Technical Appendix E1

Cultural Heritage Assessment and Management Plan – Proposed Gorgon Development, Pilbara, North-Western Australia

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Cultural Heritage Assessment & Management Plan - Proposed Gorgon Development, Pilbara, North Western Australia

April 2004

For
Environmental Resources Management Australia Pty Ltd & ChevronTexaco Australia Pty Ltd

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DISCLAIMER

The authors are not accountable for omissions and inconsistencies that may result from information which may come to light in the future but which was not forthcoming at the time of this research.

ABSTRACT

This document details the results of detailed cultural heritage desktop research conducted for the proposed Gorgon Development on the Pilbara Coast and Barrow Island. An assessment of Indigenous, historic and maritime cultural heritage research is made and a description of preliminary field investigations in March 2004 on Barrow Island is also included in Appendix 2.

It is clear from the assessment that Barrow Island holds an unusual place in the pre-history and history of Western Australia. While some cultural heritage assessments have occurred on the island and mainland pipeline route it is concluded that they are insufficient for ChevronTexaco Australia's (CTA) proposal. There remains the high probability that unidentified cultural heritage is within the proposed Gorgon Development area. The major conclusions of the report are:

1. The three Indigenous communities (Yabburara/Mardudhunera, Kurama Marthudunera and Thanlanyji) who have expressed an interest need to be consulted in relation to cultural heritage management within the proposed Gorgon Development. This consultation may include physical inspection of the proposed development on Barrow Island and on the mainland.
2. That at present:
   a) Two identified cultural heritage sites may be impacted on Barrow Island by the Flacourt Bay Gas Feed Pipeline option.
   b) Four identified cultural heritage sites may be impacted on the mainland.
3. Owing to the low level of formal investigation, prior to construction all proposed ground disturbance areas, including the seabed, should be systematically surveyed for Indigenous, historical and maritime cultural heritage.
4. Proposed construction should be monitored in areas of high potential for sub-surface cultural material.

This document also contains a detailed cultural heritage management plan (CHMP) for the proposed development.

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1 INTRODUCTION

This document details the results of cultural heritage desktop research conducted for the proposed Gorgon Development on the Pilbara Coast, Western Australia, including Barrow Island. The assessment includes three components; Indigenous anthropology and archaeology, historical archaeology and maritime archaeology. Appendix 2 details the results of a preliminary archaeological field investigation conducted on Barrow Island. Its aim was to visit a number of previously recorded sites that may be impacted by the Gorgon Development and inspect areas within the development that have the high potential for cultural material. In addition the document contains a detailed cultural heritage management plan (CHMP) for the proposed development.

1.1 PERSONNEL

The following people participated in the compilation of the report:

Name	Qualifications	Organisation & Project Experience
Fiona Hook	BA(Hons)	*Archae-aus Pty Ltd* Archaeologist – Indigenous; 10 years – Indigenous archaeological assessments; 8 years -management of cultural heritage projects.
Eddie McDonald	PhD	*Ethnosciences* Anthropologist – Indigenous; 27 years – Indigenous anthropological assessments and management of cultural heritage projects in WA.
Alistair Paterson	PhD	*Eureka, University of Western Australia* Archaeologist – Historical; 10 years – Historical archaeological assessments and management of research grants. Currently a lecturer in Archaeology.
Corioli Souter	BA, Post Grad Dip	*Department of Maritime Archaeology, Western Australian Maritime Museum* Archaeologist – Maritime; 6 years – Maritime archaeological assessments and management of research grants. Currently an assistant curator.
Bruce Veitch	PhD	*Archae-aus Pty Ltd* Archaeologist – Indigenous; 15 years - Indigenous archaeological assessments; 12 years - management of cultural heritage projects.

Each component was completed by the following people:

Heritage Component	Desktop Research & Report Writing	Barrow Island Site Visit (March 2004)	Management Plan
Indigenous Anthropology & Indigenous Community Consultation	Eddie McDonald		Eddie McDonald
Indigenous Archaeology	Fiona Hook Bruce Veitch	Bruce Veitch	Fiona Hook Bruce Veitch
Historical Archaeology	Alistair Paterson	Alistair Paterson	Alistair Paterson
Maritime Archaeology	Corioli Souter	Corioli Souter	Corioli Souter
Project Management & Report coordination	Fiona Hook		

1.2 METHODOLOGY

The project brief requested that Archae-aus "assess and report on the potential Cultural Heritage impacts (indigenous and non-indigenous) and recommend a plan (Cultural Heritage Plan) to avoid, mitigate and manage activities that may have the potential to impact Cultural Heritage Sites" for the proposed Gorgon Development. To achieve this, research involved the following components:

1. Desktop research.

   This component involved the authors utilising resources held by the following organisations:

   a) Battye Library.

   b) ChevronTexaco Library.

   c) Department of Indigenous Affairs (DIA).

   d) Heritage Commission.

   e) Western Australian Museum.

   f) Western Australian Maritime Museum.

   g) University of Western Australia Library.

   In addition the authors spoke to the following people regarding cultural heritage:

   a) Dr Ken Aplin – palaeontologist at CSIRO.

   b) Harry Butler– consultant to ChevronTexaco.

   c) Dr Alan Dench – linguist at UWA.

   d) Dr Michael McCarthy – maritime archaeologist with WA Maritime Museum.

   e) Jo Pritchard – historian with Local History Office, Shire of Roebourne.

   f) Peter Randolph – heritage officer in DIA.

   g) Dr Peter Veth – Deputy Director of Research at AIATSIS.

   h) Anna Vitenbergs - historian with Local History Office, Shire of Roebourne.

2. Indigenous Community Consultations.

   The consultations for this study aimed at ascertaining if Indigenous people wished to be consulted regarding cultural heritage within the Gorgon Development. At the time of the consultations no discussion had occurred between CTA and Indigenous groups. Discussions via telephone and email were held with the following groups:

   a) Thanlanyji were contacted through Ms Glenys Hayes (Coordinator of the Buurabalayji Thalanyji Association Inc.). In addition the anthropologist held brief discussions with a number of elders in Onslow.

   b) Kurama Marthudunera were contacted through Robin Stevens (Acting Heritage Manager for Pilbara Native Title Service).

   c) Yabburara/Mardudhunera were contacted through their heritage advisor Ron Parker (Consultant Anthropologist).

3. Preliminary Fieldwork.

   a) In March 2004 a preliminary investigation of the proposed development on Barrow Island was conducted by archaeologists Alistair Paterson, Corioli Souter and Bruce Veitch. The aim of this was twofold: firstly, to relocate previously recorded cultural heritage sites within and adjacent to the Gorgon Development; and secondly to inspected the proposed development area in preliminary detail, with spot checks undertaken at areas of high archaeological potential such as coastal areas and claypans. The results of this assessment are detailed in Appendix 2.

4. Preparation of desktop assessment and Cultural Heritage Management Plan.

1.3 GLOSSARY

This glossary list refers to technical terms in used in this report.

Adze – stone tool designed for working the surface of wooden objects (Horton 1994:36; McCarthy 1976:29-34).

Artefact scatter - locations where a range of activities has occurred such as the manufacture and maintenance of tools and the processing of foods. In the context of Indigenous archaeological sites, flaked and ground stone artefacts are the most common artefact type.

Backed artefact - a thin flake with steep, bipolar retouch on one lateral margin and a sharp edge on the opposite margin.

Barracoon - a rough barrack, set of sheds, or enclosure, in which Black slaves (originally), convicts, etc., are temporarily detained (Simpson & Weiner 1989).

Cutter – a ship with one mast rig with gaff mainsail, stay foresail, jib and topsail, and running or reefing bowsprit (de Kerchove 1961).

Eloura - large backed artefact (McCarthy 1976:29).

Flaked Artefact – stone, glass or porcelain artefacts that possess one or more of the following characteristics: a positive or negative ring crack; a distinct negative or positive bulb of percussion or force; a definite eraillure scar beneath a striking platform; and definite remnants of flake scars (e.g. dorsal scars and ridges) (Andrefsky 1998: xxi-xxxvii; Hiscock 1984: 128).

Ground Artefact – usually hard wearing stone such as granite, basalt or ironstone with clear evidence of polishing on one or more surfaces. A number of different types occur in Australia including mullers and millstones used for flat grinding of seeds, ochre; and mortars and pestles for pounding ochre, bones and plant material (Smith 1986:33).

Holocene - the most recent geologic era; from about 10,000 years ago to the present.

Last Glacial Maximum - the period of time, approximately 18,000-22,000 years ago, during the last great ice age when glaciers, ice sheets and sea ice reached their maximum thickness and aerial extent.

Lock Hospital - a hospital for the treatment of venereal diseases (Simpson & Weiner 1989).

Lugger – see pearling lugger.

Midden, Shell – scatter, pile or mound of the remains of one or thousands of shellfish meals (Horton 1991:982).

Pearling Lugger – a local name given in North West Australia to small ketch rigged boats employed in pearl fisheries. Usually planked in Australian Jarrah, copper fastened and copper sheathed. A fast sailer which is sometimes fitted with an auxiliary engine (de Kerchove 1961).

Pedestrian Survey – archaeological survey technique involving the visual inspection of the ground surface while walking across the landscape (Banning 2002:40).

Pleistocene - the glacial epoch preceding the Holocene, extending back from 10,000 years ago to about 1.8 million years ago. The Pleistocene and Holocene epochs comprise the Quaternary period (Horton 1994:876)

Reduction Area - a cluster of flaked stone artefacts which represent the remains of the flaking of a core. Artefacts within a reduction area can usually be conjoined and represent a single flaking event.

Retouched Artefact – where the artefact exhibits flake scars extending onto the ventral surface and/or deriving from the ventral surface. These flake scars may form during use or treadage, as well as during knapping.

Rock-shelter - overhang, cave or cliff face that contains evidence of human occupation in the form of stone artefacts, economic shell species, charcoal, faunal material or rock art.

Shell Scatter – see midden above.

Stratified cultural deposit –cultural material and sediment layered in a way that mimics rock layers in geology. The lower levels of the deposit are older than the levels above if no disturbance has occurred.

Systematic Survey – assessment of a given area by spacing survey team at an equal distance with each team member responsible for inspecting along linear / zigzag transect (Banning 2002:41).

Vehicle Survey – assessment of a given area by inspecting the ground surface from a slow moving vehicle (Banning 2002:40).

Windscreen Survey (see Vehicle Survey).

2 GORGON DEVELOPMENT

The development is described in detail in the 2003 EIS/ERMP (Gorgon Australian Gas 2003). In summary, the proposed Gorgon Development comprises the following components:

1. Sub-sea gathering infrastructure at the Gorgon gas fields.
2. 70 km long feed gas pipeline to bring gas/well stream fluids to Barrow Island from the Gorgon gas field. There are currently two options, one landing at Flacourt Bay and the second at White's Beach.
3. Gas processing facility on the east coast of Barrow Island.
4. Port facilities on the east coast of Barrow Island.

5. CO_2 pipeline and sequestration system from the gas processing facility. In its current form this pipeline is approximately 5 km long and extends north from the proposed gas processing facility.
6. 80 km long domestic gas (DOMGAS) infrastructure piping gas from Barrow Island to the mainland. It is proposed to run the DOMGAS pipeline parallel with the pre-existing Apache gas pipeline and join the Dampier-Bunbury Natural Gas Pipeline at Compressor Station 1.

3 LEGISLATION

3.1 INDIGENOUS HERITAGE

All Indigenous heritage sites and objects are protected under Western Australia's *Aboriginal Heritage Act 1972* (*AHA*). Section 17 of the *AHA* states that it is an offence to -

1. alter an Indigenous site in any way, including collecting artefacts;
2. conceal a site or artefact; or
3. excavate, destroy or damage in any way an Indigenous site or artefact;

without the authorisation of the Registrar of Aboriginal Sites under Section 16 or the Minister of Indigenous Affairs under Section 18 of the *AHA*.

The *AHA* protects sites and objects that are significant to living Indigenous people as well as Indigenous sites of historical, anthropological, archaeological and ethnographic significance. The *AHA* is currently administered by the Department of Indigenous Affairs (DIA).

Indigenous heritage sites are also protected under the *Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (HPA*). The *HPA* complements state/territory legislation and is intended to be used only as a 'last resort' where state/territory laws and processes prove ineffective. Under the *HPA* the responsible Minister can make temporary or long-term declarations to protect areas and objects of significance under threat of injury or desecration. The *HPA* also encourages heritage protection through mediated negotiation and agreement between land users, developers and Indigenous people.

Indigenous human remains are protected under the *AHA* and the *HPA*. In addition the discovery of human remains requires that the following people are informed: the State Coroner or local Police under Section 17 of the *Coroners Act 1996*; the State Registrar of Aboriginal Sites under Section 15 of the *AHA*; and the Federal Minister for Indigenous Affairs under Section 20 of the *HPA*.

A recent document finalised by the Environmental Protection Authority (2004:4) states that Indigenous heritage will be assessed as a *relevant environmental factor* during formal EIA assessments by the EPA.

3.2 HISTORIC HERITAGE

Indigenous archaeological sites created following European exploration and settlement in the 1800s are protected under Western Australia's *Aboriginal Heritage Act 1972* (see Section 3.1).

The Heritage Council is Western Australia's advisory body on heritage matters and focuses on places, buildings and sites under the *Heritage of Western Australia Act 1990* (*HWAA*). The Heritage Council's mission is to provide for and encourage the conservation of places significant to the cultural heritage of WA, and would thus have an interest in historic sites on Barrow Island. It should be stated however, that the Heritage Council has largely been unconcerned with the archaeological resource, focusing instead on historic standing buildings.

Barrow Island is included on the state register as: 'Place No: 14365 Name: Barrow Island Marine Area – part'. We presume this is solely on the basis of its environmental value although no boundaries or locations for this listing are provided in the register. It should be noted that:

> The Heritage of Western Australia Act 1990 requires Local Government Authorities and State Government Agencies to seek the advice of the Heritage Council if they are considering development of a place that is entered in the Register of Heritage Places. Work may not proceed before advice has been received and the work must comply with the advice (Electronic Document, accessed 1 April 2004, http://www.heritage.wa.gov.au/b_development_referrals.html)

Although CTA is not a Local Government Authority/Government Agency, the Heritage Council should be informed of the results of any archaeological surveys if historic finds are identified on the island. It would appear the listing on the State Register of Historic Places is one by default following the creation of a Marine Park on the Register of the National Estate (Place 17417) for environmental value. For that nomination there was no study of heritage value, although the potential was recognised: "It is possible that cultural values, both indigenous and non-indigenous, of National Estate significance may exist in this place".

Any historical archaeological material at Barrow Island would derive from seafaring contexts as all visitors would have arrived in boats. As such there is potential for archaeological sites and isolated artefacts to be subject to the Western Australian *Maritime Archaeology Act 1973* (see Section 3.3).

3.3 MARITIME HERITAGE

The State *Maritime Archaeology Act 1973* (*MAA*) protects the remains of ships lost before 1900 and any associated relics. Section 4 of the *MAA* defines what constitutes a maritime archaeological site: and includes remains of an historic ship; an area where any relic is known to be located; any structure, campsite, fortification or other location of historic interest associated with an historic ship. A maritime archaeological site may be below the low water mark, between the tide marks or on land. This section of the *MAA* specifically relates to material from and including the remains of an "historic ship", which is defined as any ship that before the year 1900 was lost, wrecked or abandoned, or was stranded, on or off the coast of Western Australia. The term "relic" is any thing of historic interest that appears to have formed part of, or to have been carried by or derived from or associated with any historic ship, and any thing to which the provisions of Section 6(3) of the *MAA* apply. The same legislation includes protection of material derived from or associated with any ship, regardless of whether it is "historic". Section 6(3) vests in the Western

Australian Museum, on behalf of the Crown, property in and the right to possession of any object, which in the opinion of the Director of the Museum, was abandoned in the State before 1900 and was derived from or associated with any ship and which, immediately prior to 1973, was not in the lawful possession of any person (Crown Law advice 18/02/98, MA27/80).

The *Historic Shipwrecks Act 1976* (*HSA*) is Federal legislation which protects all shipwrecks in Commonwealth waters and associated relics which are more than 75 years old. Shipwrecks which have not been located are still protected under the *HSA*.

4 CULTURAL HERITAGE ASSESSMENT

The Gorgon Development has been assessed for Indigenous anthropology and archaeology as well as historical and maritime cultural heritage with an emphasis on archaeological sites. The results of the assessment are detailed below.

4.1 INDIGENOUS HERITAGE

4.1.1 Indigenous Anthropology

4.1.1.1 Language Groups

Tindale (1974) identifies three tribal or language group territories on the Northwest coast that are of relevance to the Gorgon Development. These “tribes” are from north to south:

1. Mardudunera [Martuthunira]
2. Noala [Nhuwala]
3. Talandji [Thalanyji]

Tindale (1974:248) describes the location of the Mardudunera as follows:

> Coastal plain north of the Fortescue River; north to visited islands of the Dampier Archipelago on log rafts; inland only to the foot of the ranges. These are perhaps the people described by King, (1827:i.38) as tide riding on logs near Lewis Island.

Noala country is described by Tindale (1974:254) as follows:

> Coastal plain from about Cape Preston near the mouth of the Fortescue River southwest in a strip about 40 miles (65 km.) wide to a line running south from Onslow, but not extending to the Ashburton River, which is held by the Talandji. They kept near the seashore and went out to Barrow and Monte Bellow Islands using a form of wooden “canoe”… Inland areas, away from creeks, could only be visited after rain when the claypans were filled. Most of their livings came from tidal inlet fish traps.

Tindale (1974:256) describes Talandji country as follows:

> Along the Ashburton River from the coast to Nanutarra, Boolaloo, and the lower Henry River. .. Their extension to the coast at Exmouth Gulf coast is

> probably due to late migration, offshore fresh water spring or springs at [‘Pi:ltan] (now within Onslow township) was an ultimate water supply base.

Other research has raised issues about Tindale’s descriptions of the country of various groups in the west Pilbara area. For example, Dench (1987:5), following extensive linguistic fieldwork in the area, argues that Martuthunira country is more extensive than described by Tindale and notes that:

> On the west cost, the grass plains and mudflats between the Robe River and the Cane River were shared with the Nhuwala. Warramboo Creek (Wartampu) is described as the boundary though the Nhuwala foraged as far north to the northeast as the Robe River.

Of the groups referred to by Tindale (1974) few people now identify as Nhuwala and they tend to be considered as part of the Thalanyji community resident in Onslow and other Northwest towns (Dench 1987). The last Martuthunira speaker died some years ago, however, a number of people claim interests in Martuthunira country and these claims are symbolised in the names of their native title claims.

There are three Registered Native Title Claims encompassing the people from the language groups in the area and with registered interests in the sea and offshore islands:

1. Yabburara/Mardudhunera (WC96_089)
2. Kurama Marthudunera (WC99_012)
3. Thanlanyji (WC99_045)

Wong-Goo-Tt-Oo (WC98_040) claim is located further to the east and encompasses the sea and offshore islands in the vicinity of the Cape Preston. However, none of the active native title claims encompasses Barrow Island, though a representative of the Thalanyji group noted that it was their original intention to extend their claim to cover the island.

4.1.1.2 Ethnographic Evidence for Indigenous Offshore Island Use

Tindale (1974:254) mentions the use of offshore islands by two of the three groups mentioned above, namely the Mardudunera [Martuthunira] and Noala [Nhuwala] and specifically mentions the Noala visiting “Barrow and Monte Bellow Islands using a form of wooden ‘canoe’”. However, it is not clear what sort of craft and what type of usage of the islands he is referring to[1].

Though not referring to the use of the islands by the Thalanyji, there is no reason to believe that the Thalanyji, like their coastal neighbours, did not have water craft and

[1] It has not been possible to inspect Tindale’s field journals as the Archives in the South Australian Museum have closed for two to three months because of staffing problems. Copies of the journals are held by the Family History Unit of the Department of Indigenous Affairs. However, access to the journals is restricted to members of the Aboriginal families mentioned in the journals or those with written permission from these families. The officer in charge of the unit has reported that she can find no reference to “canoes” in Tindale’s journal entries for the Noala [Nhuwala].

visit the offshore islands. Indeed, Bates (1985:257-258) notes the exploitation of offshore islands by Aboriginal people:

> Along the Northwest coast there is [sic] a number of small islands which the natives of the Roebourne district are able to reach … In the early days the natives transported themselves to the various islands by means of logs of mangrove wood, two of these being joined neatly together end to end … while a third and shorter piece formed a primitive stern.

Bates (1985:258) goes on to mention that coastal Indigenous people of the Ashburton and Northwest Cape also used a type of raft, similar to those used in the Roebourne area, though these were made from corkwood rather than mangrove trees. Bates (1985:258) also mentions that the last of the traditional log rafts were seen in operation at Lewis Island in 1883 and that "present day" (c. 1909) Aborigines use "white man's boats" for sea excursions.

The implications from Tindale and Bates' research is that Northwest coastal Indigenous people used traditional watercraft to visit offshore islands, including Barrow and the Montebello Islands and that by the turn of the Nineteenth Century Indigenous people were using non- Indigenous boats to continue their sea based activities, possibly including visits to Barrow Island. There are also recorded visits to the island by Indigenous people in circumstances controlled by European Australians, including forced involvement with the pearling industry (see Section 4.2, below). A representative of Thalanyji community reports that elders recall at least one of the now deceased members of the community visiting the island in the company of non-Indigenous people on a regular basis when they were young.

4.1.1.3 Mythological Connections

In addition to the foraging on Barrow and other offshore island reported by Tindale (1974) one ostensible mythological connection to Barrow has been mentioned. Dench (pers. comm.) recalled that during his Martuthunira field work in the 1980s his informants had recounted the mythology relating to the origins of Pannawonica Hill [*Parlapuni*]. Basically the narrative relates how the hill had its origins in the sea to the west and was carried to its present location on the head of a spirit bird:

> .. the mark of this hill, dragged from near Mardie Station, from the ocean, has left a big flat, where Pannawonica went across. We all know, the old fells know that – you can still see it, the main highway goes across it. It's come from west to east, where he travelled in the valley there. And in the hills where he came through, he made a V mark – you can see like that for a long distance, about ten of twelve mile, where that fells went in there. He went straight for Pannawonica … (related by the late Gordon Lockyer in Brehaut & Vitenbergs 2001:35-36).

Dench (pers. comm.) recalls that in one version of the myth *Parlapuni* was reported to have come from Barrow Island. Other versions, however, point more northwest towards the Dampier Archipelago for the origins of Pannawonica Hill. However, both versions of the mythological narrative may be equally valid within the Guruma [Kurrama] and Martuthunira communities.

4.1.1.4 Known Indigenous Groups and Cultural Heritage Sites

4.1.1.4.1 Barrow Island

A search of the Register of Aboriginal Sites held by the DIA reveals that no ethnographic sites are listed on Barrow Island. This absence of listed ethnographic sites may reflect the more recent historical attenuation of links with the island. However, representatives of all the groups consulted indicated that they did have an interest in cultural heritage on Barrow Island.

1. A spokesman for the Yabburara/Mardudhunera claimants reports that:

   > They have expressed the view that the Island was once part of their area and that they have concerns regarding the new development there as far as heritage sites are concerned.

2. The Pilbara Native Title Service (PNTS) Acting Manager of Heritage has noted that a number of people in the Kurama Marthudunera group have expressed an interest in the island's heritage.
3. A Thalanyji representative reports that the group's elders say that the Thalanyji people, including people of Nhuwala descent, have interests in the Island's heritage.

