8 km in NT Coastal Waters, comprising KP0–23 and KP23–31, respectively. Construction of the pipeline between KP0 and KP31 will include:

- Pipe laying, and installation of associated infrastructure, will occur within a corridor of approximately 50 metres (m) termed the pipeline corridor, generally parallel and for the most part approximately 50–100 m from the existing Bayu-Undan pipeline between KP0–KP31, noting that within the NT coastal waters operational area (**Figure 1-2**) this distance increases to a maximum of approximately 1.5 km

- For the purposes of the current report, the following definitions are used:

- Project Area - An area including up nominal 2 km buffer either side of the pipeline route between KP0–31 which includes the Commonwealth waters operational area (KP0–23) and a NT coastal waters operational area (KP23–31) (**Figure 1-2**)
- Pipeline corridor - The corridor along the pipeline route within which impacts from the laying of the pipeline and installation of supporting infrastructure may occur between KP0–31 (nominally a ~50 m wide corridor centred on the pipeline).

2 ENVIRONMENTAL CONTEXT OF THE PROJECT AREA

As the Project Area extends along the sea floor of the Timor Sea, approximately 122 km northwest of Darwin Harbour, and travels in a southeasterly direction through the Beagle Gulf it is necessary to understand the nature of the marine environment in which the north-western part of the Project Area, comprising KP0–31, is located.

2.1.1 Marine landscapes

At the time of the Last Glacial Maximum (LGM) approximately 20,000 years ago, the entirety of the Project Area would have been aerially exposed, i.e. terrestrial, and hence would have had potential to have been occupied / utilised by First Nations people.

As sea levels have risen in the subsequent millennia, these landscapes have been transformed by sub-sea geomorphological processes and tidal forces.

At the northern-most extent of the DPD, where the pipeline connects to the Barossa GEP, the ocean floor is approximately 54 m deep, and the sea floor contains up to 20 m of sediments. These sediments consist of easily displaced sands and gravels which form sub-aqueous dunes and tidal bars.

The formation and transformation of the sea floor within the pipeline corridor from KP0–31 is discussed at greater length in **Section 5.1**.

3 ETHNOGRAPHIC CONTEXT

ABMC Consulting prepared a First Nations ethnographic assessment for the DPD Project, which includes a detailed First Nations ethnographic and historical background for Darwin focussing on the Project Area (ABMC 2024). From this, due to privacy and the sensitive nature of the collated data, ABMC Consulting prepared a publicly available summary report.

For the purpose of this archaeological summary report, we refer the reader to the ABMC 2024 summary report for a more tailored and detailed understanding of the First Nations ethnographic and cultural heritage context.

4 THE ARCHAEOLOGICAL ASSESSMENT

4.1 RELEVANT LEGISLATION

Cultural heritage is managed by several state and national Acts. Baseline principles for the conservation of heritage places and relics can be found in the Burra Charter (Burra Charter 2013).

Several Acts of parliament provide for the protection of heritage at various levels of government.

4.1.1 Commonwealth legislation

4.1.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), administered by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW), provides a framework to protect nationally significant flora, fauna, ecological communities, and heritage places. The EPBC Act establishes both a National Heritage List and Commonwealth Heritage List of protected places. These lists may include Aboriginal cultural sites or sites in which First Nations people have interests. The assessment and permitting processes of the EPBC Act are triggered when a proposed activity or development could potentially have an impact on one of the matters of national environment significance listed by the Act. Ministerial approval is required under the EPBC Act for proposals involving significant impacts to national/commonwealth heritage places and to the environment in a Commonwealth marine area.

Applicability to the Project

It is noted there are no Commonwealth or National heritage listed places within the Project Area, and as such, the specific heritage provisions of the EPBC Act do not apply to the Project.

The DPD Project (in both Commonwealth and NT waters and land) was referred to DCCEEW under the EPBC Act (EPBC 2022/09372) and determined to be a controlled action on 6 December 2022. Reasons for the controlled action were listed as being in relation threatened species and communities, migratory species, and the Commonwealth marine area. Heritage was not listed as a basis for the controlled action decision. The DPD Project was approved by a delegate of the Minister for Climate Change, Energy, the Environment and Water under the EPBC Act on 15 March 2024.

4.1.1.2 Aboriginal and Torres Strait Islander Heritage Protection Act 1984

The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* is aimed at the protection from injury and desecration of areas and objects that are of significance to Aboriginal Australians. This legislation has usually been invoked in emergency and conflicted situations.

Applicability to the Project

There are no declared areas which apply to the DPD Project.

4.1.1.3 *The Underwater Cultural Heritage Act 2018*

The *Underwater Cultural Heritage Act 2018* (UCH Act) replaced the *Historic Shipwrecks Act 1976* (Cth) and extends protection to other wrecks such as submerged aircraft and to human remains.

The UCH Act protects the heritage values of vessels and aircrafts and the remains of vessels and aircrafts that are in Commonwealth waters. Heritage items that have been in Commonwealth waters for at least 75 years is automatically protected, while other heritage items can be declared to be protected by the Minister. It is an offence to interfere with heritage items covered by this Act.

Key obligations include:

- Not disturbing protected underwater heritage during the course of a proposed action without a permit
- Observing the requirements of protected zones and obtaining a permit to enter one if required
- Notifying of the discovery of any suspected underwater heritage identified during the course of proposed action within 21 days of discovery.

The recently prepared document (June 2024), *Assessing and Managing Impacts to Underwater Cultural Heritage in Australian Waters Guidelines on the application of the Underwater Cultural Heritage Act 2018* (the Guidelines, DCCEEW 2024) was issued to provide guidance to proponents undertaking works in Commonwealth waters. They outline the requirements of the UCH Act, but also go beyond this to provide a framework for the identification, assessment, and management of risk in relation to potential impact to underwater cultural heritage.

Applicability to the Project

As the DPD Project has potential to encounter underwater cultural heritage, this Act applies to the DPD archaeological assessments, both First Nations and Maritime (OzArk 2024 and Cosmos Archaeology 2022 and 2023).

The Guidelines framed the approach to the assessment undertaken for the DFNAA.

4.1.1.4 *Native Title Act 1993*

The *Native Title Act 1993* (NTA Act) states that Native Title is "*the communal, group or individual rights and interests of Aboriginal people and Torres Strait Islander people in relation to land and waters, possessed under traditional law and custom, by which those people have a connection* *with an area which is recognised under Australian law*" (Section 223 NTA) (National Native Title Tribunal 2016).

The NTA Act establishes the processes to determine where Native Title exists, how future acts impacting upon Native Title land may be undertaken, and to provide compensation where future acts extinguish or are inconsistent with the existence or exercise of Native Title. The Act gives Indigenous Australians who hold Native Title rights and interests (including Native Title claims) the right to access and use traditional lands, be consulted and, in some cases, to participate in decisions about activities proposed to be undertaken on the land.

<u>Applicability to the Project</u>

A search of the Native Title Register indicated that there are no Native Title claims or determinations of Native Title in the Project Area.

4.1.1.5 Aboriginal Land Rights (Northern Territory) Act (1976)

The *Aboriginal Land Rights (Northern Territory) Act* (1976) changed Aboriginal reserves within the Northern Territory to freehold title held in trust. The Act mandated the formation of Land Councils to act in the interests of Northern Territory Aboriginal people in the areas of land, access to lands, employment, and the development of businesses. The Act also defined Sacred Sites as '*sites that are sacred, or otherwise significant, in the Aboriginal Tradition*'. The Act protects these sites from damage, whether accidental or intentional.

<u>Applicability to the Project</u>

The definition of Sacred Sites from this Act has formed the basis of the NT *Aboriginal Sacred Sites Act 1989* discussed in **Section 4.1.2.2**.

4.1.1.6 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2023)

The *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023* (Cth) (OPGGS(E)R) require a titleholder to ensure an environment plan is in place for petroleum activities. An environment plan must, amongst other things, describe the environment that may be affected by the activity, the values and sensitivities of the environment, environmental impacts and risks of the activity and environmental performance outcomes and standards. The definition of 'environment' includes heritage places and the cultural features of the environment.

<u>Applicability to the Project</u>

The OPGGS(E)R apply to the DPD Project in both Commonwealth and NT coastal waters and therefore the environment plans being developed for the DPD Project, including the pipeline installation and associated activities in Commonwealth and NT coastal waters operational areas, will seek approval under the OPGGS(E)R.

4.1.2 State legislation

4.1.2.1 Northern Territory Environment Protection Act 2019

The process for environmental impact assessment of development proposals in the NT is legislated under the *NT Environment Protection Act 2019* (NT EP Act). The NT EP Act replaced the *Environmental Assessment Act 1982* on 28 June 2020.

Environmental impact assessment allows the Northern Territory Environment Protection Authority (NT EPA) to analyse the significant potential environmental impacts of a development proposal, and make recommendations to the Minister about the acceptability, or otherwise, of those potential environmental impacts.

Environmental impact assessment is only required if the NT EPA decides that the proposal has the potential to have a significant impact on the environment.

The objects of the Act are:

- to protect the environment of the NT
- to promote ecologically sustainable development so that the wellbeing of the people of the NT is maintained or improved without adverse impact on the environment of the NT
- to recognise the role of environmental impact assessment and environmental approval in promoting the protection and management of the environment of the NT
- to provide for broad community involvement during the process of environmental impact assessment and environmental approval
- to recognise 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 Aboriginal people and communities in environmental decision-making processes.

<u>Applicability to the Project</u>

The DPD Project in NT coastal waters was referred and approved under the NT EP Act and is the subject Environment Approval EP2022/022-001, issued by the Minister for Environment, Climate Change and Water Security on 22 December 2023. This approval includes conditions relevant to cultural heritage.

4.1.2.2 Aboriginal Sacred Sites Act (1989)

The NT *Aboriginal Sacred Sites Act 1989* protects sites that are '*sacred and otherwise of significance in the Aboriginal Tradition*'. The Act uses this definition of sacred in its purpose of protecting these sites outside of Land Trust lands. Sacred sites are protected whether the location of the site is known or not by any person or company seeking to do work on lands.

The Act is administered by the Aboriginal Areas Protection Authority (AAPA) who are responsible for overseeing the protection of Aboriginal sacred sites on land and sea across the NT. AAPA conducts sacred site surveys with the relevant site custodians, then issue Authority Certificates under the Act.

AAPA protects Aboriginal sacred sites through:

- Sacred site avoidance surveys and the issuing of Authority Certificates for any proposed development
- The provision of information to the public about existing sacred sites data through abstracts of Authority records and access to the Registers maintained by the Authority
- The registration of Aboriginal sacred sites (AAPA 2022).

The Authority can issue a Certificate authorising any proponent for works in an area upon application and payment of a fee. The Certificate will contain conditions limiting or preventing works in and around registered and recorded Sacred Sites. The Authority Certificate will contain maps outlining any restricted work areas within the area of application.

<u>Applicability to the Project</u>

Santos applied to AAPA for an Authority Certificate to cover an area nominally 1 km either side of the pipeline route within NT waters. This includes KP23–31 in the NT coastal waters operational area. A certificate was issued – C2022/098 – with a suite of conditions to ensure the protection of sacred sites present in Darwin Harbour. This certificate will be briefly discussed further in **Section 4.6**.

4.1.2.3 Northern Territory Heritage Act (2011)

The *Northern Territory Heritage Act (2011)* (Heritage Act) came into effect on 1 October 2012. The Act provides protection for the same classes of places as the previous NT *Heritage Conservation Act 1991*, with some changes. As under the previous Act, members of the community can nominate areas, places, sites, buildings, shipwrecks, and heritage objects to the register. If the Minister agrees that these features are of special significance to the heritage of the NT, the place is added to the register and receives statutory protection. The Act allows for processes to approve works and maintenance for a heritage place. As under the previous Act, the *Heritage Act* provides a 'blanket' or 'presumptive' protection for Aboriginal and Macassan archaeological places and objects until a decision by the Council advising the Minister to either permanently protect these places or permit their disturbance or destruction. This decision-making process is triggered by an application to disturb these places. There are penalties for accidental or deliberate destruction of these sites.

The policy developed from the Heritage Act includes the following in relation to Aboriginal archaeological places and objects:

- Aboriginal explanations about the meaning and significance of places must be acknowledged

- Aboriginal people have the right to be involved in decision making concerning these places
- Traditional Owners (and Site Custodians) must be:
  - Told of the intent to carry out archaeological survey work or research
  - Involved in the field work if possible
  - Consulted about the progress and told of the findings and recommendations
  - Acknowledged for their contribution.

4.2 Purpose and Objectives

The purpose of the DFNAA was to identify and assess First Nations archaeological sites that may be relevant to the DPD Project such that they could be appropriately managed. If First Nations archaeological deposits were identified as likely within the pipeline corridor during the desktop study, further detailed investigations by a maritime archaeologist would have been considered. As noted earlier, this summary is only relevant to KP0–31 of the Project Area.

The study applied the relevant Commonwealth and NT legislation as required, as well as the Guidelines, in the completion of the DFNAA, meeting the following objectives:

Objective One: Undertake background research on the Project Area to formulate a predictive statement for site location within the submerged landforms, including from KP0–31 of the DPD.

Objective Two: Identify First Nations archaeological values of the Project Area. This includes Aboriginal objects, any landforms / sediments likely to contain archaeological deposits, and/or places of significance[1].

Objective Three: To assess the significance of any identified First Nations archaeological objects or sites.

Objective Four: Assess the likely impacts of the proposed work to First Nations archaeological values and provide management recommendations.

4.3 OzArk Involvement

4.3.1 Reporting

This summary report of the DFNAA was prepared by:

- Dr Jodie Benton (OzArk Director and Principal Archaeologist)

[1] It is of note that the Aboriginal cultural values assessment prepared by ABMC Consulting reports on intangible values / places, although it is acknowledged that the tangible and intangible values are often inextricably linked, so there may be areas of overlap.

- Reviewer: Ben Churcher (OzArk Principal Archaeologist).

4.4 MARINE ARCHAEOLOGICAL CONTEXT

The pipeline between KP0–31 will be laid on the sea floor and consequently it is important to understand the nature of the modern sea floor along this section of the pipeline corridor.

As introduced in **Section 2.1.1**, the pipeline corridor crosses the continental shelf comprising landforms that were terrestrial likely from at least 65,000 years ago, having been last exposed during the LGM about 20,000 years a years before present (YBP). It is considered highly likely that First Nations people would have utilised these terrestrial landscapes much as they are known to have utilised the rest of the NT over the past 20,000 years, which is evidenced in a large body of archaeological and ethnographic research. It is also surmised that the continental shelf of Australia is likely to have witnessed the first landing of modern humans onto the Australian continent. Overall, however, our understanding of the now-submerged archaeology of the Australian continental shelf is quite underdeveloped and our scientific understanding of the possible distribution of submerged sites, their chronology, preservation, and overall potential is very limited (Wessex 2023).