Clearly, Indigenous people have an interest in the proposed Gorgon Development on Barrow Island and clearly wish to be consulted. This consultation may include physical inspection of the proposed development on Barrow Island.

4.1.1.4.2 Mainland

The planned onshore pipeline on the mainland is within Martuthunira country (Murphy & McDonald 1990). The area is within both Martuthunira Native Title claim areas: Yabburara/Mardudhunera (WC96_089) and Kurama Marthudunera (WC99_012).

A search of the Register of Aboriginal Sites held by the DIA reveals that two ethnographic sites, both associated with Peters Creek, are located close to the proposed DOMGAS pipeline on the mainland (Map 4-2). First, Peters Creek is a Named Place: *Nyungarrarra* (Site ID 17429) (McDonald, Hales & Associates 1994) and second, Warlu Waterhole: (Site ID 17004), situated in the Creek, is listed as a mythological site with an associated artefact scatter (McDonald Hales and Associates 2001; Stevens 1998) (Appendix 1). In addition a 'waterhole' known to Martuthunira informants was identified along the Apache/Hadson pipeline (Murphy & McDonald 1990), which has not been registered with the DIA (Appendix 1). This site is associated with an archaeological site, which is discussed in Section 4.1.2.1.2, below).

These two Indigenous groups need to be consulted in relation to cultural heritage management within the proposed Gorgon Development on the mainland. The Indigenous groups may request a physical inspection of the proposed development.

4.1.2 Indigenous Archaeology

4.1.2.1 Barrow Island

Barrow Island occupies a potentially important position in the Indigenous archaeology of north-western and continental Australia. Barrow Island has remained an under researched area of the Pilbara coast with only two Indigenous archaeological surface surveys conducted on the Island (Quartermaine Consultants 1994; Quartermaine 1997).

When Indigenous people first arrived on the Australian continent approximately 45,000 BP[2] (Bowdler 1990; Roberts *et al.* 1990a; 1990b), Barrow Island was a dissected limestone hill on a large coastal sand plain with the coast 10 km to the west (Figure 4-1) (Veth 1994; Veth *et al.* in press). The first Indigenous occupation evidence for the immediate area dates to circa 32,000 years ago at Cape Range and circa 30,000 years ago on the Montebello Islands (Morse 1993a; Przywolnik 2002; Veth 1994; Veth *et al.* in press:13). At the height of glacial maximum, about 18,000 BP, the coastline moved 50 km west from Barrow Island (Figure 4-1). During this period Indigenous occupation patterns appear to have been very different from those of more recent millennia. The removal of so much water from the water cycle, of which a lowering of sea levels by 130 m was symptomatic, resulted in marked reconfigurations of Indigenous populations in many parts of Australia, especially arid areas such as Barrow Island. Indigenous populations appear to have concentrated around identified refuge and corridor areas that offered greater resource reliability, such as the arid Pilbara coast (Morse 1993c:277, 290; Veth *et al.* in press:75; Veth 1993). During the glacial maximum Barrow Island, the Montebello Islands and the Cape Range areas would have been in the hinterland of the coastal plain with perhaps reduced though still highly detectable archaeological evidence remaining from such use (eg. Morse 1993c; Przywolnik 2002; Veth 1994; Veth *et al.* in press).

As the climate ameliorated the sea level rose with Barrow and Montebello Islands cut off from the mainland around 8,000 BP (Figure 4-1) (Veth 1994). Indigenous people lived on the Montebello Islands during this period and it is most likely that they also utilised the greater Barrow/Montebello land mass. The sea reached its current level circa 7,500 BP. At 7,000 BP the Montebello Islands were abandoned by Indigenous people most likely owing to the scarcity of potable water and perhaps moving to the larger Barrow Island or to the mainland (Veth *et al.* in press:5). As no detailed archaeological excavations have occurred on Barrow Island it cannot be determined whether Indigenous people occupied the island after 7,000 BP. As sea levels rose the perched freshwater on the Montebellos was contaminated by sea water. Owing to its greater height above sea level fresh water on Barrow would not have been contaminated (Veth *et al.* in press:32). Lack of occupation evidence from the Montebello Islands and the fact that from the mainland to Barrow Island was a 60 km

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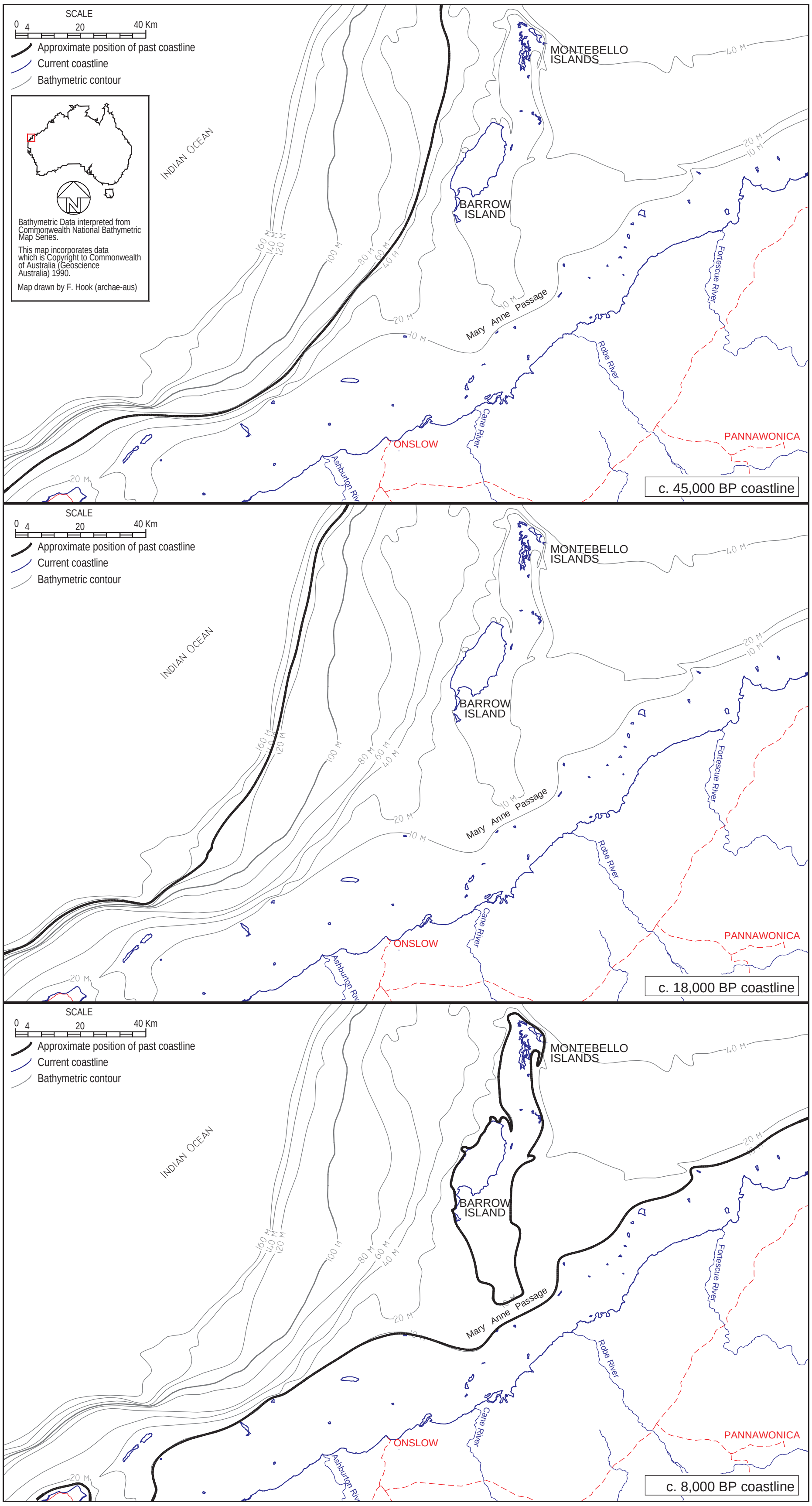
[2] Years **B**efore **P**resent (1950).

journey by sea from circa 6,000 BP suggests that Barrow would not have been revisited by Indigenous people during the mid or late Holocene (Crawford 1986 cited in Veth *et al.* in press:2, see also 70). However, the evidence of possible canoe use by Indigenous people on the Pilbara coast (Bates 1985:257-258; Tindale 1974:254) and in particular reference by Tindale (1974:254) to the Noala accessing Barrow and the Montebello Islands by a type of canoe raises the possibility of Holocene use of the island.

Furthermore, Quartermaine Consultants (1994) recorded two adze slugs and an *elouera* on the Barrow Island. The first adzes appear in the archaeological record in Australia by the mid-late Holocene after the Barrow / Montebello Islands were abandoned (Hiscock 1994; Hiscock & Veth 1991:342; Jones 1985; White & O'Connell 1982:106-133). Although some backed artefact forms may have occurred earlier in eastern Australia, convincing evidence is not found beyond the eastern seaboard (Bowdler & O'Connor 1991; Hiscock & Attenbrow 1998). Indeed adzes are seen to be confined to the mid-Holocene even by some of those who propose earlier dates for backed artefacts (Jones 1985). If the identification of adzes on Barrow is correct it suggests that the island was occupied after insulation and visited from the mainland after 7,000 BP. Alternatively, the adzes may have been made by Indigenous people visiting the island during historic times (see section 4.2). Adzes, however, were used to make objects from hardwood, of which there is very little on Barrow Island today. During the March 2004 visit to the island, the “adze slug” noted in site 883/FS01 (Quartermaine Consultants 1994:15) was seen (Appendix 3). This object, in the opinion of Bruce Veitch, is not an adze slug but a retouched flake. These three artefacts therefore need further inspection and an accurate typological identification**.** In addition, the dating of stratified sub-surface cultural deposits on Barrow Island would be desirable to resolve when / if the island was abandoned by Indigenous people.

During the historical period Indigenous people were present on the island, and historical sources describe them being brought to Barrow Island by Europeans. The evidence of their presence on the island is quite marked (see descriptions of flaked glass & porcelain artefacts in Quartermaine Consultants 1994:15-22, Fig 15 & 16). This aspect of the island’s history is discussed in more detail in Section 4.2.

Figure 4-1. Sea levels at 45,000 BP, 18,000 BP and 8,000 BP (Chappell & Shackleton 1986; Chappell & Thom 1977:281; Veth 1994).



Barrow Island therefore has the potential to contain material evidence directly relevant to "a number of fundamental and critical research questions related to the history of coastal exploitation in Australian archaeology" (Veth *et al.* in press:3). These questions revolve around the following points.

1. Barrow Island lies between Cape Range Peninsula and the Montebello Islands which were initially occupied by Indigenous people at 34,200±1050 years BP and 27,220±650 years BP respectively (Morse 1988; 1993d; Przywolnik 2002; Veth 1994; Veth *et al.* in press). The presence of two areas with such long occupation records either side of Barrow Island strongly suggests that the island will also contain Indigenous archaeological material of great antiquity in both rock shelter (Quartermaine Consultants 1994:22) and possibly stratified sites in sand dunes (Bowdler 1999; Morse 1988; 1993b; Przywolnik 2002; Veitch & Warren 1992).
2. Barrow Island has a limestone geological base offering potentially very good preservation conditions in stratified cultural deposits which is unusual for the Pilbara and arid Australia. As a consequence of both its limestone base geology and the potential to contain stratified material, Barrow Island may contain well preserved organic remains, offering possibly unique insights into past subsistence strategies and the use and manufacture of organic items (eg. Morse 1993b; Wallis & O'Connor 1998). Of note is the fact that shell beads were recovered from the Cape Range peninsula, being among the oldest jewellery known to humanity (Morse 1993b).
3. Barrow Island may contain material relevant to investigating human responses to sea level changes and other environmental changes during strategic periods of the Pleistocene and later Holocene, especially during and immediately after marine transgressive phases (Beaton 1985; 1995; Bowdler 1999:82; Veth *et al.* in press:3-4). Indeed it is still unknown whether Indigenous people remained on Barrow Island after insulation around 7,000 years ago, and if so, for how long (Dortch & Morse 1984; Quartermaine Consultants 1994; Veth *et al.* in press:5).
4. The presence of artefactual material made of volcanic, metamorphic or siliceous sedimentary stone on Barrow Island would inform on patterns of "contact and/or mobility strategies" over time given the absence of these raw materials (excluding limestone) on Barrow Island (Veth *et al.* in press:5). Other raw material types, such as ironstone, quartz and chert, that have been used to manufacture flaked and ground stone artefacts have come from elsewhere most likely the mainland.

To date documented Indigenous archaeological research on Barrow Island comprises two surveys concentrating on surface archaeology with 12 archaeological sites recorded and registered with the DIA (Quartermaine Consultants 1994; Quartermaine 1997). In addition, collected artefactual material from Indigenous sites is held by the Western Australian Museum (WAM) and by WAPET/ChevronTexaco on Barrow Island. Previous surveys, recorded Indigenous sites and the collected artefacts are discussed further below.

4.1.2.1.1 Previous Surveys

The initial survey conducted by Quartermaine Consultants (1994:11) covered 10% of the island using pedestrian and vehicular transects. In addition to the 1994 survey, a proposed Plant and Associated Facilities area measuring 4.2 km² on the north-eastern tip of the island was sample surveyed (Quartermaine 1997). Very little of the Gorgon Development has been systematically inspected for Indigenous archaeological sites. Specifically, 2.2% of the proposed Gas Processing and Port Facility (1550 ha, see Gorgon Australian Gas 2004:10, Figure 2) has been thus assessed (calculated from Quartermaine Consultants 1994:11, Figure 2). While the coverage of the proposed pipelines appears relatively high (approximately 85% of the Flacourt Bay Feed Gas Pipeline Option, 75% of the White's Beach Feed Gas Pipeline Option and approximately 71% of the CO_2 Pipeline), most of this was covered from a slow moving vehicle, with only 1.3% of the CO_2 Pipeline surveyed on foot. Windscreen surveys (from a slow moving vehicle) are usually used for preliminary inspections rather than a survey method prior to development (Banning 2002:40; Collins & Molyneaux 2003:43, 52-63).

> Older archaeological surveys typically entailed searching visually for archaeological remains … from a motor vehicle (so-called "windscreen surveys") … Although such surveys continue, at least for preliminary reconnaissance, it is now much more common for visual inspection of the surface to be accomplished through pedestrian surveys (Banning 2002:40).

Compounding the difficulty in identifying artefactual material on the ground from a slowly moving vehicle is the fact that Barrow Island has not had any major fires for the last 30 to 40 years (Quartermaine Consultants 1994:12), rendering ground visibility very low. Furthermore during the March 2004 Barrow Island visit it was observed that a number of the sites recorded by Quartermaine Consultants (1994) have been affected by cyclonic activity (see Appendix 2 for a discussion for these changes). This suggests that additional cultural material may have been exposed since the 1994 and 1997 surveys (Quartermaine Consultants 1994; Quartermaine 1997).

In light of the above, to assess adequately the possible impact of the proposed development on Indigenous cultural heritage**,** additional systematic pedestrian sample surveys will be required of the proposed disturbance areas. A number of areas of high archaeological potential exist on the island some of which were identified by Quartermaine Consultants (1994:5) and include claypans, drainage lines and coastal dunes (Map 4-3). Claypans and coastal dunes in particular have the potential for the presence of sub-surface cultural material. During construction of the Gorgon Development these areas must be monitored by qualified Indigenous archaeologists for this potential.

4.1.2.1.2 Sites

The Register of Aboriginal Sites maintained by the DIA has records of 13 Indigenous archaeological sites on Barrow Island (see Appendix 1), 12 of which were identified during the survey conducted by Quartermaine Consultants (1994). One of the 13 sites (8951) comprises six flaked stone artefacts donated to the Western Australian Museum that were collected in the 1960s by WAPET employees (Dortch & Morse 1984). This area has been assessed by the DIA as "Not a Site" because no information was provided regarding artefact provenance. The remaining 12 sites comprise surface artefact scatters with artefacts manufactured from volcanic, metamorphic and siliceous sedimentary stone as well as glass and porcelain (Quartermaine Consultants 1994). Five of the sites were assessed as of low archaeological significance, six as moderate and one as having high archaeological significance. Six of these surface sites may have sub-surface cultural material, owing to their position in claypans.

In addition to the 12 artefact scatters, four rock shelters / caves with the potential for sub-surface cultural material were recorded on the west coast of the island (Quartermaine Consultants 1994:22, 25). Evidence from these sites in particular has the potential to address some of the research issues outlined above. Of note here is the fact that none of the rock shelter / caves identified by Quartermaine Consultants (1994) and the March 2004 field trip appeared to contain surface artefacts. This is consistent with the suggestion that these sites have not been used for several millennia.

Quartermaine Consultants (1994) also recorded a number of sites that contained historical material (called Pearling Camps), including flaked glass and porcelain artefacts. These sites are discussed in more detail in Section 4.2

Of the 13 DIA registered Indigenous archaeological sites, two are either very close to or may be impacted by the proposed development (Map 4-1). Site 888 (FS06 Area C) is in the path of the proposed CO_2 Pipeline (Quartermaine Consultants 1994:33). Site 887 (FS05) appears to be located immediately north of the CO_2 Sequestration System. A site recorded during the March 2004 Field Trip (GD04-01) is located adjacent to the Flacourt Bay Feed Gas Pipeline (Map 4-1). The White's Beach Feed Gas Pipeline also passes close to a recorded freshwater soak.

Site 887 (FS05) was recorded as a sparse scatter of flaked and ground stone artefacts in the base of a deflated dune at Cape Dupuy (Quartermaine Consultants 1994:17, 39). A total of four artefacts were recorded and the site was assessed as having low archaeological significance. The site is at the northern end of the CO_2 Sequestration System and it does not appear that the site will be impacted (Map 4-1). During the March 2004 field trip Veitch, Paterson and Souter visited this site and assessed that the site had been affected by cyclonic activity. The number of artefacts present in this area was possibly up to 500 and an *in situ* flaked stone reduction area was noted. If this site is to be disturbed additional site recording and test excavation will be required.

Site 888 (FS06) is an scatter of flaked stone, glass and porcelain artefacts spread out over a series of claypans (Quartermaine Consultants 1994:17-18, 40). Artefacts occur in six areas and the proposed CO_2 Pipeline passes through Area C (Map 4-1). A total of six artefacts were recorded from Area C and this site was assessed as having moderate archaeological significance. Quartermaine Consultants (1994:18) recommend that prior to any disturbance the site be test excavated to determine the potential for stratified cultural material. During the March 2004 fieldtrip Veitch, Paterson and Souter visited this site. Some parts of the site were found to have similar numbers of flaked stone artefacts to those noted in 1994 while others such as Area C were found to be less. Area C was found to contain only one ironstone flake fragment. This result raises the possibility of movement and burial of artefacts in claypans thereby forming stratified deposits and is consistent with Quartermaine Consultants (1994) findings. This site will need to be test excavated to determine the presence/absence of sub-surface cultural material prior to any proposed disturbance by CTA.

A rock shelter with potential for sub-surface cultural material was identified in Flacourt Bay (GD04-01) during the March 2004 site visit (Appendix 1 and 2). No artefactual material was on the surface, however, and due to safety requirements the survey team did not enter the rock shelter beyond the drip-line. This site is 90 m north-east of the Flacourt Bay Pipeline option centreline and will not be impacted by the Gorgon Development.

4.1.2.1.3 Collected Artefacts

The Western Australian Museum has in its collection a total of 18 artefacts from Barrow Island. They were collected by WAPET employees in the 1960s and WAM staff in the 1980s. The artefacts include flakes, debris, a possible baler shell water carrier (*Melo* spp.), baler shell fragments and three possible artefacts (weathered limestone and ironstone) (see Dortch & Morse 1984 for a description of six artefacts). The flaked stone artefacts are manufactured from ironstone, quartz, limestone and chert. The possible baler shell water carrier was collected from a dune blow-out 0.5 km east of Cape Dupuy. This blow-out location fits that of site 887 (FS05) recorded by Quartermaine Consultants (1994:17). The remaining 17 artefacts have no provenance recorded.

A large number of collected artefacts are housed in the Barrow Island Environment Laboratory. These artefacts have been collected by WAPET staff and heritage consultants since the 1960s. In excess of 150 Indigenous artefacts are in the collection, including flaked and ground stone artefacts and flaked/retouched glass artefacts. These need to be recorded and catalogued to ascertain if they were collected from areas within the Gorgon Development. The vast majority, however, have no provenance recorded.

4.1.2.2 Mainland

This general area of the Pilbara coastline contains a range of archaeological sites that include shell scatters and middens, artefact scatters near claypans and Indigenous burials in dunes (Lantzke 1999; Murphy & McDonald 1990; Przywolnik 2002; Veitch 1993; Veitch & Hook 1993; Veitch & Warren 1992). These sites generally date to the last 7,000 years when the coastline approximated its current position (Figure 4-1).

4.1.2.2.1 Previous Surveys

A number of Indigenous archaeological assessments have been conducted in the area surrounding the proposed DOMGAS pipeline. The existing Apache/Hadson pipeline was surveyed for Indigenous archaeological sites by Murphy and McDonald (1990). Four Indigenous archaeological sites were identified, but the report has not been lodged with the DIA and the sites have not been registered. The sites comprise two flaked stone artefact scatters and two shell middens (see Appendix 1). Three sites were close the Apache/Hadson pipeline route which was moved to avoid them. The fourth site is 7 km south-west of the Apache/Hadson pipeline. Three of these sites may be impacted by the proposed DOMGAS pipeline (Map 4-2).

In addition a series of proposed drilling sites were surveyed for Indigenous sites in the vicinity of the Apache/Hadson pipeline (Lantzke 1999). Two sites were identified, one (DIA 17833) of which is located 5 km south-west of the DOMGAS pipeline and will not be impacted (Map 4-2).

While surveys for Indigenous archaeological sites have occurred in the vicinity of the proposed DOMGAS pipeline, it is not possible to state categorically that all Indigenous archaeological sites have been identified. To assess adequately the possible impact of the proposed development on Indigenous cultural heritage**,** systematic pedestrian sample surveys will be required prior to construction. Section 5 discusses procedures for the discovery, reporting and management of archaeological resources.

4.1.2.2.2 Sites

Currently there are eight Indigenous sites recorded in the general vicinity of the DOMGAS pipeline (see Appendix 1 for a complete list). Of these four may be impacted; Hadson 1, Hadson Midden 1, Hadson Midden 2 and Macey Wreck.

Hadson 1 is a scatter of flaked and ground stone artefacts in a claypan. Nine artefacts were recorded in a 2 m² sample square and the scatter was estimated as measuring 500 m by 500 m in area (Murphy & McDonald 1990). The Hadson pipeline was altered to avoid this site. The proposed DOMGAS pipeline may impact this site**,** which should therefore be relocated to determine its position in relation to the proposed pipeline. If the site is to be impacted then additional recording will be required.

Hasdon Midden 1 is a scatter of flaked stone artefacts and some shell. No site size is provided, although four artefacts were recorded in a 2 m² sample square. Economic shell species identified in the site include: *Saccostrea* spp., *Terebralia* spp., *Anadara* spp. and *Melo* spp. Given the presence of coral blocks and mangrove branches amongst the economic shell**,** Murphy and McDonald (1990) couldn’t rule out the possibility that this site may be natural; created by storm surges during cyclones. The proposed DOMGAS pipeline may impact this site, and it should be relocated to determine its position in relation to the proposed pipeline. If the site is to be impacted then additional recording will be required. Depending on the site recording it may also need to be test excavated to determine the potential for stratified cultural material.

Hadson Midden 2 is a scatter of two flakes and one muller immediately behind the coastal mangroves (Murphy & McDonald 1990). Economic shell species were identified at the site including: *Anadara* spp., *Terebralia* spp., *Melo* spp., *Syrinx* spp. and *Tectus* spp. Murphy & McDonald (1990) concluded that “at such close proximity to the shoreline, much of this shell could have been deposited through wave action, but the artefacts indicate that some were probably the result of gathering activities”. DOMGAS pipeline may impact this site, which should therefore be relocated to determine its position in relation to the proposed pipeline. If the site is to be impacted then additional recording will be required. Depending on the site recording it may also need to be test excavated to determine the potential for stratified cultural material. It is noted, however, that penetrometer tests along the Apache/Hadson pipeline indicate that beneath a thin crust the mangrove mud is semi-liquid (Murphy & McDonald 1990) and that test excavation may be pointless. This geomorphological factor requires further investigation before test excavations are conducted.

Possible retouched glass artefacts were identified on the Macey's Shipwreck site near the Apache pipeline during a maritime archaeology survey (McCarthy 1991). This site may be impacted by one of the proposed DOMGAS pipeline, even though the location of the shipwreck is uncertain. The identification of these artefacts is yet to be determined by an Indigenous archaeologist. This site needs to be relocated to determine its position in relation to the proposed pipeline. If the site is to be impacted then additional recording will be required including the identification of the retouched glass artefacts.

4.2 HISTORIC HERITAGE

4.2.1 Barrow Island

Barrow Island is potentially significant for the historical archaeology of north Western and continental Australia. The reasons are as follows.

1. Remoteness and potential for preservation (as demonstrated for Dampier Islands).
2. Types of sites (rarity).
3. Significance of association with historical activities (regional, state, national and international).

The following list summarises the historical activities reported in historical sources. The list does not contain any references, however, Appendix 3 contains an annotated summary of sources used to compile the list.

1. Explorers
   a) 1840: H.M.S. *Beagle* visited Barrow Island.
   b) 1846: J. Lort Stokes visited Barrow Island.
   c) 1864: Captain Jarman exploration of island (20 December 1864). Probably camped at Whitlock Cove.
   d) 1900: J.T. Tunney visit for two months.
   e) 1917, 1918: Naturalist F. Lawson Whitlock (1917, unknown time; 1918, two weeks). Camp based at Whitlock Cove and exploration of neighbouring coastal zone from Surf Point to Dove Point and Double Island.
2. Whaling
   a) Whalers were probably present in these waters from 1800 onwards, with records from the 1840s. Two reported whalers at Barrow Island were:
      i) 1842, 21 June, 4 August: *Stephania.*
      ii) 1864, 22 July: *Canton.*
3. Pearl shell industries
   a) The foundation for the pearling industry closely followed exploration and settlement for pastoralism. Exploration to Nickol Bay by AC Gregory in 1861 marks the inception of the industry with the collection of several tonnes of mother-of-pearl and pearls (Moore 1994). Pearl shell industries operated with varying degrees of success from this period up until the 1930's, especially on the Montebello Islands.

b) It would appear that the colonial government was not aware of how many pearling camps operated from Barrow Island. The reporting of the measles epidemic in 1885 by Blair E Mayne to the Legislative Council would indicate that some knew of the pearling operations.

c) In 1926 one pastoral lessee applicant reported that the island was used by pearlers.

4. Quarantine station

a) September 1884: measles epidemic. Barrow Island was converted into a quarantine station for Aboriginal people with measles, apparently those from the pearl shell industries, brought from mainland. Location unknown, but would be sheltered anchorage. Schooner *Amy* as medical ship, with no description of accommodation on Barrow Island for the ill. The numbers of people involved in the epidemic is no known nor is the number who died.

5. Lock Hospital

a) 1908, Barrow Island Lock Hospital, presumably for venereal diseases. Requisition for blankets in 1908 granted. Location not yet known nor relationship with Nature Reserve created in 1908.

6. Aboriginal uses

a) Pre-European use (see Section 4.1 above).

b) 1884: Quarantine Station (see above).

c) 19^{th} century: Aboriginal slave markets (reports related to 1870s), see point 7 below.

d) 1908: Barrow Island Lock Hospital (probably abandoned in favour of Bernier and Dorre Islands by 1909).

e) 1908: Aboriginal Reserve (for Lock Hospital).

7. Barracoon and slave market

a) There are references to Aboriginal people being taken from the Ashburton region to Barrow Island to be sold, presumably to pearlers, in the later 19^{th} century. In 1880 the police found 22 Aboriginal people who had been marooned on Barrow Island, a crime for which a pearler was fined.

b) Specifically, during the first half of the 1870s, Captain Cadell, an infamous Scottish adventurer, reportedly established slave markets for pearl shell operators on Barrow Island (also Delambre and Enderby islands), both of female and male Aboriginals.

8. Pastoral industry

a) 1873: application by F. McRae and Co. (Cossack, Roebourne) for a pastoral, turtle shell and fish oil lease. (In 1880 F. McRae signed for 22 Aboriginal men who were then marooned on Barrow Island by a third party).

b) 1874, August: lease for turtle and general fishing for James Grimmond Anderson, and for pastoralism.

c) 1897: leased by William MacNean (Roebourne) for pastoral purposes (transferred to Cooke).

d) 1880, August: Messrs. Henry J. Cooke and James Morrell, sheep station lease. They were reportedly not satisfied some months later and were considering abandoning the lease. It was reportedly for sale on 24 January 1882 along with 600 sheep.

e) 1892: Leased to James Archibald Haste (Carnarvon), although lease lapsed in 1893.

f) 1897, July: Application by James Clarke and Co. for pastoral lease for Barrow Island. (Probably not taken up).

g) 1900, February: Application by John Hurst for pastoral lease for Barrow Island.

h) 1902, January: Application by James Waterhouse King for pastoral lease for Barrow Island.

i) 1904, August: Application by Alexander Stevens (Onslow pearler) for pastoral lease for Barrow Island. (Lease forfeited in 1907).

9. Turtle fishing

    a) 1871, 1872: descriptions related to establishment of turtle fishing industry on Barrow and Delambre islands by C. Lambert Smith.

    b) 1873: application by F. McRae and Co. (Cossack, Roebourne) for a pastoral, turtle shell and fish oil lease. (In 1880 he signed for 22 Aboriginal men who were then marooned on Barrow Island by a third party).

    c) 1874, August: lease for turtle and general fishing for James Grimmond Anderson, and for pastoralism.

    d) 1900, November: application for turtle fishing lease by Emmeline Collier Clark (100 acres).

10. Phosphate extraction

    a) 1883: Possible extraction of guano had begun as a ship visited expecting to collect a cargo of guano.

    b) 1907, August: Application by F.C. Broadhurst for 50,000 acres of land (Barrow Island) for phosphate extraction (presumably following his successful guano extraction industry in the Abrolhos Islands).

    c) 1923: Licence for removal of guano and phosphates for A.G. Kidson-Hunter.

11. Nature Reserve

    a) 1907, August: declared a reserve for native game under the Game Act.

    b) 1910, February: declared Class A Nature Reserve. Soon after this classification visits by naturalists such as L. Whitlock occurred.

12. Oil extraction

    a) 1964: oil discovered at Rough Range. Exploration extended to include Barrow Island.

    b) 1964: first oil well drilled.

    c) 1967: commercial production began with over 800 well and production peaking in 1971 with 50,000 barrels per day.

    d) 2000: Chevron took over management of assets. Today approximately 455 wells are producing oil and people working and living on the Island number from 150-200 and rotate in two-week shifts.

It is difficult to determine whether all of these activities occurred, and some indeed may merely reflect 19th century speculation. This is most pertinent for the pastoral leases described above: there is no evidence for sheep pastoralism having occurred at this place. However, it is reasonable to suspect that many such activities did in fact take place; their absence from historical annals being common to records of much of colonial Australia.

It would appear that the island was used by pearlers for a long period of time, and had several other historical functions. A recent survey by Paterson and Souter of historical sites on islands in the nearby Dampier Archipelago found archaeological evidence for many similar activities despite a paucity of historical reports. This was a remote and poorly serviced frontier of colonial Australia, and many of the actions were intended to be conducted beyond the gaze of officialdom; accordingly the paucity of comprehensive historical accounts is not surprising.

The types of historical archaeological material that could be expected to occur on Barrow Island includes: artefact scatters, foundations, burials. There are numerous drownings reported in the waters around the island, although the bodies were not necessarily recovered. There are also murders reported for the Barracoon in the 19th century. The following are five reported burials; however, given the evidence from similar islands in the Dampier Islands, other burials would be expected along the coast of Barrow Island:

1. 1872, European man;
2. 1887, Malay seaman;
3. 1904, Malay pearler;
4. 1904, Chilean sail maker;
5. 1885: there were Aboriginal deaths at the measles quarantine station.

4.2.1.1 Previous Surveys

While the Quartermaine Consultants (1994) survey was for Indigenous archaeological sites, the report does contain information relating to historical sites. A total of five locations with historical material were recorded (labelled Pearling Camps). Three sites were recorded with flaked/retouched glass artefacts made by Indigenous people most likely brought to the island by Europeans. Modified glass artefacts have been found in Aboriginal contexts across Australia, and are essentially unknown for European contexts (cf. Wilkie 1996). If the artefacts are found to be made in ways consistent with Aboriginal tool manufacture then it is widely assumed that they are Aboriginal (Allen & Jones 1980; Cooper & Bowdler 1998; Freeman 1993; Harrison 1996; 2000). In addition historical material was noted at South End, Bandicoot Bay and Square Bay (Quartermaine Consultants 1994:19-20, 22, 25). The material identified includes limestone foundations, boat parts, bottles, brass studs and buttons most likely associated with pearling camps.

The site descriptions by Quartermaine Consultants (1994) and observations made during the visit to Barrow Island in 2004 (see Appendix 2) suggest that:

1. Where possible the beach pipeline landing sites of Whites Beach, Flacourt Bay and the area south of Town Point should be surveyed for historical sites. These

areas were surveyed briefly in March 2004 and there are no surface archaeological sites other than site GD04-02, which is a small scatter of late 19th century olive bottle glass at Flacourt Bay (see Section 4.2.1.2, below). The area at the Town Point landing was visited briefly on a medium tide and material related to the WAPET landing was present on the coast. None appeared to be older material, although a more comprehensive survey would be required to support this position.

2. The area to be developed at Cape Dupoy should be surveyed. This area was visited but no proper survey was conducted.

The historical uses of the island tend to be coastal as all visitors required access to the island by the coast. Accordingly sheltered beaches and the neighbouring islands should be considered areas of high potential for historical archaeological sites. Section 5 discusses procedures for the discovery, reporting and management of archaeological resources.

4.2.1.2 Sites

Two sites with historical material may be affected by the proposed Gorgon Development; site 888 (FS06) and GD04-02.

Flaked glass and porcelain was identified at site 888 (FS06) in Area A (Quartermaine Consultants 1994:17-18, Appendix 3). Area C may be impacted by the proposed CO_2 Pipeline and while no historical material was identified at this part of the site, there is potential for sub-surface cultural material. This site is discussed in more detail in Section 4.1.2.1.2, above (see also Appendix 1 and 2). An historical archaeologist should participate in any test excavation of this site.

Site GD04-02 was identified during the March 2004 field visit (see Appendix 1 and 2). This glass artefact scatter is in Flacourt Bay and may be impacted by the proposed Feed Gas Pipeline. The scatter comprises glass fragments from a single light olive glass bottle or a champagne beer bottle common in the late 1800s and early 1900s. While rare on Barrow Island, elsewhere along the Australian coast this is a common artefact, and could be collected prior to the site being disturbed. There may however be buried archaeological material at this site and the procedures for site disturbance detailed in Section 5 should be followed.

While not within the Gorgon Development, the most significant historical site identified to date is a pearlers' camp at Bandicoot Bay [DIA site 891 (FS09)], which is of national, state and regional significance. Of great interest are the flaked/retouched glass artefacts identified by Quartermaine Consultants (1994:19-10, Figure 15) as Kimberley points (Figure 4-2). If this identification is correct this is an extremely rare site which may indicate the presence of Indigenous people from areas beyond the Pilbara. This is not recorded in documentary sources and thus the archaeological record is the primary data set. Artefactual material has been collected from this site in the past and it must be protected from future visitation from current and future workers on Barrow Island.

4.2.1.3 Collected Artefacts

A large number of collected artefacts are housed in the Barrow Island Environment Laboratory. These artefacts have been collected by WAPET staff and consultants since the 1960s. In excess of 200 historical artefacts are in the collection, including Indigenous flaked/retouched glass artefacts, bottles, nails, buttons and shells. They have not been catalogued and no provenance is recorded for the majority of the artefacts.

Also included are historical artefacts from previously recorded site 891 (FS09) which were displayed on a foam ‘museum-type’ display in the past by WAPET employees. The artefacts included metal clothing items, fasteners, glass artefacts, ship parts and a clay pipe. Some of these items have been affixed with solvent fixatives (glue) to a backing board. The fixture of these items may have affected them and thus require attention by a curator qualified to stabilise historical artefacts subjected to damage of this type.

Other artefacts of unknown provenance are included in the collection; unfortunately these are of little scientific value outside of their archaeological context. They do however indicate quite a rich historical and maritime history of the island and should be recorded and catalogued to ascertain if they were collected from areas within the Gorgon Development.

Figure 4-2. Retouched glass artefact - Bandicoot Bay Pearling Camp (891/FS09)

4.2.2 Mainland

On the mainland the DOMGAS pipeline may impact on a maritime site. Thi shipwreck site contains possible historical flaked glass artefacts and is discussed in more detail in the Maritime Archaeology Section 4.3.1. No formal historical cultural heritage studies have taken place along the DOMGAS pipeline. To assess adequately the possible impact of the proposed development on historic/maritime cultural heritage, systematic pedestrian sample surveys will be required prior to construction.

4.3 MARITIME HERITAGE

An archival search has been undertaken to identify potential maritime archaeological sites, namely shipwrecks, in the study area. There are no known shipwreck sites on the proposed Gorgon pipeline routes although archival sources suggest that a number of significant vessels have been lost in the Onslow/Barrow Island region. The vessels identified have not been located post-wrecking and the exact position of sites is not known. Utilising Government archives from the Department of Customs, Harbour and Lights; and Police as well as newspaper reportage, research has been undertaken in an attempt to identify what vessels were lost in the vicinity of Barrow Island and to give an approximate location of the wreck sites. An assessment of the following shipping registers was also carried out to locate potential sites in the region:

1. *Register of Wrecks; Strandings and Mishaps of British Ships, Port of Fremantle* Her Majesty's Customs, Perth. (Transcribed by McKenna, R., 1967).
2. *Ships Registered in Western Australia* National Archives. Perth (Transcribed by Dickson, R. Report–Department of Maritime Archaeology, WA Maritime Museum No.80.).
3. *Register of Wrecks and Casualties in Western Australia 1897-1942, Her Majesty's Customs* Department of Marine and Harbours. (Transcribed by Dickson, R. Report–Department of Maritime Archaeology, WA Maritime Museum No. 56).
4. *Register of Accidents and Incidents from 1916-1972.* Department of Marine and Harbours. (Transcribed by Dickson, R., Report–Department of Maritime Archaeology, WA Maritime Museum No. 56).
5. *Register of Shipping Arrivals and Departures at the Port of Fremantle* (Battye Acc No. 1076).

The majority of shipwrecks recorded, occurred during cyclonic activity in the summer months in the Onslow region. It is important to note that a number of vessels engaged in pearling operations in the North West were unregistered pearling luggers. Consequently there is little archival evidence relating to the types and actual numbers of vessels working and/or lost in the region. The potential for lugger shipwreck sites to occur in the vicinity of Barrow Island must therefore be considered given the proximity of the island to 19th century pearling grounds and shipping routes related to that industry. Whether there is any residual wreckage, which would constitute an archaeological site, can only be determined on discovery. The Fugro video survey of one proposed track for the pipeline does not reveal any immediate cultural material although at particular points on the route the surveyor reported marginal visibility (Jeremy Fitzpatrick, BBG pers. comm. 25/02/04). Although shipwreck sites most often occur in shallow reef areas, the possibility of sites in deep water also needs to be acknowledged. Based on the recent inspection by the WA Maritime Museum, Department of Maritime Archaeology, of a lugger site off Port Hedland (Gainsford & Kimpton 2003), it should be noted that the potential exists for wreck sites to occur in deeper water, from vessels foundering during cyclonic conditions.

The pearl shell fishery established in Western Australia in the nineteenth century was first centred in Nickol Bay, near Karratha around 1864 and later Broome in the

Kimberley circa 1880[3]. The story of the pearling industry unfolds in contemporary accounts in the local press and in various diaries and reminiscences such as those of R.J. and T.C. Sholl, A.R Richardson, L.C. Burges, Charles Harper, the McCrae brothers and others. Streeter's (1886) account of 'Pearls and Pearling Life' gives a first hand and most useful coverage of many aspects of the industry. The subject has also been covered in recent times by de La Rue (1979), Albertus Bain (1982) and in numerous unpublished accounts.

The cyclones which resulted in major losses to the pearling fleets and other craft in the pearling grounds between and including Exmouth Gulf and Broome are as follows:

1. 1881/01/07 Five identified luggers wrecked. At least six other pearling vessels, reportedly damaged or stranded, survived on this occasion, some to be victims of similar weather patterns in later years.
2. 1882/03/06 One identified lugger lost.
3. 1905/02/08 Two identified luggers lost.
4. 1909/04/06 Four identified luggers and 24 lives lost. The luggers are unregistered but two have been identified as the *Elsie* and *Penguin*.
5. 1911/02/06 Two identified luggers lost.

The archival research undertaken to identify potential maritime archaeological sites, focuses on the area from West Tryal Rocks gas field to Barrow Island. Even though a number of potential sites have been identified in this report relating to the proposed pipeline route to the mainland, this information should be considered as preliminary only, as the mainland DOMGAS pipeline has not been surveyed. The research thus far suggests there are expected to be a number of sites in the Mary Ann Passage and Yammadery Creek areas. Appendix 4 gives a comprehensive list of 13 projected sites in the region. Four of these are considered most likely to be in the Barrow Island area:

1. *Wild Wave* (1873).
2. *Ruby* (1882).
3. *Marietta* (1905).
4. *Curlew* (1911).

Acoustic characteristics and seabed interpretation by Fugro along parts of the proposed Flacourt Bay Pipeline option and the propose Port Facility were inspected as part of this assessment (Fugro 2003). Fugro grouped 10 bottom types along the route (A-J) ranging from uniform low acoustic reflectivity (sand), grading to higher acoustic reflectivity (sand-rock/reef with vegetation). The seabed along the majority of the Feed Pipeline is smooth with the exception of areas of moderate to high relief rock outcrop [KP 10.8 (40 m depth) and KP 12.38 (43 m depth); KP24.9 (53 m depth) to KP 27.26 (55 m depth)]. The Fugro recommendation that a block survey be carried out in the anticipated areas of very uneven seabed to choose an optimum route is also

[3] The exact number of vessels operating in this industry is unclear in the archival sources as many of the vessels were unregistered. Furthermore owing to the frontier nature of the North-West colonial government controls and inspections were very limited.

supported as these locations have the highest probability for wreck sites. Any further sub-sea acoustic and/or video image of the proposed development should be made available to a maritime archaeologist for assessment.

Figure 4-3. Pearling luggers, North-west coast Western Australia (Copyright McKenna Collection, WA Maritime Museum)

Other WA Museum records relating to maritime archaeological sites mentions two on Barrow Island:

1. A whaling harpoon was discovered in 6 feet of water by Mr Charlie Alt while skin diving in 1969 at Cape Poivre on the West Coast of Barrow Island (MA 439/71).
2. A ‘man-made rock ring wall’ which is described as ‘10ft and almost circular with only two sections visible’. A small hole was dug by WAPET employees again in 1969 approximately 2x2 ft but there was ‘noting apparent’. This site was assessed as a ‘maritime’ structure and referred to the Department of Maritime Archaeology in 1985. McCarthy in his visits to the Montebellos in 1985 mentions seeing similar sites on Hermite Island which fit this description which he identified as wells or shafts (McCarthy, 1985. MA 439/71).

These sites were not investigated during the March 2004 preliminary survey as they are located outside the proposed Gorgon Development.

4.3.1 Mainland

On the mainland the DOMGAS pipeline may impact on a maritime site, but no formal maritime cultural heritage studies have taken place. There is a reported shipwreck close to Varanus gas pipeline located below high water mark. This site was examined in 1991 when identified in a preliminary survey for the Apache/Hadsen Gas pipeline (McCarthy 1991). The wreck appears to be that of a small unidentified late nineteenth-early twentieth century wooden sailing vessel of approximately 20 m in length that was engaged in the Northwest coastal pearling trade (McCarthy 1991:6). Although heavily salvaged, the wreck still possesses some cultural significance as one of the few tangible remains of the late nineteenth century pearling industry. The suggestion of Indigenous associations was made with the discovery of 'worked' nineteenth century bottle glass in association with the site. The wreck cannot be accurately dated though it is felt that it may pre-date 1900 and could therefore be protected under the *Maritime Archaeology Act 1973* (McCarthy 1991:8). In light of the above, to assess adequately the possible impact of the proposed development on historic/maritime cultural heritage, systematic pedestrian sample surveys will be required prior to construction.