To some extent this is because submerged First Nations archaeology on the Australian continental shelf is a relatively new field of endeavour, with the nature of the tides, currents, and depths being a significant impediment to field investigations at many places. Further, those same tides, currents, and weather events, combined with trawling, and have transformed the sea floor since the initial disturbance of sea level rise in ways that are likely to have seriously impacted potential First Nations archaeological material, if present. This doesn't mean that there will not be localised submerged environments within which archaeological material is preserved, for example in areas close to the current coastline, potentially where stone rather than sediments form the shoreline, or in areas where there is protection from wave action and currents. The preservation potential in the open waters of the Project Area, is almost certainly less favourable.

To support the archaeological assessment presented in this report, the investigation has relied heavily on a technical geomorphic assessment of the seabed along the pipeline corridor[2]. This assessment is based on detailed bathymetry, augmented by other forms of sonar and imaging along the corridor. The results of this for KP0–31 will be interpreted in **Section 5.1**. To provide some context for the submerged landscapes and their archaeological potential, the results of the geomorphological and archaeological assessments for the Barossa GEP are presented below.

[2] It is noted that the OzArk team do not possess technical geomorphological credentials and we do not attempt to scientifically critique the geomorphological assessments presented here.

4.4.1 Geology and archaeology: submerged landscapes of the continental shelf (Harff et al. 2015)

This article largely focusses on the consequences of sea level change and its influence on human population, pattens of occupation, and its distorting effect on the archaeological record since prehistoric times. Sea level changes would have had profound effects on patterns of cultural and biological interaction, past social and economic organisation, and in the creation of new opportunities for territorial expansion (when sea levels dropped), or for removing formerly productive hunting grounds and disrupting lines of communication (when sea levels rose) (Harff et al. 2015).

Harff summarises Nutley regarding the question of how archaeological sites may be deformed or destroyed by the process of inundation. Terrestrial landforms such as rock shelters are more likely to contain archaeological material as they are known to provide appealing locations for human activity and to preserve stratified deposits (Nutley et al. 2014). Stone fish traps are also noted as features with greater potential to survive inundation and their potential location can be estimated using the mapping of underwater stream channels. An investigation of twelve submerged rock overhangs off the south-eastern coast of Australia is used as an example and while no excavation of these submerged landforms has been conducted due to logistical constraints, their location provides an instructive sample of predictive modelling based on known terrestrial site types to target submerged archaeological locations.

The report emphasises the increasingly multidisciplinary nature of the study of submerged landscapes and the requirements of ongoing collaboration between geosciences and archaeology.

4.4.2 Barossa Field Seafloor Depositional Environment (Posamentier 2023a)

This report discusses the evolution of the seafloor along the Barossa GEP, which overlaps with the northernmost extent of the pipeline corridor, from the LGM to the present. The report outlines the known rate at which the shoreline retreated as a result sea level rise and breaks this process into three distinct phases.

At 20,000 YBP sea levels were approximately 120 m lower than today. The first phase of shoreline transgression begins between 18,000 and 12,000 YBP at a relatively slow rate. Between 12,000 and 10,000 YBP, shoreline progression accelerated, reaching up to 18 m per year at its highest rate of transgression. This process then slowed significantly between 10,000 and 8,000 YBP at which time the sea level reached its present-day position. Posamentier explains that the rate at which the shoreline migrates landward in response to sea level rise is highly dependent on the gradient of the continental shelf.

The erosion and deposition effects on the newly submerged sea floor are then reviewed in detail. Strong tidal currents, wave action associated with tropical cyclones, sediment plumes, and winnowing processes, are all discussed and conclusions regarding the impact of these processes on the preservation or destruction of archaeological material on the modern-day sea floor beneath the Barossa GEP are presented. Overall, it is noted that the seafloor was subject to erosive processes such as wave action and tidal currents, which can displace up to 5–10 m of sediment, which are then redeposited elsewhere as blanket sediments or channel fills. Posamentier concludes that any archaeological material present on the land surface of the LGM would have been eroded by waves or tidal currents during transgression and is not likely to have been preserved. Subsequently, during the time of shoreline transgression (18,000–8,000 YBP) and later, when sea-level was at its current position (8,000 YBP to present), this erosional surface was layered over by carbonates and thin fine-grained sediments caused by sediment plumes, as well as coarse-grained sediments from re-deposition. As a result, the topography of the modern seafloor has been modified to varying degrees and is now unrecognisable when compared to the LGM when it was an exposed alluvial plain.

4.4.3 Barossa Gas Export Pipeline (Wessex Archaeology 2023a and b)

Wessex Archaeology (2023a) completed an assessment of the submerged palaeolandscapes of the Barossa GEP project, which overlaps with the northernmost extent of the pipeline corridor. The technical report focusses on the submerged and buried landforms on the sea floor along the Barossa GEP and their potential to retain First Nations archaeological material.

The assessment utilised highly specialised primary geophysical and geotechnical data and devoted multiple chapters to analysing and assessing this data. Of eight datasets, only three are considered ‘good,’ meaning the data is highly reliable, whereas one dataset was classed as ‘average’ and four ‘variable,’ meaning parts of the datasets were more reliable than others. Archaeological features were identified as having archaeological potential if they were assessed as able to preserve paleoenvironmental or archaeological data about past land use by First Nations people.

Ethnohistoric review of First Nations communities in the nearby Tiwi Islands and the NT coast more broadly, indicated substantial use of coastal areas near freshwater sources and seasonal occupation towards foothills located further from the coast. It also demonstrates the centrality of marine environments to the overall worldview of these people.

The desktop terrestrial archaeological assessment, undertaken for the purpose of predictive modelling, covered an area of 40 million hectares encompassing the Tiwi Islands, Arnhem land, Darwin/Daly/Wagait, Katherine, and Ngukurr regions, and included other offshore islands. The results demonstrated continuous occupation of this landscape through the late Pleistocene period (50–11.7 thousand YBP) and Holocene periods (11.7 thousand YBP to the present).

The report combines both the ethnohistoric and archaeological desktop review and geophysical data to create a predictive model for the location of First Nations archaeological material along the Barossa GEP. Conclusions included:

- Settlement concentration increases in proximity to freshwater sources as earth mounds of Holocene origin are consistently located near bodies of freshwater
- Stone arrangements can be preserved in marine environments due to lithification processes
- Submerged paleochannels, former shorelines, and dune systems are considered to have high archaeological potential
- The region west of the Tiwi Islands would have been appealing locations for First Nations occupation when sea levels were lower (20,000–8,000 YBP).

As a result of their study, 60 P1 (high archaeological potential) features and 103 P2 (medium archaeological potential) features were documented, but no sediments of high archaeological potential could be definitively identified due to the scientific limitations relating to contextual, geophysical, and geotechnical data. What the study was able to conclude was that the palaeolandscape west of the Tiwi islands was a complex system of river channels 50,000 years ago, with available fresh water and diverse food resources to support human populations. Based on modelling and ethnohistory it is likely these areas were occupied, however, our ability to model / predict where such physical evidence may survive, remains limited.