4.4 CONCLUSIONS

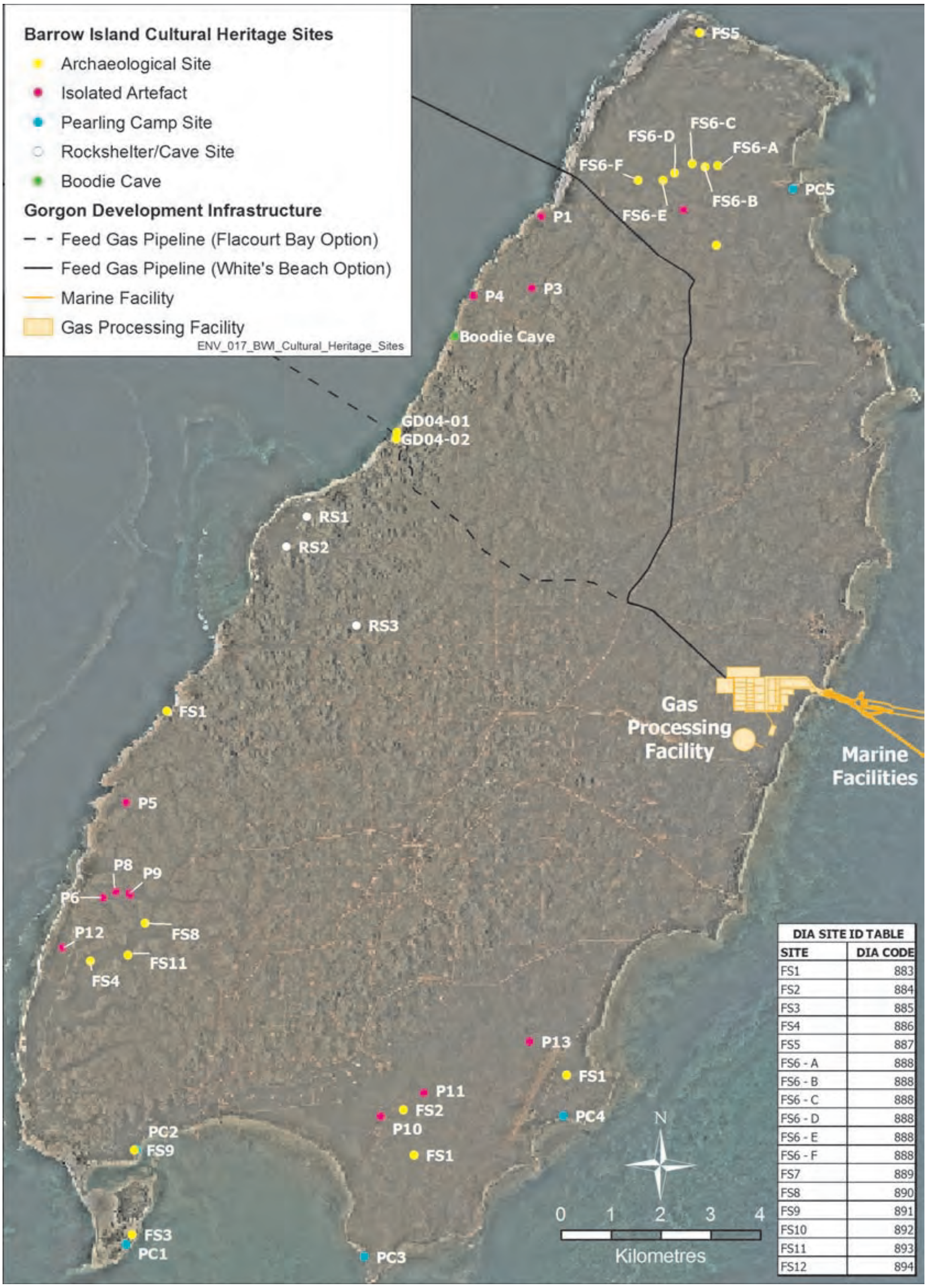
It is clear from the above assessment that Barrow Island and other islands in the immediate region like the Montebello's and Lowendal's hold an unusual place in the pre-history and history of Western Australia. While some cultural heritage assessments have been undertaken on Barrow Island and mainland pipeline route it is concluded that additional site specific cultural heritage studies are required to identify cultural heritage sites that may exist within the development.

The major conclusions of the assessment are:

1. Three Indigenous communities (Yabburara/Mardudhunera, Kurama Marthudunera and Thanlanyji) have expressed an interest and need to be consulted in relation to cultural heritage management within the proposed Gorgon Development. This consultation may include inspection of the proposed development on Barrow Island and on the mainland.
2. That at present:
   a) Two identified cultural heritage sites may be impacted on Barrow Island by the proposed Flacourt Bay Feed Gas Pipeline Option (see Map 4-1).
   b) Four identified cultural heritage sites may be impacted on the mainland (see Map 4-1).
3. Owing to the low level of formal investigation, prior to construction all proposed ground disturbance areas including the seabed should be systematically surveyed for Indigenous, historical and maritime cultural heritage.
4. Proposed construction should be monitored in areas of high potential for sub-surface cultural material. Areas of high potential have been identified as occurring in the following topographic features; claypans, coastal dunes and adjacent to drainage lines (Map 4-3).

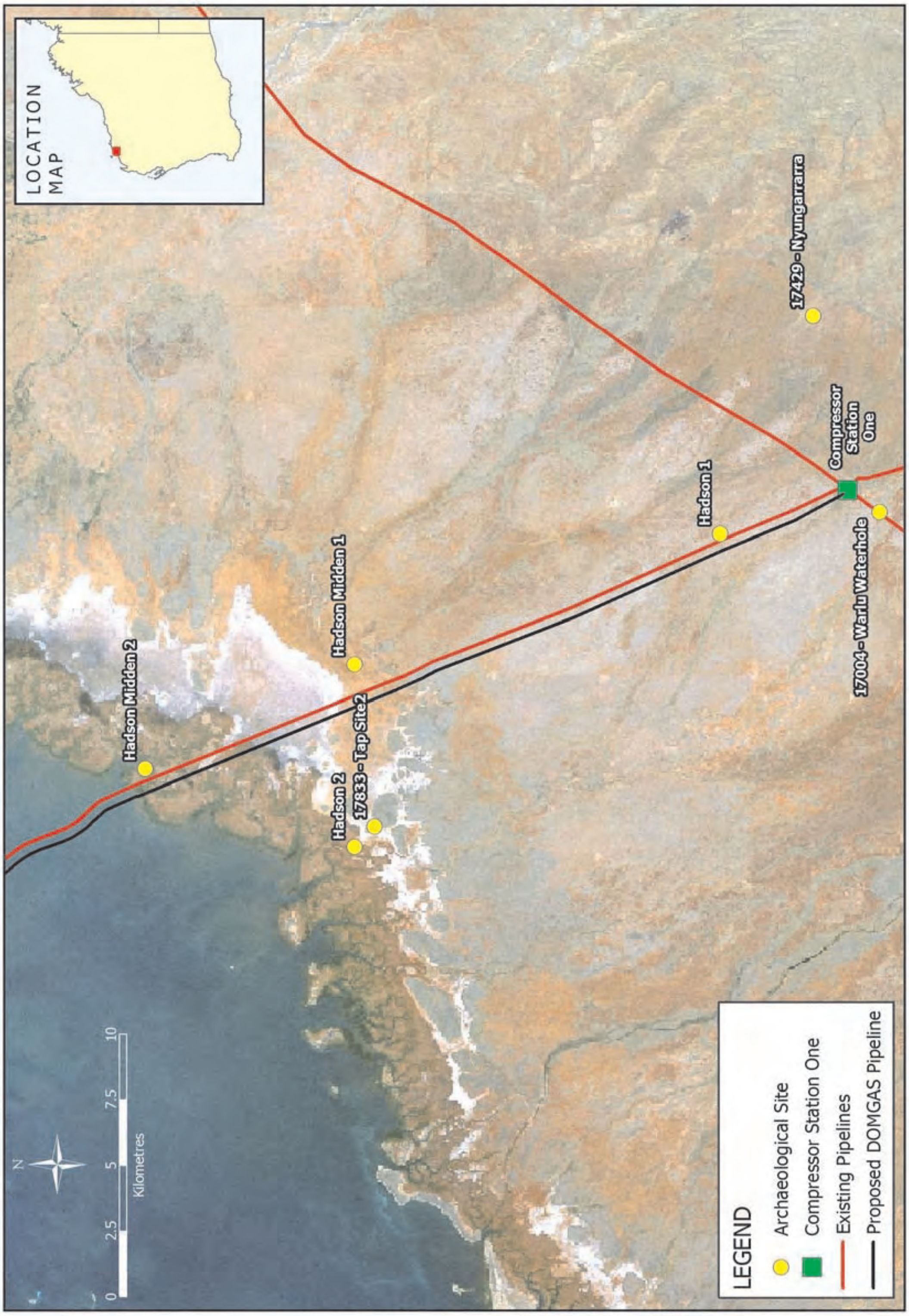
In accordance with the brief from CTA a draft Cultural Heritage Management Plan (CHMP) has been prepared for the development (see Section 5). This CHMP contains recommendations regarding how CTA can manage known and unidentified cultural heritage within the Gorgon Development.

Map 4-1. Gorgon Development- location of cultural heritage sites on Barrow Island

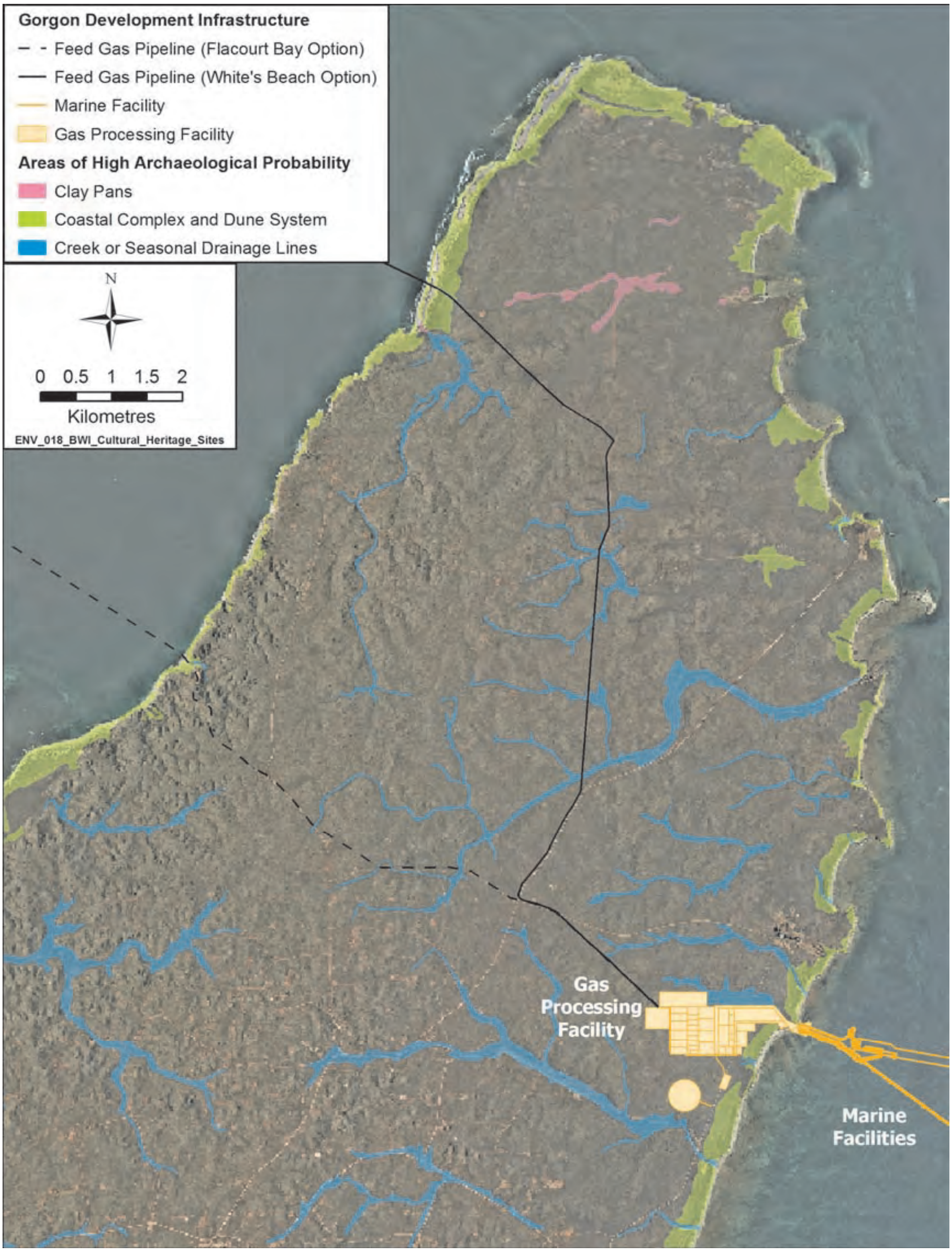


DIA SITE ID TABLE	
SITE	DIA CODE
FS1	883
FS2	884
FS3	885
FS4	886
FS5	887
FS6 - A	888
FS6 - B	888
FS6 - C	888
FS6 - D	888
FS6 - E	888
FS6 - F	888
FS7	889
FS8	890
FS9	891
FS10	892
FS11	893
FS12	894

Map 4-2. Gorgon Development- location of cultural heritage sites on Mainland



Map 4-3. Barrow Island high archaeological potential areas



5 DRAFT CULTURAL HERITAGE MANAGEMENT PLAN

5.1 CULTURAL HERITAGE PRINCIPALS

Cultural heritage is an important resource to all Australians. To protect this resource, the following principles and procedures are recommended:

1. Prior to construction all proposed ground disturbance areas should be inspected/surveyed by qualified Indigenous, historical and maritime cultural resource management (CRM) practitioners.
   a) At least 50% of the Gorgon Development should be systematically surveyed for Indigenous and historical/maritime terrestrial archaeological sites.
2. Indigenous people should be consulted and given the opportunity to inspect the proposed development on Barrow Island and the mainland with a qualified anthropologist.
3. In areas with the high potential for sub-surface cultural material (such as claypans, coastal dunes and adjacent to drainage lines), any proposed ground disturbance should be monitored by qualified CRM practitioners.
4. All reasonable precautions are to be taken to protect cultural places from damage caused by construction and associated activities.
5. To facilitate an awareness of cultural heritage, a suitable induction program should be included for all personnel associated with and involved in the construction of the Gorgon Development.
6. A Cultural Heritage Officer should be employed during the construction phase to provide on the ground advice. This cultural heritage officer should have experience in both Indigenous and historical CRM.
7. When appropriate, additional professional expertise should be sought on archaeological matters, such as advice from a physical anthropologist if human skeletal material is identified.
8. Surveying, monitoring and management of Indigenous sites should involve Indigenous people.
   a) During the ethnographic survey the anthropologist should determine the level and detail of the Indigenous community's involvement in the monitoring and management of Indigenous sites that will be impacted by the Gorgon Development.
   b) Respect for Indigenous culture by all parties is fundamental to effective Indigenous cultural heritage management.
   c) Indigenous people's beliefs and cultural knowledge remain their property.

5.2 CHMP RESPONSIBILITIES

1. CTA and its contractors should meet all its obligations with respect to the CHMP.
2. CTA should ensure that the appropriate permits governing cultural heritage management are in place before the commencement of construction. This could include but is not restricted to:

a) Permission under Section 18 of the *Aboriginal Heritage Act 1972* from the Minister of Indigenous Affairs to disturb Indigenous cultural heritage sites that will be impacted by the proposed development.

b) Section 16 permit from the Registrar of Aboriginal Sites under the *Aboriginal Heritage Act 1972* to excavate for archaeological investigation purposes any Indigenous archaeological sites with the potential for sub-surface cultural material that will be impacted by the development.

c) The Heritage Council of Western Australia should be advised of and, if required, consulted regarding historical sites given that the island is listed on the State Register of Historic Places.

d) The Director of the WA Maritime Museum and the Director of the Western Australian Museum should be advised, in writing, regarding the discovery of all maritime archaeological sites.

3. CTA should ensure that all areas likely to be impacted are assessed for cultural heritage by qualified CRM practitioners and Indigenous people before commencement of ground disturbance.

4. CTA should ensure that its staff and contractors are aware of their responsibilities under the CHMP to protect cultural heritage sites within and adjacent to the Gorgon Development. CTA should ensure that all personnel on site attend an induction course covering:

   a) Relevant cultural heritage legislation.

   b) Obligations under the CHMP, specifically their responsibilities regarding the protection and management of cultural heritage.

   c) Types of cultural heritage sites and guides on how to identify them.

   d) Procedures for reporting new cultural heritage sites and objects.

5.2.1 Notification and Reporting

1. The Cultural Heritage Officer, Government departments, Indigenous organisations and CTA should provide each other with all necessary information to carry out the CHMP and this information should be provided in a timely manner.

2. CTA and its contractors should endeavour to provide the Cultural Heritage Officer with daily briefings of work schedules at least two days prior to the implementation of the work schedule to allow coordination of any monitoring arrangements. (It is expected that the necessity for these briefings will reduce as construction on site becomes established).

3. The Cultural Heritage Officer should be informed of any substantial alterations to the work schedule as soon as is practicable and in sufficient time to allow the arrangement of the presence of the required monitors.

4. In the event of wet weather, industrial action, equipment unavailability or other factors halting construction, the Project Manager or other designated person shall notify the Cultural Heritage Officer without delay that work is to be suspended and when resumption is expected.

5. The Cultural Heritage Officer should maintain the following records:

   a) Daily work reports for Cultural Heritage Officer and monitors.

   b) Site inspection reports, including reports on discovery and disposition of material during monitoring.
   c) Incident reports relating to any breach of the CHMP.
6. Reports on fieldwork during construction should be prepared on a weekly basis by the Cultural Heritage Officer. Copies should be forwarded to CTA, the Indigenous people, the DIA, the Maritime Museum and the Heritage Council.
7. Incident reports relating to any breach of the CHMP shall be forwarded to CTA, the relevant cultural heritage authority and the Indigenous people as soon as practicable after the event.

5.2.2 Review Process

1. There should be periodic reviews (frequency to be determined by the review committee listed below) of the implementation of the CHMP. The review committee should consist of:
   a) Cultural Heritage Officer.
   b) An appointed representative of each of the Indigenous groups.
   c) Nominated authority for the DIA.
   d) Nominated authority for the Heritage Council.
   e) Nominated authority for the Maritime Museum.
   f) CTA Environmental Officer.
   g) CTA Project Manager.
2. The committee should examine all aspects of the implementation of the CHMP and prepare a report.
   a) The Cultural Heritage Officer should coordinate the report production and forward to all members of the review committee.
   b) All parties should consider in good faith all recommendations of the review committee and implement them as part of the CHMP.

5.3 PROTECTION OF CULTURAL HERTIAGE SITES

1. Prior to the commencement of ground disturbance activities CTA should ensure that the proposed development is surveyed for cultural heritage sites. Specifically:
   a) Indigenous Heritage
      i) Inspection of proposed disturbance areas by Indigenous people and a qualified anthropologist.
      ii) Sample survey by qualified archaeologists of not less than 50% of proposed disturbance areas.
   b) Historical Heritage
      i) Sample survey by suitably qualified archaeologists of not less than 50% of proposed disturbance areas.
   c) Maritime Heritage
      i) Sample survey by suitably qualified archaeologists of not less than 50% of proposed disturbance areas in terrestrial contexts (above the low water mark).

ii) In relation to the underwater development areas, detailed acoustic and/or video imaging should be carried out prior to disturbance to ensure there is no maritime cultural material, shipwreck or otherwise.

2. That ground disturbance in areas with high potential for sub-surface cultural material (coast and claypans) should be monitored by the Cultural Heritage Officer and Indigenous people.
3. All known site details are listed in Appendix 1. Each site location should be assessed by CTA to determine its position in relation to the proposed development. Some sites might be found to occur outside the proposed disturbance areas.

5.3.1 Known Cultural Heritage Sites

1. Management practices should follow the recommendations for each site as detailed in Table 5-1 and Appendix 1.
2. Known cultural heritage sites should be recorded on all work plans and maps.
3. Before any activities begin near a recorded cultural heritage site, the site should be identified and flagged by the Cultural Heritage Officer.
4. Protection of the site may include the erection of temporary barriers or fences on advice from the Cultural Heritage Officer.
5. Access to cultural heritage sites should be restricted to essential personnel and contractors should adjust activities to ensure avoidance of any culturally significant sites during their activities.

5.3.2 Inadvertent Discovery

Places and items of cultural significance may be uncovered during the construction phase, particularity on coastal and claypan areas. These could include:

1. Burials (particularly within coastal dunes).
2. Indigenous artefacts.
3. Historical / maritime artefacts, structures or shipwrecks (particularly within 200 m of the high-tide mark).

5.3.2.1 Burials

As discussed in Sections 4.2 and 4.2.2, there is the potential for burials on Barrow Island. The discovery of human remains[4] brings into play the following legislation:

1. *Coroners Act 1996* – all human remains.
2. *Aboriginal Heritage Act 1972* – Indigenous burials.
3. *Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984* - Indigenous burials.
4. *Maritime Archaeology Act 1973* and the Federal *Historic Shipwrecks Act 1976* - burials associated with "historical ships".

[4] The term 'human remains' is used as a generic term, no disrespect to Indigenous people, their relatives or other people of Aboriginal or Torres Strait Islander descent is intended or implied in its use.

Should human remains be found during construction, the following procedure should be adopted.

1. On discovery of skeletal material:
    a) All work should cease at the location and the Cultural Heritage Officer should be notified, if not already present at the location.
    b) Reasonable efforts to protect the remains shall be made. Note that the material should not be removed or disturbed further but buffer zones or temporary barriers may be appropriate.
    c) Construction workers and operational personnel should comply with the instructions of the Cultural Heritage Officer. Construction may continue at an agreed distance away from the site.
    d) All personnel and contractors on site should be advised that it is an offence under the *Coroners Act 1996* and the relevant heritage legislation to interfere with the remains.
    e) The Works Manager or Supervisor and the CTA Project Manager should be notified.
    f) Under Section 17 of the *Coroners Act 1996* the local Police / Coroners office must be notified. Direction in the first instance should be taken from the Police. However, given the potential significance of any burials, an archaeologist/physical anthropologist with demonstrable experience in excavating Indigenous and historical burials should supervise the removal of the human remains, as the skills required for this form of excavation are beyond that of police forensic teams.
    g) If human remains are suspected to be Indigenous then the Registrar of Aboriginal Sites at the DIA must be informed. In addition the Federal Minister for Indigenous Affairs needs to be informed.
    h) At the same time as other individuals and agencies are contacted, the Cultural Heritage Officer should notify Indigenous people of the discovery, the steps which have been taken and make appropriate arrangement for nominated Indigenous people to attend the site, if not already present.
    i) Indigenous people should be consulted as to the management of the material once Indigenous origin has been determined.
    j) No further work at the locations should be undertaken until all parties have been consulted and agreement has been reached.
    k) The location of the burial should be recorded in sufficient detail for its future protection.
2. In consultation with the Police/Coroner and DIA staff steps need to be taken to identify the skeletal material. A physical anthropologist should be engaged to complete this task on site.
3. Any remedial works should be undertaken in consultation with the Cultural Heritage Officer, the DIA and Indigenous people.
4. If the human skeletal remains are Indigenous or unknown, and all parties agree to the relocation of the material:

   a) Section 18 approval to disturb and a Section 16 permit to excavate for archaeological purposes under the *Aboriginal Heritage Act 1972* should be obtained to conduct this work.
   b) A data recovery programme, planned in consultation with the Indigenous people, a qualified physical anthropologist and the DIA, should be developed and implemented. This should include recording of the location of the burial and other features as required by the Indigenous people.
   c) Representatives of the Indigenous people should be present during the recovery phase.
   d) A suitable keeping place or re-interment location should be negotiated between CTA, the Indigenous people and the DIA.
5. If the human skeletal remains are non-Indigenous and of a historical nature and cannot be avoided:
   a) The Heritage Commission and the Maritime Museum should be consulted regarding the proposed disturbance
   b) A data recovery programme, planned in consultation with the Heritage Commission / Maritime Museum and a qualified historical archaeologist / physical anthropologist, should be developed and implemented.
   c) An historical archaeologist / physical anthropologist with demonstrable experience in excavating burials should supervise the removal of the grave contents.
   d) The curation / collection of any excavated materials should be negotiated between CTA and the Heritage Commission / Maritime Museum.

5.3.2.2 Indigenous Archaeological Sites

1. The potential for surface and buried cultural deposits is potentially high in coastal areas and claypans. If surface or buried material is uncovered during construction, the following procedures should be undertaken:
   a) All work in the immediate vicinity of the find must cease and reasonable efforts to secure the discovery should be made. Work can continue at an agreed upon distance from the site. Note that the material should not be removed or disturbed further but barriers or temporary fences may be erected as a buffer around the remains if required.
   b) The Cultural Heritage Officer, if not already present, and appropriate CTA managers should be notified.
   c) DIA should be contacted and advised of the situation.
   d) The Cultural Heritage Officer should create accurate records, including map references and photographs of the material and an *in situ* evaluation of the find.
   e) A written statement of the Cultural Heritage Officer findings and recommendations should be provided to the DIA and the Indigenous people for their consideration.
   f) Based on the recommendations of the Cultural Heritage Officer, decisions regarding the treatment of the find shall be made in consultation with the Indigenous people and the DIA.

2. If the find cannot be evaluated without further archaeological work, then the following procedure should be undertaken:
   a) Section 18 approval to disturb and a Section 16 permit to excavate for archaeological purposes under the *Aboriginal Heritage Act 1972* should be obtained to conduct this work.
   b) A data recovery program planned in consultation with the Indigenous people, a qualified archaeologist and the DIA should be developed and implemented.
   c) Representatives of the Indigenous people should be present during the data recovery phase.
   d) Based on the results of the data recovery program the find shall be evaluated in consultation with the Indigenous people, the archaeologist and the DIA.
   e) Should burials be located, refer to burials policy procedure in Section 5.3.2.1.

5.3.2.3 Historical Archaeological Sites

Management of historical sites in Western Australia is controlled primarily under *Heritage of Western Australia Act 1990* which follows the *Burra Charter* (www.icomos.org/australia/burra.html) which in turn provides guidelines for the management of historic sites.

1. The potential for surface and buried cultural deposits is potentially high in coastal areas. If surface or buried material is uncovered during construction, the following procedures should be undertaken:
   a) All work in the immediate vicinity of the find must cease and reasonable efforts to secure the discovery should be made. Work can continue at an agreed upon distance from the site. Note that the material should not be removed or disturbed further but barriers or temporary fences may be erected as a buffer around the remains if required.
   b) The Cultural Heritage Officer, if not already present, and appropriate CTA managers should be notified.
   c) The Heritage Council should be contacted and advised of the situation.
   d) If Indigenous cultural material is also identified refer to procedures in Section 5.3.2.2.
   e) If maritime cultural material is also identified refer to procedures in Section 5.3.2.4.
   f) The Cultural Heritage Officer should create accurate records, including map references and photographs of the material and an *in situ* evaluation of the find.
   g) A written statement of the Cultural Heritage Officer findings and recommendations should be provided to the Heritage Council for their consideration.
   h) Based on the recommendations from the Cultural Heritage Officer, decisions regarding the treatment of the find shall be made in consultation with the Heritage Council.
2. If the find cannot be avoided and evaluated without further archaeological work, then the following procedure should be undertaken:

a) A data recovery program planned in consultation with a qualified historical archaeologist and the Heritage Council should be developed and implemented.

b) Based on the results of the data recovery program the find shall be evaluated in consultation with the Heritage Council.

c) Should burials be located, refer to burials procedure in Section 5.3.2.1.

5.3.2.4 Terrestrial Maritime Archaeological Sites

1. Maritime archaeological sites located above the high water mark may be protected by the State *Maritime Archaeology Act 1973*. In the discovery of material the procedures followed should be the same as that for historical archaeological sites (see Section 5.3.2.3 above).
2. Written notice of discoveries should be given to the Director of the WA Maritime Museum.
3. Decisions regarding the treatment of the find shall be made in consultation with the Director of the WA Maritime Museum or his delegated representative and the Heritage Council.
4. If the site also contains Indigenous material consultation should be extended to include Indigenous people, and the DIA.

5.3.2.5 Underwater Maritime Archaeological Sites

1. Maritime archaeological sites located below the high water mark are protected by the Federal *Historic Shipwrecks Act 1976*. If identified the following should occur:

a) All work in the immediate vicinity of the find must cease and reasonable efforts to secure the discovery should be made. Work can continue at an agreed upon distance from the site. Note that the material should not be removed or disturbed further.

b) The Cultural Heritage Officer, if not already present, and appropriate CTA managers should be notified.

c) The WA Maritime Museum should be contacted and advised of the situation.

d) The Cultural Heritage Officer should create accurate records, including GPS positions and photographs of the material (if possible).

e) Decisions regarding the treatment of the find shall be made in consultation with the Director of the WA Maritime Museum or his delegated representative who may then recommend an *in situ* evaluation of the find by a qualified maritime archaeologist.

Table 5-1. Gorgon Development – Cultural Heritage Management Issues and Strategies

COMPONENT	CURRENT SITUATION	DESIRED OUTCOMES	STRATEGIES & RECOMMENDATIONS
Indigenous Heritage - Anthropology	Barrow Island No ethnographic surveys have occurred. Indigenous people associated with the Yabburara/Mardudhunera, Kurama Marthudunera and Thanlanyji Indigenous groups have expressed an interest in being consulted regarding Indigenous heritage issues on Barrow Island.	Involvement of Indigenous people in the management of cultural heritage on the island well in advance of construction.	The Yabburara/Mardudhunera, Kurama Marthudunera and Thanlanyji Indigenous communities need to be consulted and physical inspection of the proposed development on Barrow Island with a qualified anthropologist and selected members of the Indigenous communities may be required.
	Mainland No ethnographic surveys have occurred. Two ethnographic sites identified close to Apache/Hadson pipeline. Indigenous people associated with the Yabburara/Mardudhunera, and Kurama Marthudunera Indigenous groups have expressed an interest in being consulted regarding Indigenous heritage issues on the mainland.	Involvement of Indigenous people in the management of cultural heritage on the mainland well in advance of construction.	The Yabburara/Mardudhunera, and Kurama Marthudunera Indigenous communities need to be consulted and physical inspection of the proposed development on the mainland with a qualified anthropologist and selected members of the Indigenous communities may be required.
Indigenous Heritage - Archaeology	Barrow Island Limited Indigenous archaeological assessment has occurred.	Identification of all Indigenous archaeological sites within/adjacent to proposed development well in advance of construction.	Detailed pedestrian sample survey conducted by qualified archaeologists of the proposed disturbance areas. Survey should cover at least 50% of the proposed disturbance areas.
	Potential for sub-surface cultural material on the coast and in claypans.	Management of potential sub-surface cultural material during construction.	Engagement of Cultural Heritage Officer during ground disturbance activities. Test-excavation of potential locations if warranted. Monitoring of construction in coastal and claypan areas by qualified archaeologist and Indigenous people.
	At present one known Indigenous site may be impacted by the Flacourt Bay Pipeline Option (see Appendix 1). Until the development footprint is finalised by CTA and those proposed disturbance areas are inspected the possibility exists that additional Indigenous archaeological sites are present.	Avoid if possible. If cannot be avoided then suitable recording work will be required and the appropriate permits obtained to disturb the sites.	Ensure sites are protected from inadvertent damage. To facilitate this CTA should: 1. Engage a Cultural Heritage Officer. 2. Ensure that all construction personnel participate in a Cultural Heritage Induction. If Indigenous sites cannot be avoided then: 1. An application should be made under Section 18 of the *Aboriginal Heritage Act 1972* to disturb the required sites. 2. Detailed recording of sites will be required by qualified archaeologists. 3. If the potential for sub-surface cultural material is identified the site must be test-excavated to determine this potential. A Section 16 permit (*Aboriginal Heritage Act 1972)* will need to be obtained from the DIA to conduct this work.

COMPONENT	CURRENT SITUATION	DESIRED OUTCOMES	STRATEGIES & RECOMMENDATIONS
			4. Indigenous people will have to be consulted regarding the proposed site disturbance.
	Mainland No archaeological assessment has occurred on the mainland infrastructure. The Apache/Hadsen pipeline was surveyed for Indigenous sites; however, no details are available.	Identification of Indigenous archaeological sites within/adjacent to proposed development well in advance of construction.	Detailed pedestrian transects of mainland infrastructure conducted by qualified archaeologists. Survey should be at least a 50% sample.
	There is the potential for sub-surface cultural material on the coast and in claypans.	Management of potential sub-surface cultural material during construction.	Engagement of Cultural Heritage Officer during ground disturbance activities. Test-excavation of potential locations if warranted. Monitoring of construction in coastal and claypan areas by qualified archaeologist and Indigenous people.
	Three known Indigenous archaeological sites are in the vicinity of the DOMGAS Pipeline (see Appendix 1). Until the footprint is finalised by CTA and those proposed disturbance areas are inspected the possibility exists that additional Indigenous archaeological sites are present within the proposed development.	Avoid if possible. If cannot be avoided then additional recording work will be required and the appropriate permits obtained to disturb the sites.	Ensure sites are protected from inadvertent damage. To facilitate this CTA should: 1. Engage a Cultural Heritage Officer. 2. Ensure that all construction personnel participate in a Cultural Heritage Induction. If Indigenous sites cannot be avoided then: 1. An application should be made under Section 18 of the *Aboriginal Heritage Act 1972* to disturb the required sites. 2. Detailed recording of sites will be required by qualified archaeologists. 3. If the potential for sub-surface cultural material is identified the site must be test-excavated to determine this potential. A Section 16 permit (*Aboriginal Heritage Act 1972)* will need to be obtained from the DIA to conduct this work. 4. Indigenous people will have to be consulted regarding the proposed site disturbance and the ethnographic significance of the sites.
Historical & Maritime Heritage – terrestrial	**Barrow Island** Limited historical archaeological assessment has occurred. There is a strong potential for sites to be found, particularly in the near coastal zone.	Identification of historical archaeological sites within / adjacent to proposed development well in advance of construction.	Detailed pedestrian sample survey conducted by qualified archaeologists of the proposed disturbance areas. Survey should cover at least a 50% of the proposed disturbance areas, with emphasis on coastal zones.
	Potential for sub-surface cultural material on the coast, especially burials.	Management of potential sub-surface cultural material during construction.	Engagement of Cultural Heritage Officer during ground disturbance activities. Test-excavation of potential locations if warranted. Monitoring of construction in coastal areas by Cultural Heritage

COMPONENT	CURRENT SITUATION	DESIRED OUTCOMES	STRATEGIES & RECOMMENDATIONS
			Officer.
	At present one known historical site may be impacted by the development (see Appendix 1). Until the development footprint is finalised by CTA and those proposed disturbance areas are inspected the possibility exists that additional historical archaeological sites are present.	Avoid if possible. If cannot be avoided then suitable recording work will be required and the appropriate permits obtained to disturb the sites.	Ensure sites are protected from inadvertent damage. To facilitate this CTA should: 1. Engage a Cultural Heritage Officer. 2. Ensure that all construction personnel participate in a Cultural Heritage Induction. If historical sites cannot be avoided then: 1. Detailed recording of sites will be required by qualified archaeologists. 2. If the potential for sub-surface cultural material is identified the site must be test-excavated to determine this potential: a) The Heritage Council must be informed and give their approval. b) If the site contains Indigenous or maritime components refer to relevant procedures above and below.
	Mainland No historical archaeological assessment has occurred. There is a strong potential for sites to be found, particularly in the near coastal zone.	Identification of all historical archaeological sites within/adjacent to proposed development well in advance of construction.	Detailed pedestrian sample survey conducted by qualified archaeologists of the proposed disturbance areas. Survey should cover at least 50% of the proposed disturbance areas, with emphasis on coastal zones.
	Potential for sub-surface cultural material on the coast, especially burials.	Management of potential sub-surface cultural material during construction.	Engagement of Cultural Heritage Officer for life of construction. Test-excavation of potential locations if warranted. Monitoring of construction in coastal areas by qualified historical archaeologist.
	At present one known historical/maritime site may be impacted by the Flacourt Bay Pipeline Option (see Appendix 1). Until the development footprint is finalised by CTA and those proposed disturbance areas are inspected the possibility exists that additional historical archaeological sites are present.	Avoid if possible. If cannot be avoided then suitable recording work will be required and the appropriate permits obtained to disturb the sites.	Ensure sites are protected from inadvertent damage. To facilitate this CTA should: 1. Engage a Cultural Heritage Officer. 2. Ensure that all construction personnel participate in a Cultural Heritage Induction. If historical sites cannot be avoided then: 1. Detailed recording of sites will be required by qualified archaeologists. 2. If the potential for sub-surface cultural material is identified the site must be test-excavated to determine this potential: a) The Heritage Council must be informed and give its approval. b) If the site contains Indigenous or maritime components refer to relevant procedures above and below.

COMPONENT	CURRENT SITUATION	DESIRED OUTCOMES	STRATEGIES & RECOMMENDATIONS
Maritime Heritage - underwater	Barrow Island There has been no physical archaeological assessment of the underwater area designated for the proposed pipelines. Until the development footprint is finalised by CTA and those proposed disturbance areas are inspected the possibility exists that shipwreck sites are present.	Identification of shipwreck sites within/adjacent to proposed development well in advance of construction.	Detailed acoustic and/or video imaging should be carried out along proposed disturbance areas, similar to that already conducted by Fugro for sections of pipeline and port facility. As recommended by Fugro (2003), additional detailed video/sonar survey work should be carried out in areas of moderate to high relief rock outcrop only. The Fugro recommendation that a block survey is carried out in the anticipated areas of very uneven seabed to choose an optimum route is also supported. This material should be made available to a maritime archaeologist to determine whether maritime cultural material, shipwreck or otherwise is present. Depending on the results of the above physical inspection by maritime archaeologists of potential areas may be required.
	At present no shipwreck sites have been identified within the proposed development.	If shipwreck sites are identified avoid if possible If cannot be avoided then suitable recording work will be required and the appropriate permits obtained to disturb the sites.	Ensure sites are protected from inadvertent damage. To facilitate this CTA should: 1. Ensure that all construction personnel participate in a Cultural Heritage Induction. If shipwreck sites cannot be avoided then: 1. Decisions regarding the treatment of the find shall be made in consultation with the Director of the WA Maritime Museum or his delegated representative. 2. Recommendations may include: a) An *in situ* evaluation of the find. b) Detailed excavation and recording. c) Removal of cultural material and curation in the WA Maritime Museum.

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APPENDIX 1

LIST OF KNOWN CULTURAL HERITAGE SITES IN IMMEDIATE VICINITY OF GORGON DEVELOPMENT

Barrow Island

Category	Code (Site Name)	Site Type	Location	Easting*	Northing*	Brief Description	Within Gorgon Development?	Recommendation if Cannot be Avoided	Reference
Indigenous	GD04-01 (Flacourt Bay 01)	Possible Site, Rock shelter	Flacourt Bay	331540	7705613	Identified during March 2004 field visit. Rock shelter with potential for sub-surface cultural material. No surface material noted.	Possibly c. 80 m north-east of Flacourt Bay Gas Feed Gas Pipeline centreline	Record in more detail. Test excavate to determine potential for sub-surface cultural material.	Appendix 2
Historical	GD04-02 (Flacourt Bay 02)	Bottle Scatter	Flacourt Bay	331534	7705477	Identified during March 2004 field visit. Five pieces of light olive beer bottle glass manufactured in late 19th – early 20th Century.	Yes Flacourt Bay Gas Feed Gas Pipeline centreline	Record in more detail. Test excavate to determine potential for sub-surface cultural material.	Appendix 2

* = Zone 50; Datum GDA 94; Grid Reference Accuracy ± 20m

Mainland

Category	Code (Site Name)	Site Type	Location	Easting*	Northing*	Brief Description	Within Gorgon Development?	Recommendation if cannot be avoided	Reference
Indigenous	17429 (*Nyungarrarra*)	Ethnographic (named place)	Inland Peters Creek	398502	7629610	Named creek, '*Nyungar*' translates as Blue Sky.	No		McDonald, Hales & Associates (1994)
Indigenous	17004 (*Warlu* Waterhole)	Ethnographic (mythological)	Inland Peters Creek	390974	7627050	'Waterhole' located in Peters Creek Associated with water-source is a scatter of flaked artefacts	No	Relocate to define location accurately.	Stevens (1998) McDonald, Hales & Associates (2001)
Indigenous	(Hadson 1)	Ethnographic (water-source) Artefact Scatter	Inland Adjacent Apache pipeline	390141	7633154	'Waterhole' known to Martuthunira informants; "used by local Aboriginal people as a water source as they moved to the coast". Associated with water-source is a scatter of flaked and ground stone artefacts in a claypan. Nine artefacts recorded in a 2 m^2 sample square. Scatter measures 500 m by 500 m in	Possibly DOMGAS Pipeline	Consult with relevant Indigenous groups Relocate and record archaeological component in detail. Possible test excavation.	Murphy & McDonald (1990)

Category	Code (Site Name)	Site Type	Location	Easting*	Northing*	Brief Description	Within Gorgon Development?	Recommendation if cannot be avoided	Reference
						area.			
Indigenous	(Hadson 2)	Artefact Scatter	Coast	378141	7647154	Scatter of flaked stone artefacts on a sand island in coastal flat. Shell fragments (*Melo* spp., *Anadara* spp.) present, however, the report does not state whether cultural or natural.	No	Relocate to define location accurately.	Murphy & McDonald (1990)
Indigenous	(Hadson Midden 1)	Shell & Artefact Scatter	Saltpan/sandplain Adjacent Apache pipeline	385141	7647154	Scatter of flaked stone artefacts and some shell: *Saccostrea* spp., *Terebralia* spp., *Anadara* spp. and *Melo* spp. Given the presence of coral blocks and mangrove branches shell scatter may be natural.	Possibly DOMGAS Pipeline	Relocate and record in detail to determine whether shell scatter is cultural or natural. .Possible test excavation.	Murphy & McDonald (1990)
Indigenous	(Hadson Midden 2)	Shell & Artefact Scatter	Coast Adjacent Apache pipeline	381141	7655154	Scatter of two flakes and one muller immediately behind coastal mangroves. Economic shell species present: *Anadara* spp., *Terebralia* spp., *Melo* spp., *Syrinx* spp. and *Tectus* spp. Shell scatter may be result of water action given close proximity to mangroves.	Possibly DOMGAS Pipeline	Relocate and record in detail to determine whether shell scatter is cultural or natural. Possible test excavation.	Murphy & McDonald (1990)
Indigenous	17833 (Tap Site 2)	Shell & Artefact Scatter	Coast	378938	7646377	Small scatter of shells and flaked stone artefacts. Artefacts manufactured from chert, dolerite and basalt. Site on shore of salt flat island.	No	Relocate to define location accurately.	Lantzke (1999:4)
Indigenous	18026 (PC 33)	Artefact Scatter	2 km south-west of Compressor Station 1	390068	7625886	Sparse scatter of four flaked stone artefacts. Artefacts in a stony exposure.	No	No further work required	McDonald Hales and Associates (2001)
Historical Maritime Indigenous	(Maceys Wreck)	Shipwreck Artefact Scatter	Coast, near Hadsen/Apache pipeline	Not provided	Not provided	Remains of nineteenth century lugger with associated glass remains, including possible Indigenous material	Possibly DOMGAS Pipeline	Relocate and record. Indigenous archaeologist to identify possible retouched glass artefacts.	McCarthy (1991)

* = Zone 50; Datum GDA 94; Grid Reference Accuracy ± 100m

APPENDIX 2

CULTURAL HERITAGE ASSESSMENT ON BARROW ISLAND – MARCH 2004 (VEITCH, PATERSON & SOUTER)

Activity Summary

Day	Activity	Description
16 March 2004	Travel to Barrow Is. Induction Project Orientation	Preliminary inspection of proposed development and general tour of island.
17 March 2004	Reconnaissance	Inspected previously recorded sites 888 (FS06) and 889 (FS07). Also visited possible Gas Feed Pipeline landing at Flacourt Bay. Spot checks on road side along possible pipeline routes.
18 March 2004	Reconnaissance	Inspected possible Gas Feed Pipeline landing White Beach and Gas Processing Facility Area. Inspected previously recorded sites 887 (FS05), Boudie cave, Pearlers Camp 891 (FS09). Examined collected Indigenous and historical artefacts in Environment laboratory.
19 March 2004	Reconnaissance Travel to Perth	Inspected Port Facility on eastern side of Island and possible jetty location. Photographed artefacts from Environment laboratory collection.

The proposed development areas were inspected in preliminary detail, with spot checks undertaken at areas of high archaeological potential such as coastal areas and in claypans (see Quartermaine Consultants 1994 for a discussion of some of these areas). Inspections were made at the coastal pipeline crossings at Flacourt Bay, White's Beach and Town Point. In addition a 60 m wide transect was walked through the centre of the proposed Gas Processing Facility area. Inspections were made of the coast at Town Point and at low tide the seaward side of Town Point was also inspected.

Four previously recorded Indigenous sites were visited [887 (FS05), 888 (FS06), 889 (FS07) and 891 (FS09)]. In addition two new cultural heritage sites were identified in Flacourt Bay; a rock shelter with the possibility for sub-surface Indigenous cultural material (GD04-01); and one historical site (GD04-02) (Appendix 1).

Indigenous Archaeology – summary of findings (B Veitch)

Previously Recorded Sites

Site 887 (FS05)

This artefact scatter is located well north of the proposed Gorgon Development and will not be impacted. The original recording identified six artefacts, including four collected artefacts (Quartermaine Consultants 1994:17, Appendix 3). During the March 2004 visit an estimated flaked stone artefact population of between 100 and 500 was noted. The artefact scatter also comprises exposed stone artefact reduction areas that have been revealed as the dune has deflated. The new artefacts have been exposed as a result of cyclonic activity. If the site is to be impacted it is recommended that further recording work including test excavation is warranted.

Site 888 (FS06 Area C)

This artefact scatter is located well north of the proposed Gorgon Development and will not be impacted. Quartermaine Consultants (1994:17-18, Appendix 3) recorded six flaked stone artefacts in Area C, however, during the March 2004 visit only one artefact was relocated. In other parts of the site (Area A, B, D) less material was also noted. This is most likely the result of siltation and water action during cyclonic weather, exposing and burying artefacts. As recognition of this Quartermaine Consultants (1994:18) recommended that test excavations were warranted at this site. In most cases on the mainland, artefacts are noted on the margins of claypans, while on Barrow they appear to be in them. This raises the possibility that the artefacts observed by us and Quartermaine Consultants (1994:17-18) are not in primary locations of discard. Given that CTA intend to place concrete footings every 2 m along the length of the proposed CO_2 Pipeline (Tony Cotton pers. comm.), Area C should be test excavated in accordance with the recommendations made by Quartermaine Consultants (1994:18).

Site 889 (FS07)

This artefact scatter is located well north of the proposed Gorgon Development and will not be impacted. The scatter was recorded in 1994 as comprising four artefacts in a small claypan (Quartermaine Consultants 1994:18). During the March 2004 visit only the quartz flake was relocated. Like site 888 the claypan at site 889 has been affected by cyclonic activity burying and exposing artefacts. This site, therefore, has the potential for sub-surface cultural material and should be test excavated prior to any disturbance (cf. Quartermaine Consultants 1994:18).

General Comments

The differences between the numbers of artefacts in 1994 and 2004 in sites 887, 888 and 889 all stem from cyclonic activity. Two cyclones have passed over the area since 1994 (Olivier and Monty), leaving their mark on the landscape:

1. Scoured out deposits in the eastern part of the dunes swale in which 887 is located, resulting in one reduction area and considerably more artefacts being revealed.
2. Wash-sedimentation occurring at 888 and 889 that seems to have either buried or washed artefacts away.
    a) It seems unlikely that artefacts would have been washed away given that the claypans are in low points on the landscape.
    b) It seems more likely that the artefacts that Quartermaine Consultants (1994) recorded have been buried in the claypan features by siltation associated with wash from cyclonic rains. A sea sponge was noted in site 888 Area B which may support this proposition.

As a result of this cyclonic activity the surface archaeological signature of these sites and therefore other parts of the island has altered since 1994.