As a result of the study, Wessex Archaeology (2023b) did not define any specific Archaeological Exclusion Zones in reference to the Barossa GEP. They did recommend that any future geophysical / geotechnical survey work should involve an archaeological contractor from the outset, such that the location, type, and number of sample locations is more suitable for archaeological interpretations. They further recommended that a protocol for archaeological discovery be established in case any archaeological material was encountered during pipeline works.

4.4.4 Analysis of Features Identified in the Wessex Report (Posamentier 2023c)

Posamentier responded to the results of Wessex Archaeology (2023 a and b) and reviewed each of the 163 features identified. He concluded that 96 features were formed sub-aqueously, after flooding of the LGM surface, so no habitation of this surface would have ever occurred, and consequently consideration of the preservation potential for archaeological objects within these seafloor features was not warranted.

The other 67 features in the vicinity of the pipeline route had been subject to the geological processes described above in **Section 4.4.2**, being erosional forces such as shoreface and storm wave erosion and tidal currents, immediately post-LGM, and then later overlain and mantled (i.e., blanketed) by sediments (ABMC 2023). Consequently, erosion, sedimentation, and carbonate growth, which characterises post-LGM time, would likely have modified to varying degrees the original LGM topography (i.e., the landforms) from its earlier subaerially exposed character.

4.5 DESKTOP DATABASE SEARCHES CONDUCTED

A desktop search was conducted on the following databases to identify any previously recorded Aboriginal sites within the Project Area. The results of this search, as they are relevant to KP0–31, are summarised in **Table 4-1**. A search of the NT Archaeological Database was also undertaken, but no results were retrieved for the KP0–31 pipeline corridor section.

Table 4-1: First Nations cultural heritage: desktop-database search results.

Name of Database Searched	Date of Search	Type of Search	Comment
Commonwealth Heritage Listings	23/2/24	Litchfield Municipality LGA	No places listed on either the National or Commonwealth heritage lists are located within the Project Area KP0–31.
National Native Title Claims and Determinations Search	23/2/24	NT	No Native Title Claims or Determinations that Native Title exists that cover the Project Area KP0–31.

4.6 SACRED SITES

There are many sacred sites within Darwin Harbour and the surrounding waters. In coastal and sea areas, sacred sites may include features which lie both above and below the water. As introduced in **Section 4.1.2.2**, AAPA is responsible for overseeing the protection of First Nations sacred sites on land and sea across the NT. This includes the section of the pipeline corridor in NT coastal waters between KP23–31, that is partly the subject of this summary report.

Santos received an Authority Certificate from AAPA on 23 December 2022 (C2022/098) which covers an area nominally 1 km either side of the pipeline route in the Project Area. This certificate covers the Project Area between KP23 and the Darwin Liquid Natural Gas Plant (DLNGP). A second certificate was issued in 2023 for minor project variations but is not relevant to the Project Area between KP23–31 and so will not be discussed further.

4.6.1 AAPA Certificate 2022/098

Authority Certificate C2022-098 did not identify sacred sites within the Project Area between KP23–31. Sacred sites identified on Authority Certificate C2022-098 are located considerably distant from the focus area of this summary report, being KP0–31, no further discussion of the recommendations made in the AAPA certificates has been included.

5 RESULTS OF THE ARCHAEOLOGICAL ASSESSMENT

The following sections summarise the results of the desktop archaeological assessment aimed at categorising the First Nations the archaeological potential of the Project Area. It is noted that this summary report does not include the assessment related to the terrestrial impact footprint, or that related to the pipeline corridor from KP31 into Darwin Harbour, as it is beyond the KP0–31 scope.

5.1 PIPELINE CORRIDOR – MARINE LANDSCAPE GEOMORPHOLOGICAL REVIEW

5.1.1 Introduction and brief methodology

The pipeline corridor extends from the connection with the Barossa GEP to the DLNG facility at Wickham Point. It follows the route of the existing Bayu-Undan pipeline to Darwin Harbour to the DNLG facility, always to the north or east of the Bayu-Undan pipeline by approximately 50–100 m for the most part, with the exception of a deviation at KP 20–30 where the pipeline corridor diverges to approximately 1500 m distant, and a section of the pipeline in Darwin Harbour where the pipeline corridor crosses the Bayu-Undan pipeline at two places. Archaeological assessment of the potential for the pipeline corridor to contain identifiable First Nations archaeological sites/deposits is based on a geomorphological assessment of the sea floor within the pipeline corridor prepared by Santos (2024), with reference to the other sea floor assessments for the Barossa GEP, reviewed in **Section 4.4**.

The objective of the Santos 2024 seafloor geomorphological assessment was to:

- Describe the present-day seafloor and shallow geological features imaged in the Fugro (2021) Barossa Pipeline to Darwin Shore Survey (as summarised in Santos 2024). This survey was a geophysical survey of the pipeline corridor using vessel-mounted and towed techniques, covering an investigation corridor of up to ~300 m wide. Data acquired includes:
  - High frequency, 2D seismic sub-bottom profiles (Boomer and Sparker source)
  - Multi-beam Echo Sounder and Sidescan Sonar bathymetry
  - Magnetometer.
- Integrated into the Santos (2024) study was data acquired in legacy seafloor site surveys, covering in part, or located in the immediate vicinity of the pipeline corridor. Most of this data was acquired during various stages of the Bayu-Undan pipeline project, which included:
  - High resolution bathymetry
  - High frequency, shallow, 2D seismic from other projects
  - Seafloor sediment grab and shallow core sample descriptions, and associated laboratory analysis

  - Site survey reports.

5.1.2 Background marine conditions

A brief description of the maritime characterises of the Timor Sea is as follows (Santos 2024):

Timor Sea

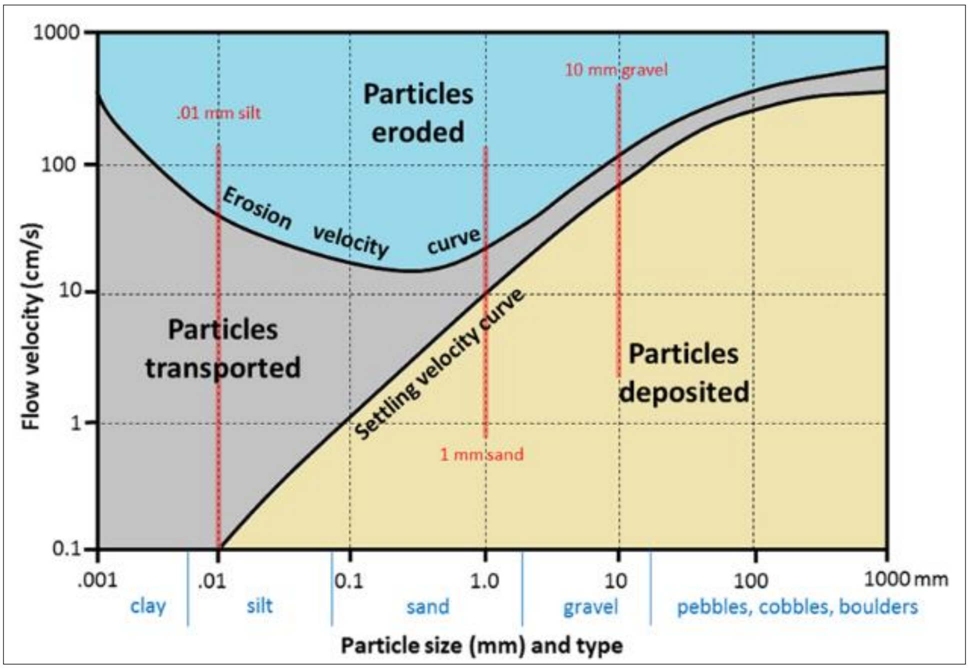
- The Timor Sea is a relatively narrow seaway, just 300 km at its narrowest between the Tiwi Islands and the Timor-Leste archipelago
- Shallow waters (<100 m) extend 100 km offshore to the Australian continental margin before plummeting into the Timor Trough at approximately 250 km offshore, reaching a depth of over 2,000 m
- Warm surface waters are responsible for generating regular cyclonic activity in summer months, and producing conditions that modify the seafloor across the entire continental shelf.

The entire pipeline corridor is subject to strong tides, generating high-velocity bottom currents averaging 60 centimetres (cm)/second and locally, exceeding 100 cm/second (Griffin et al. 2021, as reported in Santos 2024). In relation to sediment movement, this means:

- Fine-grained particles (clay-silt) will only be deposited during slack water (low and high tide maxima)
- During peak tidal flow, particles up to “gravel” size can be eroded and transported
- Once exhumed, pebble or cobble-sized clasts can be transported (reworked) kilometres from their source.

The Hjulström-Sundborg diagram (**Figure 5-1**) shows the relationships between particle size and the tendency to be eroded, transported, or deposited at different current velocities, after Hjulstrom 1935.

Figure 5-1: Hjulström-Sundborg diagram showing the relationships between particle size and erosional movement (after Hjulström 1935).



5.1.3 The geomorphological assessment

The approach to the assessment overlaid the multiple datasets described above while progressively reviewing chainages along the pipeline corridor. This enabled the preparation of a spreadsheet summary as presented in **Appendix 1**, and included here as it is a primary source document for this assessment of archaeological potential. **Appendix 1 Figure 1** provides a montage stratigraphic section of the seafloor along the pipeline corridor and can be read in conjunction with **Appendix 1 Table 1**.

This assessment breaks the corridor into portions of like characteristics per relevant chainage (KP) and comprised review of the following features per chainage:

1. Water depth

   This provides an assessment of the minimum and maximum number of metres of water from the surface to the seabed relative to mean sea level. **Figure 5-2** provides a visual representation of water depth.

2. Seafloor morphology

   This assessment describes the appearance and characteristics of the pipeline corridor seabed as it appears today. The descriptors used include terms relevant to terrestrial landforms, such as valley, flat plain, mound, tributary etc., as well as terms relevant to the submerged nature of these features when they formed, such as sub-aqueous.

3. Seafloor sediments

Sediment sample descriptions refer to seafloor samples and core samples from legacy surveys, primarily relating to the Bayu Undan pipeline project, and are provided where relevant, together with a description of the surface sediments.

4. Contemporary subsea environment

   This describes the ocean energy classification for each chainage as well as the location in terms of classification (i.e. in relation to the shelf, harbour etc.) and the tidal characteristics.

5. Contemporary deposition processes

   This describes the dominant current forces at play in terms of sediment deposition and erosion in relation to tides and currents.

6. Sediment depth to LGM

   The assessment attempts to interpret the likely depth of sediment that covers what would have been the terrestrial land surface exposed at the LGM. References to coloured (blue etc.) 'surfaces' refers to a stratigraphic section map of the pipeline corridor, which is shown at the end of **Appendix 1**. No dating of sediment recovered from coring was obtained, so the position of the LGM is interpreted from stratigraphic geometries and is likely to be a maximum possible depth.

7. Subsurface stratigraphy

   From review of the subseafloor data available, this assessment attempts to interpret the likely stratigraphic sediments down to and beyond the LGM surfaces where feasible. Image quality and resolution of the 2D seismic profiles is dependent on many factors affecting the propagation of sound waves, notably water depth and lithology. Subsurface imaging deteriorates rapidly along the shallowest inboard section of the DPD survey.

8. Subsurface lithology

   In relation to the stratigraphy described above, this assessment aims to characterise the specific nature of the sediments identified.

9. Post-LGM depositional processes

   This assessment aims to identify the most likely process that have impacted / transformed the LGM terrestrial surface since inundation.

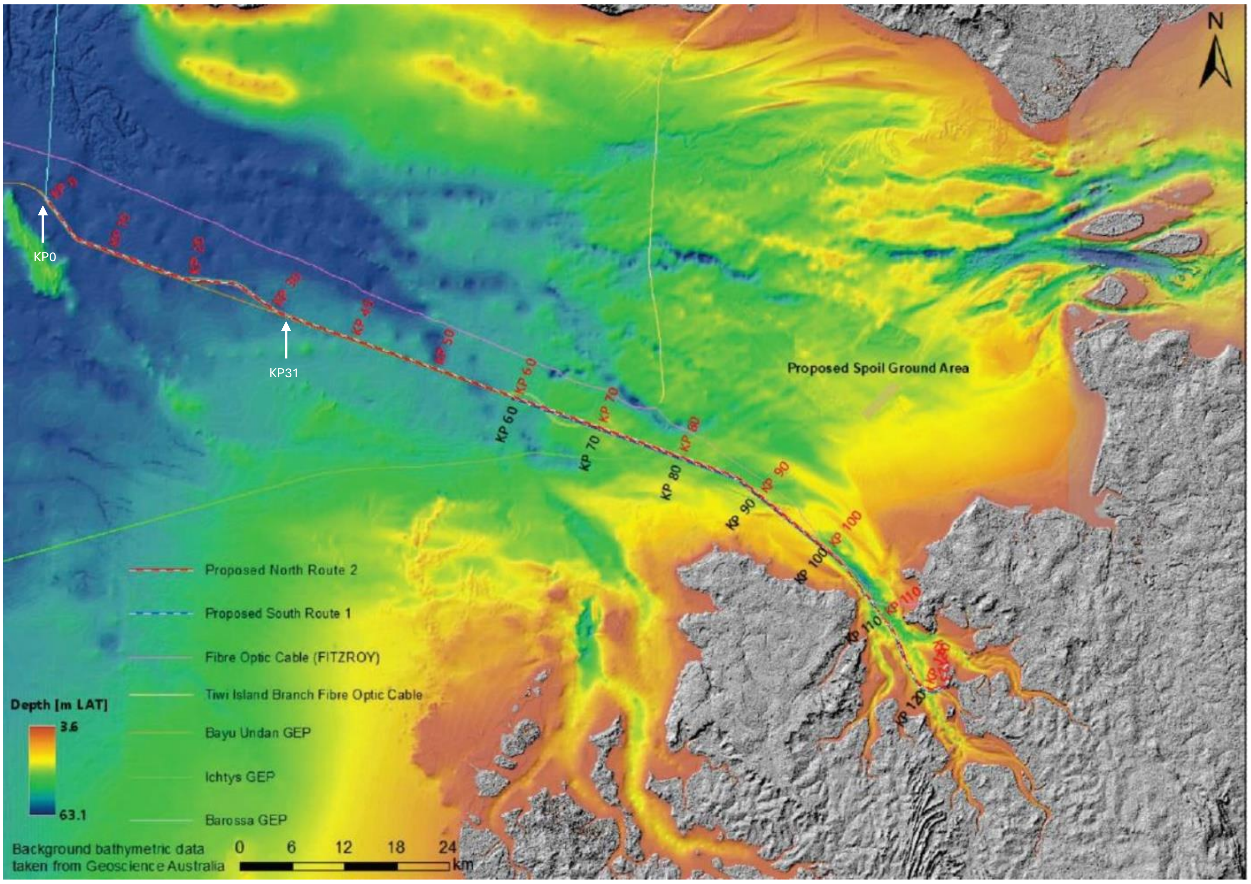
10. Preservation potential of sediments associated with the LGM.