Newly Recorded Sites

GD04-01

A potential site was recorded at Flacourt Bay (50K 331540mE 7705613mN; Datum GDA 94). GD04-01 is a small rock shelter with the potential for sub-surface cultural material. No artefactual material was on the surface, but due to safety requirements the survey team did not enter the rock shelter beyond the drip-line. The proposed Flacourt Bay Gas Feed Pipeline option may disturb this rock shelter. The rock shelter should be test excavated prior to any disturbance to determine the potential for sub-surface cultural material.

Boodie Cave

In addition, Boodie Cave was visited. This was recorded by Quartermaine Consultants (1994:22, 25) as a site with potential sub-surface cultural material**,** but is not in the proposed Gorgon Development. This cave has considerable potential to contain stratified cultural remains; however, as with site GD04-01 no surface artefactual material was noted during the March 2004 visit. The lack of surface cultural material is consistent with the proposition that Barrow Island was abandoned from approximately 7,000 BP.

Proposed Development

A number of factors suggest that the surface archaeology on and near the proposed Gorgon Development has undergone substantial changes since Quartermaine Consultants conducted their assessment in 1994. As a result of cyclonic weather some sites have more artefactual material than originally recorded as a result of erosion, while in other sites sedimentation appears to have concealed artefacts, possibly forming stratified cultural deposits. These processes have been occurring for millennia. The possibility exists therefore that there will be stratified and newly revealed archaeological material within the proposed Gorgon Development that was not visible during the 1994 survey (Quartermaine Consultants 1994)[5]. Most of the proposed development covers areas that have low potential for Indigenous archaeological material. However, given that parts of the development occur on the coast or in low lying areas that may have features such as claypans, a systematic pedestrian survey is the only way to establish with any confidence the presence or absence of additional cultural heritage.

[5] It also needs to be emphasised that the assessment by Quartermaine Consultants (1994) did not cover very much of the proposed Gorgon Development. Further, as has been shown, their results may no longer apply to the contemporary situation given the geomorphic processes outlined above.

Historical & Maritime Archaeology – summary of findings (A Paterson & C Souter)

Previously Recorded Sites

Site 891 (FS09)

This artefact scatter is on the southern end of the island and will not be impacted by the proposed Gorgon Development. The original recording identified many historical artefacts, including glass retouched by Indigenous people (Quartermaine Consultants 1994:19-20, Figure 15). The site originates from a pearlers' camp, although not surprisingly the identity of the ship associated with the site is not known given the paucity of historical accounts. The presence of Indigenous people in a pearlers' camp is supported by the documentary review, although it is not clear whether they were present willingly or by force. During the March 2004 visit an estimated flaked glass artefact population of between 10 and 20 was noted. If the site is to be impacted in future it is recommended that a complete excavation by conducted by an archaeologist qualified in contact archaeology. All workers on the island should avoid the site. Removal of any material may contravene the Western Australian *Aboriginal Heritage Act 1972* and the *Maritime Archaeology Act 1973*.

Newly Recorded Sites

GD04-02

This artefact scatter, of glass, is in Flacourt Bay (50K 331534mE 7705477mN; Datum GDA 94) and may be impacted by the proposed Gorgon Development, specifically the Flacourt Bay Feed Gas Pipeline option. The site comprises glass fragments from a single light olive glass bottle of a champagne beer type common in the late 1800s and early 1900s. While rare on Barrow Island, elsewhere along the Australian coast this is a common artefact and could be collected prior to the site being disturbed. There may however be buried archaeological material at this site and the procedures for site disturbance detailed in Section 5 of this report should be followed.

General Comments

As with the Indigenous archaeology it is clear from the review of documents and the field visit that there is the potential for additional historical sites within the Gorgon Development on Barrow Island. Additional survey and monitoring work will be required to identify historical sites prior to construction.

It is also suggested given number of references to Whitlock Cove in the historical sources that that this area should be surveyed for historical/maritime material. It is acknowledged that this area is not within the proposed Gorgon Development, however, for wider management issues on the island it would be advisable to have this area inspected (see below).

Interest in the archaeological survey was expressed by some workers on the island in March 2004 to those taking part in the survey. Such interest could be harnessed to protect the archaeological resources, especially when it is made clear that the archaeological resource is non-renewable. One worker who knew of a site stated he wanted to return with a metal detector and explore the locality for more finds: an understandable curiosity which however would contravene a number of heritage acts. Workers should be made aware of these limitations and procedures should reflect a policy of reporting archaeological finds and not removing anything from a site until the proper procedures have been followed.

Conclusions

Most of the proposed Gorgon Development on Barrow Island covers areas that have low potential for cultural heritage. But since parts of the development are likely to take place in places of high cultural heritage potential, such as on the coast and along creeks or seasonal drainage lines, a systematic pedestrian survey is the only way to establish with any confidence the presence or otherwise of additional cultural heritage within the Gorgon Development on Barrow Island. It is therefore strongly recommended that an Indigenous, historical / maritime pedestrian survey of the proposed development on Barrow Island be undertaken prior to construction activities. Given the potential for sub-surface cultural material in these high potential areas it is also suggested that proposed construction works are monitored by qualified Cultural Heritage Management practitioners.

During the field visit the collection of flaked stone artefacts in the Barrow Island Environmental Laboratory was inspected. The idea was discussed with Tony Cotton (CTA HES Supervisor) that the collection might be better housed in the Western Australian Museum. It is suggested that this matter be raised with relevant State heritage departments such as the DIA, the WA Museum and the Maritime Museum.

The field visit strengthened the proposition that a number of Indigenous sites on Barrow Island could contain sub-surface cultural material, with Boodie Cave having the highest such potential. Results from archaeological excavations at rock shelters/caves such as Boodie Cave and to a lesser extent open surface scatter sites such as 888 and 889 have the potential to answer fundamental questions regarding Indigenous occupation of the region from 30,000 years ago. Barrow Island also has unusual historical sites that warrant further research. CTA, in our opinion, has the opportunity to support cultural heritage research on the island, similar to research currently conducted into the rare fauna, palaeofauna and flora. Such cultural heritage research places CTA in a proactive and positive situation with regard to cultural heritage.

In view of the interest expressed by some of the workers on Barrow Island in cultural heritage and their lack of knowledge regarding the protection of these sites, it is also suggested that the proposed Gorgon Development Cultural Heritage Induction (see Section 5) is extended to include all workers on the island. In addition, CTA may wish to consider the production of information boards detailing the cultural history of the island and the types of sites and artefacts present. These information boards may be strategically placed on the island, perhaps at the airport or in the induction room.

APPENDIX 3

ASSESSMENT OF HISTORICAL SOURCES RELATED TO BARROW ISLAND – FEBRUARY 2004 (PATERSON)

Introduction

A survey of historical documents was conducted to establish the range of historical events that occurred on Barrow Island. The focus of this survey was on 19th century events as these tend to be considered more significant than those of the 20th century; this, however, is a subjective distinction and a more comprehensive knowledge of the potential total history of site use is the intention of this survey.

Historical sources are not necessarily true. Where it is felt a source is unsubstantiated we have suggested cautionary use.

Historical events described in these documentary sources are not always linked to a specific site on Barrow Island. This clearly presents a problem for management; however the combined use of historical and archaeological surveys provides the most comprehensive understanding of the cultural resources of Barrow Island. The archaeological surveys provide the most useful record of historical sites on the island which, together with the data detailed here and in earlier documentary surveys (see below), provides a list of known historical sites in the surveyed areas plus a "best fit" interpretation of their historical use.

There have been several earlier studies of the historical sources related to Barrow Island. This desktop study does not repeat such data (which may however feed into Appendix 1 and Section 4.2 above).

This survey was assisted by Ms Annie Carson (BA Hons, UWA) and Jo Pritchard and Anna Vitenbergs (Local History Office, Shire of Roebourne).

Primary Sources

Author(s):	Robert Langdon (ed)
Title:	Where the Whalers Went: An index to the Pacific ports and islands visited by American whalers, and some other ships, in the 19th century.
Archive:	Mitchell Library, Sydney
Reference no.	Q387.54041
Year(s):	1984

Site/person/event(s) associated with: Barrow Island – early whaling – *Stephania* (1842) and *Canton* (1864)

Description: The list of places on page 263 lists Barrow Island early whaling as being reportedly visited by the *Stephania* (21 June, 4 August 1842) and *Canton* (22 July, 1864). The latter is possible, as is the former, however this is a very early era for whaling in the northwest which predates permanent occupation in the region. Any sites related to either would be extremely significant. There were many reports of American whalers operating in this region in the 1840s and later decades. Other key places were the Montebello Islands, the Dampier Islands (especially Rosemary Island which was reportedly visited in 1801 by whalers), Exmouth Gulf, Shark Bay, and Bedout Island. These reports suggest regular informed whaling in the region with a probable presence on Barrow Island of whalers in the period after 1801, especially after 1840.

Author(s): Jarman, Capt.
Title: The ‘Tien Tsin’s’ Track to the Harding River
Archive: Exploration Diaries; Volume 5, 1858-1865
Reference no. PR 5441 / Battye
Year(s): 1863

Site/person/event(s) associated with: Barrow Island – early sightings – Capt. Jarman

Description: The ‘Exploration Diaries’ consist of six volumes of excerpts taken from the original diaries and papers of various explorers and pioneers in Western Australia. Pages 54-60 are excerpts from Captain Jarman’s journey to Nickol Bay in the barque ‘Tien Tsin’ in 1863. He mentions sighting Barrow Island:

“Saturday, May 2. – Lat. 20deg. 21min., long. 114deg. 21min., abreast of Barrow Isle; the soundings from N.W. Cape thus far on Admiralty Chart are very correct…” (p. 55).

Author(s): Burges, L. C
Archive: Battye – Exploration Diaries; Volume 5, 1858-1865
Reference no. PR 5441
Year(s): 1864
Date: October 8, 1864

Site/person/event(s) associated with: Barrow Island – early sightings – L.C. Burges

Description: Extract from the journal of Mr. L.C. Burges, a pastoralist who travelled on board the *Flying Foam* from Fremantle to Roebuck Bay to explore the north-west and assess the suitability of the area for settlement. Left Fremantle October 3, 1864, arrived Roebuck Bay October 13, 1864. This passage describes sailing close to Barrow and Montebello Islands.

“Saturday, October 8. – We are ….. [words obliterated] distance north of the Cape this morning in consequence of a strong current out of the gulf, running in a southerly direction. 4 p.m. – Barrow Island visible from the masthead. 5 p.m. – The Monte Bello Isles are in view now. At 8 p.m. the captain changed his course after passing between the reef and one of the Monte Bello Isles, and got into a regular harbour where we had to come to an anchor for the night in 2 ¾ fathoms of water.” (p.397).

Author(s): Captain Jarman
Title: Perth Gazette and Times
Archive: Battye Microfilm
Reference No. 994.11/ PER
Date: 27.1.1865

Site/person/events associated with: Barrow Island – early exploration – Capt. Jarman

Description: Jarman describes anchoring at Barrow Island in what is probably Whitlock Cove, on December 18, 1864. He provides a detailed account of the surrounding environment and vegetation he and his party encountered during their walk on the island. Observations of interest include an apparent lack of water, plenty of wallabies and some kangaroo, and turtle tracks. Camped overnight and commenced turtle hunting in the early hours of the next morning.

December 19, 1864, traversed westward across the island, noting dense masses of spinifex and sporadic outcrops of calcined limestone. Jarman notes stumbling across a solitary tree, the only one noted by him on the island. Jarman then set the island alight in order to increase the quality of the spinifex for grazing by the wallabies in the hope they would ‘fatten up’. Left the island early December 20, 1864.

Author(s): Whitlock, F. Lawson
Title: Notes on Northwestern Birds. *Emu,* Vol. 17(4): 166-179.
Archive: 2nd Floor Battye Stack
Reference No. 590 EMU
Year(s): 1918

Site/person/events associated with: Barrow Island – visit by F. Lawson Whitlock, 1918

Description: Naturalist F. Lawson Whitlock describes in detail his two-week visit to Barrow Island. His aim was to learn all he could about the little-known Black and White Wren of Barrow Island. Hence, most of the article is concerned with the description and recording of his observations of these animals. As the article could not be photocopied, relevant details about his trip to the island have been transcribed here:

"We left Cossack on Wednesday, 24th October 1917, and reached Barrow Island on Saturday, 27th October." (p.171).

"… more often the coast was a mere fringe of low sand hills, with infrequent and small patches of mangroves. Our anchorage was a natural little port, easily entered at high tide, and well protected from a heavy sea by its very narrow entrance [Whitlock Cove]. Immediately to the east, and not more than a half-mile away, was Double Island. Fresh water was obtainable on Double Island and near our anchorage by digging in the sand above high water mark." (p.173).

"My beat was the before-mentioned sandy peninsula, and also about 5 miles of coastal country on the north side of our harbour. I also made several trips half-way across the island, but the bird-life of the interior was so sparse and uninteresting…" (p.173).

"I was on the island to a fortnight, and also put in a day on the neighbouring Double Island." (p.173).

"There was no shade or shelter apart from an awning over our boat and a small patch of mangroves a hundred yards away. I tried camping ashore, and erected a tent-fly furnished with mosquito netting, but this was soon torn off by strong winds." (p.174).

"Turtle were plentiful, and my Japanese boatmen brought many eggs back to the cutter." (p.174).

Whitlock drew a map of his 'beat', the area he covered on the island during his visit; a photograph of the map was taken and has been attached.

Author(s): Mayne, Blair E

Title: Votes and Proceedings of the Legislative Council, 1885

Archive: Batty Microfilm

Reference No. Q328.941 WES

Year(s): 1885

Date: 21 May, 1885

Site/person/events associated with: Barrow Island – quarantine station; Montebello Islands – pearl diving

Description: "Report by the Inspector of Pearl Shell Fisheries, for the Season 1884-1885." 2-page letter written by Inspector Mayne who was stationed at Cossack when he wrote this report.

"At the commencement of the season, September, we had the misfortune to have the measles epidemic raging amongst the natives, thereby causing the boats to be very late at starting. I have great pleasure in now being able to contradict many statements that are afloat with regard to the inhuman treatment the natives get from their employers. For as soon as it was observed that measles has broken out, Barrow Island was converted into a quarantine station, with the schooner *Amy* into the medical ship tending to their wants; whilst the schooners *Expert* and *Pearl* were kept constantly running to and from the main, bringing over the sick ones and returning the convalescent. So, from the great care that was bestowed, the death rate was very small. I am unable to procure any definite figures. The natives themselves speak very highly of the treatment shown towards them by the whites." (p.3).

"The boats using the Diving Apparatus have also found some new ground at the Monte Bello Group, where some very fine specimens of both shell and pearls have been got. They afterwards migrated to King Sound, where also they have been doing good work…" (p.3).

Author(s): Haynes, T.H.

Title: Mother-o'-pearl shell culture: report to the Montebello Shell Syndicate Ltd.

Archive: Battye PR Cabinet

Reference No. PR 1692

Year(s): 1912

Site/person/events associated with: Montebello Shell Syndicate

Description: Report on the state of the mother-of-pearl cultivation venture begun by the Montebello Shell Syndicate, brainchild of Thomas Haynes. There is a proposition its management over to the federal government.

No references to Barrow Island.

Author(s): Department of Fisheries and Wildlife. Extension and Publicity Service

Title: The pearling industry of Western Australia, 1850-1979.

Archive: Battye Stack

Reference No. 338.372411 WES

Year(s): 1979

Site/person/events associated with: Pearl Industry W.A – history – Montebello Shell Syndicate

Description: Brief overview of the development of the pearling industry in Western Australia, with explanations of pearl formation and cultivation. No reference to Barrow Island, but p.16 refers to the unsuccessful venture into pearl shell cultivation at the Montebello Islands with Thomas Haynes and the Montebello Shell Syndicate in 1900.

Author(s): Montague, P.D

Title: The Monte Bello Islands. *Geographical Journal* 42(1): 34-44

Archive: JSTOR – www.jstor.org/

Year(s): 1913

Site/person/events associated with: Montebello Islands – visit by P.D. Montague

Description: P.D. Montague was a scientist who visited the Montebello Islands and then published this article about the vegetation and wildlife on Hermite and Tremouille islands and several surrounding lagoons. He often refers to similarities in the ecology of both Barrow Island and the Montebellos suggesting that he may also have visited Barrow Island at some stage, or perhaps, given his description of Barrow's location, he may simply have sailed around it and taken notes.

Title: The Marine Underwriters' Association of Western Australia: Report of Committee with Balance Sheet for the Year Ended 30th April 1967

Archive/Location: Battye Serial Stack

Reference no. 368.22 MAR/ Battye

Year(s): 1966-1967

Site/person/event(s) associated with: Barrow Island Oil Shipment

Description: (p.19) "The tanker P.J. Adams began loading the first commercial cargo of Barrow Island oil on Sunday, April 23 and will earn the first pay cheque in 15 years for the West Australian Petroleum Pty. Ltd."

"This shipment marks the culmination of an intensive testing programme of the Barrow Island discovery."

Author(s): Serventy, D.L and A.J. Marshall

Title: A Natural History Reconnaissance of Barrow and Montebello Islands 1958

Archive/Location: Battye Cabinet

Reference no. 591.99413 SER

Year(s): 1964

Site/person/event(s) associated with: Barrow Island – Natural History

Description: Serventy and Marshall report on the findings of their visit to the Barrow, Lowendall and Montebello islands between 18-24 September 1958. Includes a referenced overview of previous visits to the islands by other naturalists, and includes details of Servent**y's** and Marshall's own research and campsites. Most of the report describes the vegetation, mammals and birds recorded during reconnaissance. 18-21 September was spent on Barrow Island, 21-22 on Lowendall Island and 22-24 on the Montebellos (p.3).

Relevant details of Barrow Island include (p.4):

- 1840 H.M.S. *Beagle,* type specimens of the local race of the euro were collected
- 1846 J. Lort Stokes recorded observations on the euro and other fauna
- 1900 J.T Tunney collected birds and mammals
- 1917 and 1918 F. Lawson Whitlock camped and observed the bird life
- 1945 G.P Whitley skirted the western coastline of Barrow Island on a fisheries survey in lugger *Isobel* but did not land.
- 1952 Personnel associated with the testing of the atomic bomb made sparse natural history observations.

Serventy and Marshall camped in the same general area as Whitlock. A little cove (Whitlock Cove) opposite Double Island (p.5).

Author(s): Tull, Malcolm

Title: The development of Western Australia's fishing industry: a preliminary survey.

Archive: Battye Cabinet

Reference No. 338.3727 TUL

Year(s): 1990

Site/person/events associated with: Maritime industries – Western Australia

Description: Report for Murdoch University on the historical development of the whaling, sealing, pearling and fishing industries in Western Australia. It details the importance of major industry areas such as Shark's Bay, however neither Barrow Island, nor the Montebello Islands are mentioned.

Lease Applications and Maps

Title: The Eastern Districts Chronicle

Archive: Battye Microfilm

Reference No. 994.12 YOR

Date: 27 August, 1880

Site/person/events associated with: Barrow Island – pastoral use

Description: Short newspaper article announcing the commencement of Messrs. Henry J. Cooke and James Morrell's pastoral lease on Barrow Island.

"Messrs. Henry J. Cooke and James Morrell, who as already notified, have taken Barrow Island on the N.W Coast for a sheep station, leave overland for the destination in about a fortnight from the present time, travelling with a flock of sheep, with which to make a start on their new run. The best wishes of many friends in these districts will go with them. Accounts given by those who have recently visited this Island are favourable in the extreme…"

Title: The Eastern Districts Chronicle

Archive: Battye Microfilm

Reference No. 994.12 YOR

Year(s): 1881

Date: 23 September 1881

Site/person/events associated with: Barrow Island – pastoral use

Description: Short newspaper article announcing that Messrs. Cook and Morrell are leaving Barrow Island.

"We much regret to learn that Messrs. Cook & Morrell who went up some months ago with sheep to take possession of Barrow Island are by no means satisfied with this locality which we hear they have some idea of abandoning. These gentlemen however, have succeeded in securing other runs with which we heartily wish them better luck."

Archive: State Records Office – CSO Files / Battye

Reference No. RM/R23 – Battye Microfilm

Year(s): 1871

Date: 11 August, 1871

Site/person/events associated with: Barrow Island – leases – C.L Smith

Description: A letter drafted from the Governor Resident of Roebourne to the Surveyor General's Office in Perth to request a Class A licence for turtle fishing on Barrow Island (50,000 acres) and Delambre Island on behalf of Mr. C. Lambert Smith. May have been one of the first applications for the lease of an island other than for pastoral purposes given the nature of the application and the response in which the Survey General instructed that the applicant could have access to the islands until the time when proper rental regulations could be drawn up. There is no map accompanying this application.

Archive: State Records Office – CSO Files / Battye

Reference No. SDUR/S6/611/ Battye Microfilm

Year(s): 1872

Date: 9 July 1872

Site/person/events associated with: Barrow Island – leases – C.L. Smith

Description: Application by C. Lambert Smith to the Surveyor General for an extension of his lease to fish turtle at Barrow and Delambre Islands. Extension was granted until June 1873.

Archive: State Records Office – CSO Files / Battye

Reference No. N352/ Battye Microfilm

Year(s): 1874

Date: August 30, 1874

Site/person/events associated with: Barrow Island – leases – J.G. Anderson

Description: Special Lease application form by James Grimmond Anderson for '…turtling and fish preserving generally, and the rights of grazing stock on same if found not to interfere with the habits of the turtle.'

There is no map accompanying this application but the lease does not appear to be restricted to any one area of Barrow Island.

Archive: State Records Office – CSO Files / Battye

Reference No. 67/1212/ Battye Microfilm

Year(s): 1897

Date: 23 July, 1897

Site/person/events associated with: Barrow Island – leases – James Clarke and Co.

Description: Application for pastoral lease of 50,000 acres of land on Barrow Island by James Clarke & Co. No map accompanying application.

Archive: State Records Office – CSO Files / Battye

Reference No. 94/281/ Battye Microfilm

Year(s): 1900

Date: 5 February, 1900

Site/person/events associated with: Barrow Island – leases – John Hurst

Description: Application for a pastoral lease for 50,000 acres of land on Barrow Island by John Hurst from Perth. Includes a sketch map of Barrow Island.

Archive: State Records Office – CSO Files / Battye

Reference No. 152/316 / Battye Microfilm

Year(s): 1900

Date: November, 1900

Site/person/events associated with: Barrow Island – leases – E.C Clark

Description: Application for a special lease for turtling on Barrow Island by Emmeline Collier Clark from East Fremantle. Unlike previous applications, Clark only applied for 100 acres and not the whole island, the positioning of which is shown in the sketch map drawn on the application.

Archive: State Records Office – CSO Files / Battye

Reference No. 94/489 / Battye Microfilm

Year(s): 1902

Date: 28 January, 1902

Site/person/events associated with: Barrow Island – leases – J.W. King

Description: Application for a pastoral lease for 50,000 acres of land on Barrow Island by James Westerhouse King. Sketch map included.

Archive: State Records Office – CSO Files / Battye

Reference No. 96/307 / Battye Microfilm

Year(s): 1904

Date: 22 August, 1904

Site/person/events associated with: Barrow Island – leases – A. Stevens

Description: Application for a pastoral lease for 50,000 acres of land on Barrow Island by Alexander Stevens. Listed as a pearler from Onslow. Sketch map included.