    This assessment thread essentially provides a conclusion, per chainage section of the pipeline corridor, as to the likelihood for archaeological deposits associated with the LGM to be preserved. Sediment refers to all organic and inorganic materials transported and left in position by natural processes. A more detailed description of these categories is provided in **Table 5-1**.

All inferences to the likely preservation of archaeological artefacts related to the LGM are made at the discretion of OzArk, but it is noted that this relies on the assessed likelihood for sediments associated with the LGM to be present within the pipeline corridor.

This assessment uses a grading system for the likelihood of archaeological deposit preservation, from very high through to very low. A more detailed description of these categories is provided in **Table 5-1**.

Figure 5-2: Visual representation of water depths along the pipeline corridor.



5.1.4 Summary of the geological/ geomorphological considerations KP0‑31 (from Santos 2024)

- From KP0–KP40, which is deeper than 40 m below sea level, a relatively thin wedge of Quaternary sediment is preserved (<20 m thick)
  - The frequency of significant erosional unconformities in the stratigraphic sequence along this section suggests the strata have undergone multiple episodes of down-cutting (erosion).
- Numerous Quaternary channels are present, displaying complex, nested, cut-and-fill geometries, indicating they have repeatedly reactivated old channel pathways over multiple sea-level cycles.
- Likely Late Pleistocene and Holocene sediment is largely limited to:
  - KP0–40: Mud-dominated calcareous hemipelagic marine sediment; muddy coarse-grained siliciclastic sand and gravel, likely supplied by storm-induced currents then bioturbated; and carbonate sand and gravel produced in-place and/or delivered via bottom currents

5.1.5 Conclusions

5.1.5.1 Geomorphological conclusions

The following conclusions are from Santos 2024:

- The depositional history recorded along the pipeline corridor suggests a dynamic, relatively high-energy environment with either low sedimentation rates or net erosion during the Quaternary
- Lowstand fluvial incision followed by shoreline erosion during post-glacial transgression is indicated by multiple erosional unconformities in the near surface seismic stratigraphy
- Presently, strong tidal currents along the pipeline corridor are evidenced by the presence of large tidal bars and sub-aqueous dune sets. These consist of recycled coarse-grained sands and gravels eroded from siliciclastic bedrock and nearby carbonate factories, transported and concentrated
- It is unlikely that un-lithified sediments or clasts would remain *in situ* along the pipeline corridor since the LGM land surface was last exposed.

5.1.5.2 Conclusions re First Nations archaeological potential relating to the LGM

Review of **Appendix 1** in conjunction with **Table 5-1** enables the following summary points relevant to KP0–31 to be made:

<u>KP0–KP64</u>

- From KP0 to approximately KP64, the interpreted LGM surfaces are buried by sediments, most of which demonstrate significant reworking as a result of transgression, tides, currents. and storm action
- In general, the preservation potential for sediments associated with the LGM to be preserved between KP0–64 was assessed as low to very low (see **Table 5-1**) with one exception in the vicinity of KP36.4–KP37.9, which is beyond the focus of the current summary.

Table 5-1: Assessment categories used to describe the archaeological preservation potential of sediments along the pipeline corridor.

Grading	Description of preservation	Example terrestrial environment
Very High	Organic and inorganic objects of any size remain *in situ* or with little evidence of remobilisation or transportation. Little or no alteration of form by physical, chemical, or biological processes.	Arid terrestrial environment protected from aeolian, meteoric and fluvial processes, such as a cave.
High	Moderately hard organic objects (i.e. wood) of decimetre or larger size, and hard organic (i.e. bone) and inorganic objects of centimetre or larger size. Evidence of some remobilisation and transportation. Minor or surficial alteration by physical, chemical, or biological processes.	Low-energy an-oxic aquatic environment, such as lake, lagoon, swamp, or marsh providing rapid burial by clay-dominated sediment; or arid terrestrial aeolian system with rapid burial by migrating sand dunes.
Moderate	Moderately hard organic objects (i.e. wood) of metre or larger size, and hard organic objects (i.e. bone) of several centimetres or larger, or inorganic	Low-energy oxygenated fluvio-deltaic setting such as a back-barrier embayment or bayhead delta; or outer-shelf to upper-slope marine environment

Grading	Description of preservation	Example terrestrial environment
	objects of centimetre or larger size. Evidence of transportation and moderate alteration of form by physical, chemical, or biological processes.	with infrequent exposure to storm-induced bottom current processes.
Low	Hard organic objects (i.e. bone) of decimetre or larger size or indurated inorganic objects of decimetre or larger size. Evidence of significant remobilisation. Form is highly altered by physical, chemical, or biological processes.	Moderate-energy fluvial distributaries, tidal channels, or wave-dominated shallow marine environments where daily currents erode and transport particles of sand-size considerable distances; or shelfal marine environment with frequent exposure to storm-induced bottom current processes.
Very Low	Only indurated inorganic objects of decimetre or larger size. Evidence of significant remobilisation. Form very strongly altered by physical, chemical, or biological processes.	High-energy fluvial and tidal channels or wave-dominated shallow marine environments where daily currents erode and transport particles up to pebble-size considerable distances.

5.1.6 Pipeline corridor impact assessment

In summary, the only section of the pipeline corridor where potential sediments associated with the LGM were indicated was in the vicinity of KP36.4–37.9, where they are assessed likely to be at a depth of approximately 18 m below seafloor. At this depth, no activities related to the construction of the DPD Project will have any direct or indirect impact on these potential sediments.

There were no identified areas of archaeological potential between KP0–31.

6 RECOMMENDATIONS

The following recommendations have been summarised from OzArk 2024. They are relevant to KP0–31 of the pipeline corridor and are made based on the desktop assessment of the identified First Nations archaeological resource and sacred sites in relation to the likely impacts of the DPD Project in Commonwealth and NT coastal waters.

6.1 PIPELINE CORRIDOR

The desktop First Nations archaeological assessment of the submerged pipeline corridor between KP0–31 did not identify any locations which will be impacted by the DPD Project where First Nations archaeological material relating to the LGM is anticipated to be preserved, and hence there are no known impacts of the pipeline corridor to First Nations archaeology.

Nonetheless, in line with best practice and the precautionary principle, the following recommendations are made:

1. Ahead of pipeline laying, a survey should be undertaken of the pipeline corridor to identify in detail the characteristics of the seafloor, to ensure that the installation of the pipeline can be undertaken in a streamlined fashion and to identify any objects of interest. This survey comprises a number of optional data generating sources, including but not limited to, capturing video and still footage, side scan sonar, echosounder and multibeam data of the seafloor.
2. The First Nations Unexpected Finds Protocol (FNUFP) and the Protocol for Protecting Underwater Cultural Heritage (PPUCH) prepared for this DPD Project have been approved and the provisions contained within them should be applied to any unexpected heritage finds encountered.
3. The FNUFP and PPUCH should be provided to crews of vessels undertaking pre-lay survey and laying the pipeline.
4. All staff and contractors should undertake First Nations cultural heritage inductions to ensure they are aware of the legislative protection afforded to sacred sites and First Nations archaeology and to become familiar with the requirements of the FNUFP and the PPUCH.

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APPENDIX 1: PIPELINE CORRIDOR GEOMORPHOLOGICAL ASSESSMENT

This snapshot provides a brief review of the geomorphological assessment approach used in the pipeline corridor assessment in terms of use of the varying data sets. This has been summarised to contain just the relevant data for KP0–31 of the pipeline corridor.

- Loaded data to *Petrel* (geophysical and geological interpretation software) (Projection and datum: *GDA94 MGA Zone 52 CM 129 E*)
  - Gridded bathymetry point data, then created dip-angle surface products.
- Interpreted seabed features of the *2010/2011 Matthew Flinders* data.
  - Ground-truthed interpretations with seabed samples and intergrated observations from legacy surveys.
- Categorised seafloor into facies types, based on:
  - Depth
  - Dip angle and texture
  - Geometry
  - Sediment samples

Six Facies Scheme

A. Tidal bars
B. Muddy seafloor
C. Sub-aqueous dunes
D. Hard organic sea floor
E. Hard clastic sea floor
F. Hard clastic incised sea floor

- Made conclusions about the primary depositional processes.
- Interpreted the Fugro *2005* and *2021* bathymetry grids.
  - Note; using both greatly increased the ability to interperet seafloor features accurately (300m corridor is insufficient for analysing km-scale features i.e. sub-aqueous dune field vs beach ridges).
- Identified seafloor features and sediment types, and categorised into the Facies scheme.
- Interpreted the *2021 Fugro* high-frequency shallow 2D seismic (boomer only), identifying:
  - Major erosional or disconformity boundaries (including channels)
  - Structural elements (faults and angular unconformities) and
  - Defined gross relative chronostratigraphic packages
- Made conclusions/comments about the geology and the recent deposition history relative to the seafloor processes that have prevailed along the proposed DPD route.

Definitions

sub-aqueous dune: A mound or ridge of unconsolidated, usually sand-sized sedimentary particles, formed by the action of a fluid medium which may be wind or water.

- sub-aqueous dunes are larger bedforms than ripples and are formed at higher current speeds.
  - Have metre to tens of metre-scale amplitudes and multi-metre to hundreds of metre wavelengths.
  - Include megaripples, sandwaves, starved sub-aqueous dunes and ribbons.

- **Ripple**: centimetre-scale amplitude
- **Megaripple**: >5cm amplitude
- **Sandwave**: metre to tens of metre-scale amplitude, multi-metre to kilometre-scale wavelength – *lacking scours on the lee-side.*
- **Starved sub-aqueous dunes**: Flat expansive ground between ridges (no peak-trough connection).
- **Ribbon**: Isolated metre-scale high ridges, hundreds of metre to kilometre-scale length crests.

Appendix 1 Table 1: Part 1 (Table columns are broken over two sections).

Abbreviations:

mBSF = metres below seafloor
msTWT= milliseconds two-way-time
VC=vibrocore
RC=Rotary Core
GS=Grab Sample
DCN and GSN are grab samples
SEP are rotary cores
KP=Kilometre Point

DPD Section	KP		Water Depth		Seafloor Morphology	Seafloor Sediment	Contemporary Environment	Contemporary Depositional Processes	Sediment Depth to LGM*
	From	To	Min	Max					
A	0	0.5	53	54	Flat and smooth with very subtle NW-SE oriented, very linear sub-aqueous dunes. 0.1-0.2m amplitude, 200-500m long crests, wavelengths of 10-30m, foreset dips ~1 deg. Background dip ~0.2 deg.	Nearby samples (GS10 & DCN_47) Grey-brown, very loose coarse carbonate sand to fine gravel.	Moderate-energy, Inner shelf, sub-tidal.	Hemipelagic sedimentation during slack tide, moderately strong tidal currents during peak ebb and flood tidal phase, and regular storm-induced wave generated processes.	Unknown. Maximum depth likely the (Blue) erosional unconformity at 77-84 msTWT (10-12 mBSF)
B	0.5	3.2	50	55	Very flat, smooth, and featureless. Background dip ~0.2 deg.	BH03: Grey to green or brown, loose muddy carbonate sand to fine gravel. Abundant shell and some coral fragments up to 60mm.	Moderate-energy, Inner shelf, sub-tidal.	Hemipelagic sedimentation during slack tide, weak to moderately strong tidal currents during peak ebb and flood tidal phase, and regular storm-induced wave generated processes.	Unknown. Maximum depth likely the (Blue) erosional unconformity at 77-84 msTWT (10-12 mBSF)
C	3.2	8.3	51.5	62	Broad valley with multiple channels, terraces on shoulders. NW trending relatively low-sinuosity channel deposits imaged on valley floor. Valley sides ~1.5 deg, locally up to 2.5 deg.	VC19: Grey, loose fine to coarse sand with ~50% shell fragments. BH2: Yellow to light grey, fine to coarse grained sandy gravel. Angular to sub-rounded clasts, trace clay.	Moderate to high-energy, Inner shelf marine channel, sub-tidal.	Channel-focused tidal currents and storm-induced bottom currents. Upper 3-4m on western valley shoulder preserves laterally aggrading strata. Eastern valley shoulder is erosional. Suggests valley is currently migrating east.	Base of channel likely cuts down to LGM. sample BH2 potentially intercepts a karstified surface (vuggy calcarenite) that may represent the LGM or a compound lowstand exposed surface.

DPD Section	KP		Water Depth		Seafloor Morphology	Seafloor Sediment	Contemporary Environment	Contemporary Depositional Processes	Sediment Depth to LGM*
	From	To	Min	Max					
D	8.3	14.5	48	53	Flat and smooth with very subtle NW-SE oriented, very linear sub-aqueous dunes. 0.1-0.2m amplitude, 500-800m long crests, wavelengths of 20-40m, foreset dips ~1 deg. Background dip ~0.2 deg.	VC18: Grey loose, fine to coarse silty sand. GC GC30: Clayey fine sandy gravel	Moderate-energy, Inner shelf, sub-tidal.	Hemipelagic sedimentation during slack tide, moderately strong tidal currents during peak ebb and flood tidal phase, and regular storm-induced wave generated processes.	
E	14.5	22	45	49	Very flat, smooth and featureless. Background dip ~0.2 deg, locally up to 0.3 deg.	Nearby sample (VC18) Grey loose, fine to coarse silty sand. Nearby sample (DCN_48 & 49) Grey-brown very loose, clayey, gravelly, medium to coarse carbonate sand with rock fragments.	Moderate-energy, Inner shelf, sub-tidal.	Hemipelagic sedimentation during slack tide, weak to moderately strong tidal currents during peak ebb and flood tidal phase, and regular storm-induced wave generated processes.	Unknown. Maximum depth likely the (Blue) erosional unconformity at 79-83 msTWT (16-18 mBSF)
F	22	36.4	42	51	Seafloor channel intercepted sub-parallel to oblique angle. Intercepts survey centreline at KP22-KP27, KP31 and from KP35.7-KP36.3. Channel is 500m wide with very low-sinuosity, 5-6m relief with channel margins dipping up to 3 deg. Background slope ~0.3 deg. Isolated, steep-sided mounds located on channel floor at KP22.3, KP22.65 and KP25.9 150x50m size with 2-3m relief, sides up to 6 deg.	Samples from outside channel on survey include (VC6) a grey soft clay, and (GC31 & GS32) very shelly coarse sand. Nearby sample outside of channel (DC50a) Grey, soft to firm, sandy gravelly carbonate clay. Nearby sample from inside channel (DCN_49): Grey-brown very loose, clayey, gravelly, medium to coarse carbonate sand.	Moderate to high-energy, Inner shelf marine channel, sub-tidal.	Channel-focused tidal currents and storm-induced bottom currents. isolated mounds in the channel floor are most likely isolated carbonate buildups.	Unknown. Maximum depth likely the (Blue) erosional unconformity at 80-85 msTWT (14-21 mBSF)

Part 2 (Table columns are broken over two sections).