Archive: State Records Office – CSO Files / Battye

Reference No. 152/967 / Battye Microfilm

Year(s): 1907

Date: 6 August, 1907

Site/person/events associated with: Barrow Island – leases – F.C. Broadhurst

Description: Entry in the Dept. Lands and Surveys Lease Applications book under the name of F.C. Broadhurst. Application for a special lease of 50,000 acres of land on Barrow Island for the purpose of 'shipping, working and exporting phosphates.'

Author(s): Dept. Lands and Surveys

Title: North West Division – West Pilbara

Archive: State Records Office – Dept. Lands and Surveys records

Year(s): 1908-1971

Site/person/events associated with: Maps – West Pilbara, including the coastline and offshore islands, eg. Barrow and Montebello Islands.

Description: A series of 5 maps drawn up by the Dept. Lands and Surveys to supplement one after the other as each was cancelled. Each one is roughly 1m x 0.65m in dimension and they all use the scale of 1:237600, or 3¾ of a mile per inch on the map. Each one is listed:

> *Cons 4567, Item 111/2, Title 506009, 1908-1914:* The section of Barrow Island has 'A.E. Hall' written on it, a reference perhaps to the lease that A.E Hall once owned on the island. All leases became void after the island was reclassified as an Aboriginal Reserve in 1908. Harry F. Johnston was the Surveyor General. (see photo).
>
> *Cons 4567, Item 111/3, Title 506010, 1914-1921:* Very similar to 506009, Harry F. Johnston Surveyor General. (see photo).
>
> *Cons 4567, Item 111/4, Title 506011, 1921-1925:* H.S. King Surveyor General.
>
> *Cons 4567, Item 111/5, Title 506012, 1925-1951:* J.P Camm Surveyor General
>
> *Cons 4567, Item 111/6, Title 506013, 1951-1971:* W.V Fyfe Surveyor General. Increased detail regarding the contours of the island and its bays.

Secondary Sources

Author(s): Cox, Josephine M

Year: 1977

Title: Barrow Island: an historical documentation

Publisher: Author

City: Perth

Call no./Library: Q994.13 BAR/ Battye

Site/person/event(s) associated with: Barrow Island – documentary sources and history

Description: A comprehensive research thesis which documents known historical evidence for the visitation and/or use of Barrow Island prior to oil exploration and settlement by WAPET. Includes information regarding the first sightings of the island and hydrographic surveys, leases, scientific studies, reserve history and conservation.

Where possible, the original documents referred to in this study have been obtained and/or copied. Includes some maps.

Author(s): Butler, H. and J. Cox

Year: 1982

Title: Barrow Island

Publisher: West Australian Petroleum Pty. Ltd.

City: Perth

Pages: 1-16

Call no./Library: PR 994.13 BAR/ Battye

Site/person/event(s) associated with: Barrow Island – history, oil exploration

Description: Small tourist-style information booklet with a brief outline of the island's history, climate, geology, vegetation, fauna, oil history and current status. Includes an index of place names and their history where possible.

History (unreferenced) –1801-1803 French Commander-in-Chief Nicolas Baudin sighted the island and thinking it was part of the mainland, did not survey. Named Cape Dupuy, Cape Malouet, Cape Poivre and Flacourt Bay.

- 1818 Lieutenant Phillip Parker King named the island Barrow Island
- 1840 Commander John Clements Wickham and Lieutenant John Lort Stokes in the *Beagle* visited the island and made observations of the fauna.
- 1900 Tunney, John T. spent two months collecting birds and mammals.
- 1908 Declared Nature Reserve
- 1910 Class 'A' Reserve.
- 1917-1918 Naturalist F. Lawson Whitlock visits
- 1952 F.L. Hill of the Royal Navy
- 1964 D. Goodall – botanist
- 1969 A.A Burbidge and A.R Main
- 1964-1967 W.H. Butler frequently visits

Oil Field History - 1954 – first recognised as anticline to trap oil

- 1962-62 Light airplane landing strip and beach landing facilities built
- 1964 Drilling commences
- 1967 First oil shipment

Includes small map of Barrow Island oil fields

Author(s): De La Rue, Kathy

Year: 1979

Title: Pearl Shell and Pastures

Publisher: Cossack Project Committee (Inc)

Edition: 1st

Call no./Library: 994.1 1979/ Reid Library (UWA).

Site/person/event(s) associated with: Barrow Island – Aboriginal quarantine station.

Description: Detailed and well-referenced social history of the North-West, particularly the Pilbara region and the districts of Roebourne and Port Hedland. Focuses on the development of the pearling and pastoral industries at places like Onslow, Cossack, Roebourne and inland Pilbara. The reference to Barrow Island indicates the presence of a quarantine station c.1884-1885.

"On one occasion at least, they surpassed the terms of the Act by setting up a quarantine station with intensive medical care on Barrow Island, when a measles epidemic broke out among the Aboriginal divers in the 1884-1885 pearling season." (p.99).

Author(s): Forrest, K

Year: 1996

Title: The Challenge and the Chance: the colonisation and settlement of North West Australia 1861-1914.

Publisher: Hesperian Press

City: Perth, Western Australia

Edition: 1st

Call no./Library: 994.1303 1996 CHA/ Reid Library (UWA).

Site/person/event(s) associated with: Barrow Island – barracoons and slave markets; Exploration history of Barrow Island

Description: Referenced history of the exploration, colonisation and settlement of the north-west of Western Australia. References to exploration of the north-west coastline:

"Earlier, when King [Phillip Parker] surveyed Barrow, Lowendal and Trimouille Islands he decided these were the elusive Tryal Rocks, 'the dread of every voyager to the Eastern Islands for the last two centuries.'" (p.3)

"The first settlement in Western Australia took place in 1829, and Lort Stokes made the next voyage of coastal survey in the H.M.S *Beagle* in 1838. He came to the same conclusion as King. The group of islands, named by the French the Monte Bello, and consisting of Barrow, Lowendal and the Trimouille Islands, within their encircling reefs, were the dreaded Tryals of former days…" (p.3).

"The *Mystery* (17 tons) came from Fremantle and in July Sholl paid her master, Peter Hedland, ten pounds to search the Monte Bellos, Barrow Island and the islands off Exmouth Gulf." (p.47).

"The following year Sholl received verification of Cadell's infamies by letters from the Government Resident of Koepang and from Lt. Ross of *The Flower of Yarrow*. Ross informed him of Cadell's barracoons on Barrow Island an the ill-treatment he and his crew meted out to 30-40 divers. He starved them all. Cadell himself maimed two for life and murdered another." (p.111).

"David Forrest, brother of the Surveyor General, and one of the first pastoralists to openly defend the Aborigines, rarely put pen to paper but now, deeply angered at the continuing 'plight of the poor creatures', he wrote at length on the kidnapping still rife on the Ashburton. He described the 'well-equipped' and 'fully rationed' parties who travelled down from the Hammersley Ranges to the head of the Ashburton 'procuring all the young natives for pearl shell diving.' He maintained Rouse and his brother-in-law Joseph McCarthy led well equipped armed parties and took the natives against their will, shipping them out from Hooley's Creek to Barrow Island." (p.192).

Author(s): Bain, M. A

Year: 1982

Title: Full Fathom Five

Publisher: Artlook Books

City: Perth, Western Australia

Pages: (see chapter 2: pp.26-37)

Edition: 1st

Call no./Library: 338.371412 1982 FUL/ Reid Library (UWA).

Site/person/event(s) associated with: Barrow Island – barracoons and slave markets

Description: Comprehensive referenced history of the pearling industry in North-West Western Australia. Refers to Captain Francis Cadell and his association with establishing slave markets for pearling vessel operators on Barrow Island:

"Intermingled with lengthy reports of murder and rape were serious rumours of blackbirders having established barracoons (slave markets) on islands near the coast where kidnapped Aborigines were sold when the pearling season commenced. There was talk too, of female barracoons on Enderby, de Lambre and Barrow Islands where women were sold to the highest bidder." (p.28).

"In 1874 when an English yacht arrived at Cossack to commence pearling, the captain delivered a letter to Sholl from the Resident at Koepang. He stated that the local rajahs were complaining strongly that their indentured men were not being paid in many cases and a large number were being ill-treated. The Resident confirmed, too, the rumours of established barracoons run by a pastoralist and Cadell on the de Lambre and Barrow Islands and that Sustenance and another stranger to the coast had been responsible for the female market on Enderby Island." (p.30).

Author(s): Bain, M.A.
Year: 1983
Title: Some incidents in the heyday of pearling
Journal/Vol/No: Early Days; Volume 9, No.1
Pages: 37-48
Call no./Library: 994.1 WES/ Battye
Site/person/event(s) associated with: Barrow Island – barracoons and slave markets

Description: Referenced social history of the pearling industry of the North-West, focusing on the treatment of Aboriginal and Asian divers. Refers to the existence of a slave market on Barrow Island.

"Some men gave up the idea of searching for m.o.p. when they realised that easier money was to be made by establishing slave markets or 'barracoons' on islands that lay off shore from Shark Bay to King Sound. Young female aborigines at such markets at Enderby, Lambre and Barrow Islands were sold to the highest bidder. When the police began searching islands around the Dampier Archipelago, the 'barracoons' were transferred further to the north-east, and the Lacepede Islands … became a favoured resort." (p.41).

Unfortunately this particular situation described has not been referenced and so the original source could not be consulted for further investigation.

Author(s): McCarthy, Mike
Year: 1992
Title: Failure and success: the Broadhursts and the Abrolhos guano industry
Journal/Vol./No: Studies in Western Australian History, V13
Pages: 10-23
Call no./Library: 994.1 STU
Site/person/event(s) associated with: Barrow Island – guano collection

Description: Article documents the exploits of Charles Edward Broadhurst involved in a range of industries in the North-West such as pearling in Shark's Bay and collecting Guano in the Abrolhos islands.

With regards to Broadhurst's initial forays into collecting guano McCarthy states that, "Unknown to officials in Perth, however, a large amount of unauthorised harvesting of guano occurred on several remote islands further north. It is now known that guano was worked on the Lacepede Islands, Browse Island, Ashmore Reef, Jones Island (in Napier Broome Bay), Lesueur Island, Monte Bello Islands and Barrow Island." (p.12).

Author(s): Cairns, Lynne and Graeme Henderson
Year: 1995
Title: Unfinished Voyages – Western Australian shipwrecks 1881-1900
Publisher: University of Western Australia Press
City: Nedlands, Perth, Western Australia
Edition: 1st
Call no./Library: 994.1 CAI/ Reid Library (UWA)
Site/person/event(s) associated with: Barrow Island – guano collection

Description: Reference guide to shipwrecks and shipping history of Western Australia. Refers to the barque *Oleander* and the shipping of guano from Barrow Island.

"During September 1883, the barque *Oleander* (Official Number 43921) was in Fremantle Harbour awaiting a suitable charter. After the master, James Joass, had obtained a licence to load guano at Shark Bay, the ship was chartered for that purpose and left Fremantle in ballast on 24 September. On arrival at Shark Bay, some 80 tonnes of cargo was loaded. Then the vessel proceeded to Barrow Island where it was intended to complete loading, but as no cargo was available there, Joass returned to Shark Bay to take on more guano." (p.63).

Author(s): George, C. D.
Year: 1996
Title: The pearling industry in Australia and Papua New Guinea, 1949-1977, and the part played by the author and the Japanese.

Call no./Library: Q639.412 GEO

Site/person/event(s) associated with: Montebello Shell Syndicate

Description: There is no reference to Barrow Island in this book, however George does mention the establishment of the Montebello Shell Syndicate by T.H. Haynes in 1904 in his brief discussion on the early development of pearling in Australia.

Author(s): Marie-Stephanie

Year: 1996

Title: Monte Bello Island Pearling

Journal/Vol/No: Exmouth Expression, January 1996

Pages: 10

Call no./Library: Q994.13 EXM/ Battye

Site/person/event(s) associated with: Montebello Island group - pearling history

Description: 1-page article describing the history of the islands from the visit of Nicolas Baudin in 1801 to the pearling industry today.

Early pearling - Thomas Haynes held pearling licence from 1902-1913. 1981 Dick Morgan established Morgan & Co., a pearling company that operates from Hermite Island.

Author(s): Stanbury, Myra

Year: 1994

Title: Mother-of-Pearl shell cultivation: an early 20th Century experiment in the Montebello Islands, Western Australia.

Journal/Vol/No: The Great Circle, 16(2)

Pages: 90-120

Call no./Library: 387.2 GRE/ Battye

Site/person/event(s) associated with: Montebello Islands – pearl shell cultivation

Description: Article describes the history of pearl shell cultivation in the Montebello Islands, with reference to similar experiments conducted elsewhere in the state at the time such as Broome. Details the attempts by Thomas Haynes to cultivate m.o.p. shell in the Montebello Islands from 1901 to 1908. Includes archaeological evidence for pearling camps on the islands and hence gives a good idea of what similar pearling camps on Barrow Island may or may have looked like.

Author(s): Bartlett, Norman

Year: 1954

Title: The Pearl Seekers

Publisher: Andrew Melrose Limited

City: London

Edition: 1st

Call no./Library: 639.412/ Reid Library (UWA)

Site/person/event(s) associated with: Barrow Island - pearling

Description: Unreferenced history of the pearling industry in Australia and Torres Strait. Emphasis has been placed on the industry of Western Australia, particularly in the north around Broome. Bartlett describes the pearling grounds of Barrow Island:

"Thirty miles south of the Monte Bellos are the Barrow Island Shoals, probably the richest of the Australian pearling grounds, where they still fish the best pearls, although the area is too dangerous to tempt present-day pearlers who can get good shell easier elsewhere." (p.23).

Author(s): Coate, Yvonne and Kevin

Year: 2000

Title: More Lonely Graves of Western Australia

Publisher: Hesperian Press

City: Perth, Western Australia

Edition: 1st

Call no./Library: B/994 COA/ Battye

Site/person/event(s) associated with: Montebello Islands – burials

Description: Reference guide to individual burials and cemetery records for West Australia, including off-shore and at-sea burials.

"BRAHNN, died 2.1.1887 aged about 30 years on the MONTE BELLO ISLANDS. A Malay seaman on the Osprey, who died of natural causes." (p.44).

Author(s): Coate, Yvonne and Kevin

Year: 2000

Title: More Lonely Graves of Western Australia

Publisher: Hesperian Press

City: Perth, Western Australia

Edition: 1st

Call no./Library: B/994 COA/ Battye

Site/person/event(s) associated with: Barrow Island – burials

Description: Reference guide to individual burials and cemetery records for West Australia, including off-shore and at-sea burials.

"ANDREAS, died 5.10.1904 aged 45 years on board the lugger *Marietta* – buried on BARROW ISLAND in the Mary Ann Passage by Allic. Witnesses present at the burial were Dolha and Mattir. The informant was M. Fredrikson, master pearler, Onslow. A seaman, who died suddenly of unknown causes. He was born on one of the Malay islands and he had lived in Western Australia for 18 years." (p.10).

Author(s): Coate, Yvonne and Kevin

Year: 2000

Title: More Lonely Graves of Western Australia

Publisher: Hesperian Press

City: Perth, Western Australia

Pages:

Edition: 1st

Call no./Library: B/994 COA/ Battye

Site/person/event(s) associated with: Barrow Island – burials

Description: Reference guide to individual burials and cemetery records for West Australia, including off-shore and at-sea burials.

"LOCHRIN Joe, died 1.10.1904 aged 55 years, on board the schooner *Cutty Sark* off Barrow Island near Mary Ann Passage – buried on BARROW ISLAND by J. Montengre. Witnesses present at the burial were Rubino and Pablo. The informant was A. Harding, resident and partner of Onslow. A sail maker, whose sudden death was of unknown causes. He was born in Chile, South America, and had lived in Western Australia for 2 years." (p.224).

Author(s): Coate, Yvonne and Kevin

Year: 2000

Title: More Lonely Graves of Western Australia

Publisher: Hesperian Press

City: Perth, Western Australia

Edition: 1st

Call no./Library: B/994 COA/ Battye

Site/person/event(s) associated with: Barrow Island – burials

Description: Reference guide to individual burials and cemetery records for West Australia, including off-shore and at-sea burials.

"Bin Usop Dollah, died 8.2.1905 aged 20 years from lugger *Ellen* off Pascoe Island near Barrow Island – drowned at sea. A sailor, who drowned and his body was not recovered. He was born in Malacca and had lived in Western Australia for 9 months." (p.36)

Author(s): Coate, Yvonne and Kevin

Year: 2000

Title: More Lonely Graves of Western Australia

Publisher: Hesperian Press

City: Perth, Western Australia

Edition: 1st

Call no./Library: B/994 COA/ Battye

Site/person/event(s) associated with: Barrow Island – burials

Description: Reference guide to individual burials and cemetery records for West Australia, including off-shore and at-sea burials.

"Deichi Matsumoto, died 8.2.1905 aged 24 years – drowned at sea off Pascoe Island near Barrow Island. A sailor on the lugger *Ellen*, who was drowned and his body was not recovered." (p.101)

Author(s): Gribble, John B.

Year: 1905

Title: Dark deeds in a sunny land or, blacks and whites in the North-west Australia

Publisher: Daily News

City: Perth

Call no./Library: CSO 3678/86

Site/person/event(s) associated with: Barrow Island – burials

Description: European man at Barrow Island died in 1872. Both Carley and Captain Tuckey, who first saw the body, swore an oath that they felt he had been murdered. Official inquiry resulted in a suicide decision. Victim was supervising a large number of Aborigines.

Author(s): WAPET

Year: 1987

Title: Barrow Island Environmental Research: list of references on Barrow Island and adjacent areas

Publisher: WAPET Technical Information Services

Pages: 1-15

Call no./Library: Q333.72 BAR/ Battye

Site/person/event(s) associated with: Barrow Island - environmental research

Description: Bibliographic reference to reports, documentation and journal articles associated with the environmental and ecological aspects of Barrow Island to date (1987). Also includes a list of references regarding publicity relating to Barrow Island.

Author(s): Butler, W. H.

Year: 1983

Title: The Barrow Island experience: a presentation to the 53rd ANZAAS Congress

Publisher: WAPET

City: Perth, W.A

Pages: 1-7

Call no./Library: PR12958/ Battye

Site/person/event(s) associated with: Barrow Island – conservation and preservation

Description: Provides a brief outline of Barrow Island's history and the development of its oil resources. Historical section is brief and not referenced, the emphasis of the presentation highlighting WAPET's procedures for the conservation and preservation of the island's environment.

Author(s): Murray, Robert

Year: 1991

Title: From the edge of a timeless land: a history of the North West Shelf gas project.

Publisher: Allen and Unwin

City: Sydney, Western Australia

Edition: 1st

Call no./Library: 338.27285 MUR/ Battye

Site/person/event(s) associated with: Barrow Island – oil production

Description: History of the development of the North West gas shelf project and the oil and gas industries. References to Barrow Island refer mainly to the oil production and its value. Early references briefly describe WAPET's exploration on the island from the 1950s to the drilling of Barrow 1.

Author(s): Wilkinson, Rick

Year: 1988

Title: A Thirst for Burning: the story of Australia's oil industry

Publisher: David Ell Press

City: Sydney, NSW

Pages: 21 & 38

Edition: 2nd

Call no./Library: 338.27282 WIL/ Battye

Site/person/event(s) associated with: Barrow Island – oil production

Description: Details the history and current status of the oil industry throughout Australia and the major oil fields. References to Barrow Island refer mainly to the early phases of exploration (1954, 1956, 1962, 1963), and the current status of WAPET's drilling on the island.

Author(s): Playford, Phillip E.

Year: 1970

Title: Petroleum exploration in Western Australia; past, present and future.

Journal/Vol./No: Journal of the Royal Society of Western Australia, V54, No.1.

City: Perth

Pages: 1-13

Call no./Library: 506 ROY/ Battye

Site/person/event(s) associated with: Barrow Island - oil fields

Description: Article briefly describes the history of oil exploration in Western Australia with particular attention paid to the developments of West Australian Petroleum Pty. Ltd (WAPET).

Barrow Island oil discovered 1964, first shipment of crude oil from the island 1967. Provides a map of the oil fields on the island, including oil and gas wells and abandoned wells.

Author(s): Gorgon Australian Gas

Year: 2003

Title: Environmental, Social and Economic Review of Gorgon Gas Development on Barrow Island

Publisher: ChevronTexaco

City: Perth, Western Australia

Location: http://www.gorgon.com.au/

Site/person/event(s) associated with: Barrow Island - oil fields

Description: Contains summary of history of oil exploration and extraction on Barrow Island.

"In 1953 West Australian Petroleum Pty Ltd (WAPET) discovered oil at Rough Range, near Exmouth. This prompted an extensive program of geological surveys and exploration drilling in the northern Carnarvon Basin.

Drilling commenced on the Barrow One well on 7 May 1964 and in the first week of July the well produced flowing oil. Two years later, Barrow Island was declared a commercial oil discovery, Western Australia's first. Production began in April 1967 at over 8000 barrels of oil per day, peaking in 1971 at 50 000 barrels per day and in December 2003, the 300 millionth barrel of oil was produced.

Since 1967, more than 800 wells have been drilled, including more than 500 oil production wells, over 250 water injection wells, and various gas producer and water disposal wells. Oil is pumped to the surface using beam pumps in the majority of producing wells, the remaining wells using gas-lift or natural flow. Today, approximately 455 wells are producing oil.

In February 2000 Chevron took over operatorship of the assets previously managed by WAPET. Today ChevronTexaco continues the task of managing a producing oilfield on behalf of its partners Santos Offshore Pty Ltd and Mobil Australia Resources Company Pty Ltd. Personnel working and living on the Island number from 150-200 and rotate in two-week shifts. By 2024, the expected life of the field, it is estimated that Barrow Island will have produced 360 million barrels of oil" (p. 6).

Author(s): Gibbs, Martin

Year: 1995

Title: The Historical Archaeology of Shore-Based Whaling in Western Australia 1836-1879

City: Perth

Call no./Library: Q338.37295 GIB

Site/person/event(s) associated with: Whaling Western Australia – history

Description: PhD Thesis, submitted to the University of Western Australia, 1995.

Whilst there are no references to Barrow Island or the Montebello Islands in this text, Gibbs' discussion of the history of shore-based whaling in the North-West includes details of the history and archaeological survey of the operation that existed on Malus Island (Dampier Archipelago) from 1870-1877.

Author(s): Idriess, Ion L.

Year: 1937

Title: Forty Fathoms Deep: pearl divers and sea rovers in Australian seas

Publisher: Angus and Robertson Limited

City: Sydney

Call no./Library: 639.412/ Reid Library (UWA)

Site/person/event(s) associated with: Pearling Western Australia - history

Description: Unreferenced social history recounting stories of individual pearl divers, most of whom worked around Broome.

No references to Barrow Island or Montebello Islands.

Author(s): Shepherd, B.W

Year: 1975

Title: A History of the Pearling Industry off the North-West Coast of Australia From its Origins Until 1916.

Call no./Library: Q639.412/ Battye

Site/person/event(s) associated with: Pearling industry, North-West Western Australia

Description: MA Thesis submitted to the University of Western Australia, 1975.

Comprehensive history of the pearling industry of the North-West, focusing on the contribution of the Shark Bay industries to the overall economic growth of this part of the state. Covers the contribution of Aboriginal and Asian labour to the industry as well as the development of pearling technology until 1916.

No references to Barrow Island or the Montebello Island group.

Author(s): Battye, J.S

Year: 1985

Title: The History of the North West of Australia: embracing the Kimberley, Gascoyne and Murchison districts.