DPD Section	KP		Water Depth		Sub-surface Stratigraphy	Sub-surface Lithology	Post-LGM Depositional Processes	Preservation Potential of Sediment Associated with LGM
	From	To	Min	Max				
A	0	0.5	53	54	Down to Lime surface (Upper 4 mBSF): sub-parallel aggredational sediment, conformable with seafloor. From Lime to Teal surface (4 to 12 mBSF: low relief erosional surfaces on-lapped with sub-parallel bedding. Below Blue surface (?LGM) strata is relatively chaotic and higher amplitude, with numerous cut-and-fill geometries.	BH03 (0.9-1.1 mBSF): Grey-green sandy clay, stiff to very stiff. Sand decreasing with depth. Fine shell and coral fragment gravel layers present.	Likely, initial transgressive ravinement by high-energy wave-dominated shoreface processes, followed by regular modification of seafloor by storm-induced wave processes and bottom currents, and ongoing bioturbation and comminution of sediments and organic objects.	**Low.** Significant physical reworking and biogenic comminution.
B	0.5	3.2	50	55	Down to Lime surface (Upper 4 mBSF): sub-parallel aggredational sediment, conformable with seafloor. From Lime to Teal surface (4 to 12 mBSF): low relief erosional surfaces on-lapped with sub-parallel bedding. Below Blue surface (?LGM) strata is relatively chaotic and higher amplitude, with numerous cut-and-fill geometries.	BH03 (0.9-1.1 mBSF): Grey-green sandy clay, stiff to very stiff. Sand decreasing with depth. Fine shell and coral fragment gravel layers present.	Likely, initial transgressive ravinement by high-energy wave-dominated shoreface processes, followed by regular modification of seafloor by storm-induced wave processes and bottom currents, and ongoing bioturbation and comminution of sediments and organic objects.	**Low.** Significant physical reworking and biogenic comminution.
C	3.2	8.3	51.5	62	Multiple cut-and-fill nested channels incise below likely Late Pleistocene unconformities (Blue & Pink).	VC19: (2 - 3.4 mBSF) Grey, soft to very soft, fine to coarse sand. BH2: (1.35-1.85 mBSF) Dark grey, clayey shell fragment gravel, sub-angular to sub-rounded. Overlying well to very well cemented, white fine to medium grained calcarenite, vuggy.	In early post-glacial time, the valley was likely occupied by fluvial channels, but would likely have been completely reworked by high-energy wave-dominated shoreface processes and strong tidal currents focused into the valley. During the highstand, regular modification of the seafloor would continue by regular storm-induced wave processes and bottom current, and by daily moderate-energy tidal currents focussed into the valley.	**Very Low.** Significant physical reworking and biogenic comminution.

DPD Section	KP		Water Depth		Sub-surface Stratigraphy	Sub-surface Lithology	Post-LGM Depositional Processes	Preservation Potential of Sediment Associated with LGM
	From	To	Min	Max				
D	8.3	14.5	48	53	Down to Lime surface (Upper 6-10 mBSF): sub-parallel aggredational sediment, conformable with seafloor. From Line to Teal 6 to 16 mBSF: low relief erosional surfaces on-lapped with sub-parallel bedding. Below Blue surface (?LGM) strata is relatively chaotic and higher amplitude, with numerous cut-and-fill geometries.	VC18: (0.9 - 3.1 mBSF) Grey, very stiff to hard silty clay, traces of medium sand.	Likely, initial transgressive ravinement by high-energy wave-dominated shoreface processes, followed by regular modification of seafloor by storm-induced wave processes and bottom currents, and ongoing bioturbation and comminution of sediments and organic objects.	**Low.** Significant physical reworking and biogenic comminution.
E	14.5	22	45	49	Down to Lime surface (Upper 3-8 mBSF): sub-parallel aggredational sediment, conformable with seafloor. From Lime to Teal surface (3 to 16 mBSF): low relief erosional surfaces on-lapped with sub-parallel bedding. Some internal, low relief cut-and-fill geometries. From Teal to Blue surface (5 to 16 mBSF) between KP20 & KP22: Lense of laterally aggrading sediment preserved on Blue unconformity. Below Blue surface (?LGM) strata is relatively chaotic and higher amplitude, with numerous cut-and-fill geometries.	Down to Teal surface, sediments likely to consist of those cored in nearby VC18: stiff to hard clay. Lenticular unit imaged between KP20 & KP22 interpreted to be sub-aqueous dunes, comprised of loose, coarse, largely carbonate sand.	Likely, initial transgressive ravinement by high-energy wave-dominated shoreface processes, followed by regular modification of seafloor by storm-induced wave processes and bottom currents, and ongoing bioturbation and comminution of sediments and organic objects.	**Low.** Significant physical reworking and biogenic comminution.

DPD Section	KP		Water Depth		Sub-surface Stratigraphy	Sub-surface Lithology	Post-LGM Depositional Processes	Preservation Potential of Sediment Associated with LGM
	From	To	Min	Max				
F	22	36.4	42	51	Sediment packages thickening to SE with nested cut-and-fill geometries directly below seafloor channel, imaging 4 major erosional events. Deepest event incises below Blue surface. Down to Lime surface (Upper 5-8 mBSF): sub-parallel aggredational sediment, semi-conformable with seafloor. From Lime to Teal surface (2.5 to 10m thick): conformable aggrading strata. From Teal to Blue surface (1 to 10m thick). Lense of seismically transparent sediment preserved on Blue unconformity (KP24.5-KP26, KP28.7-KP30.4 and KP33-34.7). Below Blue surface (?LGM) strata is relatively chaotic and higher amplitude, with numerous cut-and-fill geometries. Older ?Quaternary erosional unconformity surface (Pink) imaged between KP27.5 to KP32, rising to SE where it is truncated by the Blue (?LGM) unconformity.	Down to Teal surface, sediments likely to consist of those cored in nearby VC18: stiff to hard clay. Lenticular unit imaged between KP20 & KP22 interpreted to be sub-aqueous dunes, comprised of loose, coarse, largely carbonate sand.	In early post-glacial time the channel was likely a fluvial system, but would likely have been completely reworked by high-energy wave-dominated shoreface processes and strong tidal currents focused into the channel. During the highstand, regular modification of the seafloor would have continued by regular storm-induced wave processes and bottom currents, and by daily moderate-energy tidal currents focussed into the valley.	**Low.** Significant physical reworking and biogenic comminution.

Appendix 1 Figure 1

Montage reconstruction of the seafloor and stratigraphic sediments below, with reference to the likely / potential LGM surface and possibly earlier surfaces.

KP0-31 is located at the left-hand portion of the diagram.