Publisher: Hesperian Press

City: Carlisle, Western Australia

Edition: 2nd

Call no./Library: Q994.13 HIS / Battye

Site/person/event(s) associated with: North-West Australia - history

Description: History of the exploration and settlement of the North West, particularly the Kimberley, Gascoyne and Murchison districts. Although there is some detail given about early explorations up north, the details regarding the voyage of the H.M.S 'Beagle' and Captain Wickham do not include visits to Barrow Island. Barrow Island does not feature in the chapters on the pearling and pastoral industries either.

Author(s): Hardie, Jenny

Year: 1981

Title: Nor'-Westers of the Pilbara Breed

Publisher: Sands & McDougall (Aust.) Pty. Ltd.

City: Perth, Western Australia

Edition: 1st

Call no./Library: 994.1 1981 NOR/ Reid Library (UWA)

Site/person/event(s) associated with: North-West History – Port Hedland

Description: Referenced social history of the settlement of the Pilbara, particularly Port Hedland, and the development of the pastoral and to a lesser extent, pearling industries. History does not extend back to include earlier exploration phases for the North-West coast.

No references to either Barrow or Montebello Islands or the use of offshore islands in the vicinity.

APPENDIX 4

ASSESSMENT OF HISTORICAL SOURCES RELATED TO SHIPWRECK SITES IN THE BARROW ISLAND REGION – FEBRUARY 2004 (SOUTER)

Shipwreck Sites Protected Under the *Historic Shipwrecks Act 1976*– Not Found

Vianen	**Ship**	**1628/01/25 (refloated)**

Historical Precís: One of the earliest ships to founder on the West Coast, the VOC ship *Vianen* was a wooden vessel of 400 tons enroute from Batavia (Jakarta) to Goeree, Zeeland in the Netherlands. In a letter from the Governor-General to the managers of the East India Company, November 3, 1628, the grounding and refloating of the vessel in the vicinity of Barrow Island is described;

…[We] thought fit to give orders for the ship Vyanen to sail to the strait of Balamboan. [She] sailed [from Batavia] thither on the 14th of January, and from there stood out to sea on the 25th do. She was by head-winds driven so far to south-ward that she came upon the South-land beyond Java where she ran aground, so that she was forced to throw overboard 8 or 10 lasts of pepper and a quantity of copper, upon which through God's mercy she got off again without further damage….

The incident is recorded in Tasman's instructions where it is noted that after the *Vianen* had come across the coast unexpectedly in latitude 21º S she had sailed for 50 miles along the coast but no specific observations had been made. A chart by VOC cartographer Hessel Gerritsz in 1618 has annotations which date to the *Vianen's* sighting of the coast. These marks conform to modern charts and suggest that the vessel grounded in the Port Hedland region, incorporating Barrow and the Montebello islands.

Location:

Lat Max	20º 00	Long Max	115º 10
Lat Min	21º 00	Long Min	115º 50

Sources:

Schilder, G., 1976, Australia unveiled, the share of the Dutch navigators in the discovery of Australia. Theatrum Orbis Terrarum, Amsterdam.

Letter of the Governor General and Councillors to the Heeren XVII, 3 November 1628, in Heeres, J.E., 1899. The part borne by the Dutch in the discovery of Australia 1606-1765., Royal Dutch Geographical Society, Leiden.

Ariel	**Schooner/Lugger**	**1868/01/04**

Historical Precís: This Tasmanian built wooden schooner (Official number 30805), of 26 tons was built in Hobart in 1845 was engaged in pearling when it foundered with Joseph Barrett as Master.

On 25 January 1868 *Ariel* was lost off Locker Point, 50 km west of Ashburton with all hands and around a ton of shell. This was the first recorded tragedy on the pearling grounds of Western Australia and though it was an indication of the risks associated with the industry it did not deter the rest of the pearlers (McCarthy 1996).

Location:

Lat Max	10º 00	Long Max	115º 00
Lat Min	21º 45	Long Min	115º 50

Sources:

Perth Gazette, 3 April 1868

Inquirer, 1 April 1868

RJS, 25/1/1868, Battye Library

Henderson, G., 1988 *Unfinished Voyages: Western Australian Shipwrecks 1851-1880* UWA Press. Nedlands.

McCarthy, M., 1996 *Charles Edward Broadhurst: A Remarkable Nineteenth Century Failure*. Unpublished Mphil Thesis. Murdoch University.

Wild Wave (China) **Brig** **1873/08/30**

Historical Precís: The *Wild Wave* (Official number 43302) was built at Abenraa in Denmark, in 1858 by Peter Lund. The vessel's master was Captain Edward Fothergill and the owner George Howlett. The 180-ton wooden vessel, measuring 31.4 metres by 7.4 metres by 3.9 metres, had one deck with a break, two masts, a round stern and a snake's head figure (Henderson 1988:134).

The ship was enroute to Singapore with a cargo of sandalwood at the time of wrecking. The evidence indicates that the *Wild Wave* was normally employed in the intercontinental trade out of Singapore and that its brief trading period along the Australian coast was speculative until a return cargo to Singapore could be arranged (Batten, MA 439/71). The *Wild Wave* sailed from Fremantle on August 25 with 27 passengers and a crew of 15 Malays. At noon on the 30th, the ship was in latitude 25º 55' South, with Point Cloates bearing north-east 50 kilometres away. The vessel sped past the North West Coast and Barrow Island. Captain Fothergill thought the brig would be well to the west of Barrow Island, but a current had brought it quite close to land. The studding sails were taken in and a lookout posted on the foreyard at midnight. However, the brig was going at 13 kilometres per hour, one and a half hours later, when the officer saw breakers ahead (Captain Edward Fothergill, evidence at the Inquiry held at Cossack, 18 October 1873, CSR 736, fol. 128). The brig struck and at once filled with water. The boats were made ready to leave the ship, and at daylight the crew saw the Montebellos, 13 kilometres to the East (Henderson 1988:133). They made for the Southern end of the group and set up camp, probably on Hermite Island. Lockier Burges in his reminiscences *The Pioneers of the Nor'-West, Australia* in 1913 states that the *Wild Wave* was lost in the vicinity of 'Big Sandy Island' but that name is not listed in the *Gazetteer* (Henderson 1988:133). The wreck was later sold at auction for £200 to Cossack importer Charles Crouch, who salvaged most of the cargo of sandalwood and mining equipment (*Inquirer*, 29 October 1873).

Location:

Lat Max	20º 00	Long Max	115º 10
Lat Min	21º 00	Long Min	115º 50

Sources:

George Howlett to John Absolon, 1 May 1872, Habgood Papers, 813A, Battye Library

Captain Edward Fothergill, evidence at the Inquiry held at Cossack, 18 October 1873, C.S.R. 736, fol. 128

Henderson, G & K.J., 1988 *Unfinished Voyages: Western Australian Shipwrecks 1851-1880* University of WA Press, Nedlands.

Division of Natural Mapping, Dept. of Minerals and Energy, 1975 *Gazetteer* Australian Government Publishing Service, Canberra.

Inquirer, 29/10/1873

Inquirer 29/10/1873 fr 3d

Inquirer 5/11/1873 fe 3d

Inquirer 27/8/1873

Morning Star **Lugger** **1881/01/07**

Historical Precís: At the beginning of the 1880s**,** those involved in the pearling industry were still ignorant of the weather patterns in the North West. A devastating cyclone struck the coast between Exmouth Gulf and Cossack on 7 January 1881 and decimated the unsuspecting pearling fleet (*Herald* 12/2/1881).

In April 1867, the first of a new style of larger pearling boats, the *Morning Star*, was employed for the purpose of harvesting shell. (RJS, 28/4/1867 Battye). These vessels ranged from around 5 tons upwards. Despite the early failures, large boats such as the *Morning Star* were to prove the next step in the developing pearling industry. Not only could they act as a mother vessel to their smaller counterparts and as a transport and storage medium for the shell, but they also could accommodate the shell gatherers themselves. They were the next step up from a small land based open boat and were obviously needed in the efficient pursuit of the shell (McCarthy 1996).

Details of the vessel have not been found as it was unregistered. Archival sources indicate that it was anchored at the time of the cyclone in the vicinity of Yammerdery Creek along with the luggers *Alpha, Baningara, Emma, Florence, Kate, Nautilus, Adela and Yule* (Henderson & Cairns 1995:14). Similarly an *Unidentified Lighter* was also reported lost in the pearling grounds west of Yammadery Creek during this cyclone (Henderson & Cairns 1995).

Location:

Lat Max	10º 00	Long Max	115º 00
Lat Min	21º 45	Long Min	115º 50

Sources:

Herald 12 /2/1881

Henderson, G., and Cairns, L., 1995 *Unfinished Voyages: Western Australian Shipwrecks 1881-1900* UWA Press. Nedlands.

McCarthy, M., 1996 *Charles Edward Broadhurst: A Remarkable Nineteenth Century Failure*. Unpublished Mphil Thesis. Murdoch University RJS, 28/4/1867 Battye Library

Ruby **Lugger/Cutter** **1882/03/06**

Historical Precís: The cutter *Ruby* (Official Number (753089) set sail for the pearling grounds from Point Walcott and was lost when a cyclone struck the region. The Custom's revenue vessel *Myra* was dispatched to search for the missing vessel. A report indicated that Aborigines had seen wreckage near Depuch Island, but a thorough search of the area around the islands of the Montbello and Lowendal groups found no trace of the cutter. Bad weather had prevented Captain Pemberton Walcott of the *Myra* from searching Barrow Is and there was a faint hope that the *Ruby's* crew may have reached there, but it was generally concluded that the vessel must have foundered at sea during the cyclone, all hands being lost.

Location:

Lat Max	10º 00	Long Max	112º 00
Lat Min	26º 40	Long Min	115º 50

Sources:

Inquirer 29 /5/1882

Inquirer 5 /4/ 1882

West Australian 4 /4/ 1882

West Australian 12 May 1882

Herald 13 /5/ 1882

Herald 3 /6/ 1882

Henderson, G., and Cairns, L., 1995 *Unfinished Voyages: Western Australian Shipwrecks 1881-1900* UWA Press. Nedlands.

Register of British Ships. National Archives Perth. Transcribed by Parsons, R., (1971)

SS Dolphin **Cutter** **1902/06/14**

Historical Precís: The *SS Dolphin* (Official number 72472), of 24 tons foundered off Beadon Point, NW Coast of WA. J. Clarke (Owner); Crew 4; Osman bin Buleah (Master); passengers 3; Vessel valued at £200; Cargo values at £400.

Location:

Lat Max	10º 00	Long Max	115º 00
Lat Min	21º 45	Long Min	115º 50

Sources:

Register of Wrecks and Casualties in Western Australia 1897-1942, Her Majesty's Customs, Department of Marine and Harbours. (Transcribed by Dickson, R Report–Department of Maritime Archaeology, WA Maritime Museum No. 56)

Marietta **Lugger** **1905/02/08**

Historical Precís: The *Marietta*, a pearling lugger working off the North West coast was not a registered vessel, and is therefore not listed in the Shipping Registers. McKenna's transcription of the Register of Wrecks however, records the following details:

Stereas (Owner); Scuttled at Barrow Island to avoid total loss.

Another secondary source corroborates this and adds that the vessel may also have been called *Marutta* or *Marcella* (Barnett, 1983). No entries for these names were found in a search of the Registers.

Location:

Lat Max	20º 00	Long Max	115º 10
Lat Min	21º 00	Long Min	115º 50

Sources:

McKenna, R., 1967 Transcription of *Register of Wrecks; Strandings and Mishaps of British Ships, Port of Fremantle* Her Majesty's Customs, Perth.

Barnett, J., 1983 *An Illustrated Map and Brief History of Shipwrecks along the WA Coast*. Unpublished. Battye Library.

Ellen	**Lugger**	**1905/02/08**

Historical Precís: The *Ellen* was an unregistered lugger; Alex Burney (Owner); Harry B. Johnson (Master) which was swamped by heavy seas at Onslow, WA. While the vessel was at anchor, the chain parted causing the boat to drift and founder. All five crew were lost and the vessel valued at £500.

Location:

Lat Max	10º 00	Long Max	115º 00
Lat Min	21º 45	Long Min	115º 50

Sources:

Register of Wrecks and Casualties in Western Australia 1897-1942, Her Majesty's Customs, Department of Marine and Harbours.(Transcribed by Dickson, R Report–Department of Maritime Archaeology, WA Maritime Museum No. 56)

McKenna, R., 1967 Transcription of *Register of Wrecks; Strandings and Mishaps of British Ships, Port of Fremantle* Her Majesty's Customs, Perth.

RN 791 Battye Library

Curlew	**Lugger**	**1911/02/06**

Historical Precís: The *Curlew* (Official Number 101614); was a pearling lugger of 11 tons built and registered in Fremantle in 1892; A.R. Harding (Owner); Crew 7; C,F Nyshom (Master). The *Ships Registered in Western Australia* archive records it as wrecked in a hurricane at Onslow in cyclone, with one survivor while the *Register of Wrecks and Casualties in Western Australia* records the vessel as wrecked lagoon at Hermite Is. Montebellos with all 7 crew saved, no cargo.

Location:

Lat Max	20º 00	Long Max	115º 10
Lat Min	21º 00	Long Min	115º 50

Sources:

Register of Wrecks and Casualties in Western Australia 1897-1942, Her Majesty's Customs, Department of Marine and Harbours.(Transcribed by Dickson, R Report–Department of Maritime Archaeology, WA Maritime Museum No. 56)

Ships Registered in Western Australia National Archives. (Transcribed by Dickson, R. Report–Department of Maritime Archaeology, WA Maritime Museum No.80.)

McKenna, R., 1967 Transcription of *Register of Wrecks; Strandings and Mishaps of British Ships*, Port of Fremantle Her Majesty's Customs, Perth.

Lapwing	**Lugger**	**1911/02/07**

Historical Precís: The pealing schooner *Lapwing* (Official no. 102227) of 11.26 tons was reported as a total wreck near the MonteBello Islands. The owner is recorded as F.L. Parkes.

Location:

Lat Max	10º 00	Long Max	115º 00
Lat Min	21º 45	Long Min	115º 50

Sources:

McKenna, R., 1967 Transcription of *Register of Wrecks; Strandings and Mishaps of British Ships, Port of Fremantle* Her Majesty's Customs, Perth.

Moana	**Lugger**	**1920/08/17**

Historical Precís: The *Moana*, (Official number 118529) a lugger engaged in pearling, was for a large part of it's life ownded by the Broome Pearling Company. The vessel foundered in Mary Ann Passage after a collision with the *SS Bambra* resulting in the loss of 7 lives. P.J Smith is listed as the owner at the time of wrecking. The vessels is also sometimes referred to as *Moara* (Dept. Harbour and Lights *Record of Shipping Casualties* AN16/3 ACC 1056).

Location:

Lat Max	10º 00	Long Max	115º 00
Lat Min	21º 45	Long Min	115º 50

Sources:

Register of Wrecks and Casualties in Western Australia 1897-1942, Her Majesty's Customs, Department of Marine and Harbours.(Transcribed by Dickson, R Report–Department of Maritime Archaeology, WA Maritime Museum No. 56)

Ships Registered in Western Australia National Archives. (Transcribed by Dickson, R. Report–Department of Maritime Archaeology, WA Maritime Museum No.80.)

McKenna, R., 1967 Transcription of *Register of Wrecks; Strandings and Mishaps of British Ships*, *Port of Fremantle* Her Majesty's Customs, Perth.

Dept. of Harbour and Lights *Record of Shipping Casualties* AN16/3 ACC 1056

SS Bambra Log Book 1920(2) AN 16/14 ACC 1056

AN 16/5 ACC 1036 & 1066 *SS Bambra* collision with lugger *Moara* in Mary Ann Passage

Shipwreck Sites Not Protected– Not Found

Boreas **Lugger** **1932/05/04**

Historical Precís: Official number 140171; A.E. Iverson, G.W. Lort, L. J. Jones of Onslow (Owners) Wrecked NE end of Weld Is.

Location:

Lat Max	10º 00	Long Max	115º 00
Lat Min	21º 45	Long Min	115º 50

Sources:

AN 16/5 ACC 1066 1936 837 Wreck of luggers.

Rosebud **Lugger** **1933/09/12**

Historical Precís: Official number 1022417, 12 tons wrecked nr Broome(?) or Airlie Is. NE of Onslow Samuel H. J. N. Clark, of Beadon, storekeeper (Owner).

Location:

Lat Max	10º 00	Long Max	115º 00
Lat Min	21º 45	Long Min	115º 50

Sources:

HMC 40/3 McKenna Collection 681, WA Maritime Museum

AN 16/5 ACC 1066 1936 837 Wreck of luggers

McKenna, R., 1967 Transcription of *Register of Wrecks; Strandings and Mishaps of British Ships*, *Port of Fremantle* Her Majesty's Customs, Perth.

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Technical Appendix E2

Visual Assessment Report

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FINAL REPORT

GORGON

Technical Appendix
Visual Assessment Report

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FINAL REPORT

GORGON

Technical Appendix

Visual Assessment Report

0013438 RPT1 Revision b

For and on behalf of Environmental Resources Management Australia

Approved by: Keryn James

Signed:

Keryn James

Position: Partner

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Executive Summary

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Aims

The Gorgon Joint Venture Project Development Team aims to reduce the visual impacts of the proposed works by considering the landscape character of the development area in the design, construction, rehabilitation, operation and ongoing maintenance of all facilities and associated infrastructure.

The proposed Gorgon Development comprises the following components:

1. Sub-sea gathering infrastructure at the Gorgon gas fields.
2. 70 km long feed gas pipeline to bring gas/well stream fluids to Barrow Island from the Gorgon gas field. Onshore Barrow Island there are currently two options, one landing at Flacourt Bay and the second at North White's Beach.
3. Gas processing plant & port facilities on the east coast of Barrow Island.
4. 80 km long domestic gas (DOMGAS) infrastructure piping gas from Barrow Island to the mainland.
5. On the mainland the DOMGAS pipeline corridor remains underground along side an existing gas easement. This alignment crosses through Mardie Station (Stock Grazing Property) to join the Dampier-Bunbury Natural Gas Pipeline at Compressor Station One (CS1).

Existing Environment

The Development area has been divided into offshore and onshore components. The onshore component will generally relate to Barrow Island, whereas the mainland (Mardie Station) underground component will mostly be referred to in construction and mitigation measures outlined in the main report.

Offshore

The sub-sea gas-gathering system will be located on the sea floor at the Gorgon gas fields 70 kilometres west of Barrow Island. The feed gas pipeline both from the sub-sea gas-gathering system to Barrow Island and the 80km long domestic feed gas pipeline from Barrow Island to the mainland does not have any visual impact implications above the waterline.

Onshore Barrow Island

The landscape of Barrow Island is arid and rugged accommodating spectacular views of low grey green vegetation interspersed with ochre red termite mounds. On the coastline weathered rocky headland contrast with white secluded sandy beaches and aqua-blue water.

Landscape form consists of limestone uplands, dry creek beds, red inland sands, white coastal dunes, beaches, clay and salt flats and intertidal flats.

Due to the arid climate vegetation covers is low, generally sparse and up to 90% of species are related to three types of spinifex, *Triodia wiseana, Triodia angusta* and *Triodia epactica*.

Existing oil extraction infrastructure, such as wells and associated pumping equipment are intermixed throughout the central region of the island with the tallest structure being the communication tower (120m high) situated on the highest central upland point (65m above sea level).

In 1910 Barrow Island was pronounced a Class A Nature Reserve with the unique status of attaining no introduced species, flora or fauna.

For the purpose of the visual assessment the landform on the island can be broadly divided into five landscape units defined on the basis of dominant plant species, associated landform, soils, underlying geology and vegetation unit surveys.

These five landscape units are:

- West Coastal Complex;
- East Coastal Complex;
- Valley Slopes and Escarpments;
- Limestone Ridges; and
- Creek or Seasonal Drainage lines.

These units are described in Chapter 2.4 'Baseline Landscape Character'.

Onshore Mainland DOMGAS Pipeline

The mainland landscape, upon leaving the coastal mangrove zone, is described as a non-vegetated salt plain. Following the proposed/existing easement east, low hummocks of grassland/spinifex become dispersed through the red soil salt flats. These vegetated hummocks join to provide a flat open sparsely vegetated shrub and grassland, as it approaches CS1.

The landscape can be described as being moderately disturbed with evidence of local soil erosion, cleared vegetation evident along existing pipeline easement, disturbed soil/rock due to stock grazing. There is evidence of introduced vegetation species within this landscape.

The Mainland can be described as having the following 4 landscape units:

- Coastal Mangrove Zone
- Red/Grey Non-vegetated Salt Flats
- Vegetated Hummocks within Salt Flats
- Low Lying Shrub and Grasslands

These units are further described in Chapter 2.4 'Baseline Landscape Character'.

Potential Visual Impacts and Visual Mitigation

Methodology

The assessment process commenced at the very broad scale in order to gain an understanding of the landscape setting in which the project was located. It then focussed in greater detail on the position of the components and their relationship within their immediate setting.

The landscape on Barrow Island was initially divided into 5 units as listed above to discuss **baseline landscape character**. Within each of these units, change resulting from the infrastructure can be accommodated to varying degrees without significantly altering the setting. This was determined as **Landscape Absorptive Capability** and is assessed in broad terms within the **Baseline Landscape Character** study. This process assists in the understanding of the visual interaction occurring between the project infrastructure and the setting as a precursor to the more detailed analysis.

At the more detailed level, due to the deficiency of human receptors which is applied in the process of measuring **Visual Amenity**, the seen value of a landscape character, the assessment concentrated on evaluating **Visual Effect**, the degree to which the project infrastructure changed the appearance of the landscape as a result of development. Through qualitative and quantitative assessment tools these values were then considered in determining the relative levels of **Visual Impact** (the measure of visual effect in the landscape) during and immediately after construction.

Various **Visual Impact Mitigation** measures were then recommended to assist in obtaining a greater visual integration of the infrastructure into the setting, thereby reducing its visibility or visual effect.

The assessment methodology is discussed in detail within Appendix A. The remainder of the chapter is summary of the assessment findings.

Areas of Visual Amenity

Offshore

The amenity of this visual setting is considered to be nil due to the gas collecting and transporting infrastructure situated below sea level.

Onshore Barrow Island

Visual Amenity is described as 'the value of a landscape in terms of what is seen' (GLVIA 2002). Therefore it was concluded that due to the deficiency of human receptors within this landscape visual amenity is perceived as low to very low.

Onshore Mainland DOMGAS Pipeline

Due to the lack of human receptors within close proximity to the proposed DOMGAS pipeline location (all 220,000ha of the station is used for stock grazing purposes), visual amenity is also perceived as low to very low.

Visual Absorption Capability

Visual Absorption Capability is a measure of the relative ability of a landscape character type to absorb visual change. A landscape with a high absorptive capability is able to absorb more visual change than one with a low capability. The Visual Absorption Capabilities of the landscape units in the Development area are listed in Table 1 below.

Table 1. Visual Absorptive Capability of Landscape Units in the proposed Barrow Island Development Area

Landscape Character Units	Visual Absorption Capability
West Coast Complex	Low
East Coast Complex	Moderate
Valley Slopes and Escarpments	Low to Moderate
Limestone Ridges	Low
Creek or Seasonal Drainage lines	Moderate

Onshore Mainland - Mardie Station

As with Barrow Island the landscape character of the mainland is predominantly open & flat with sparse covering vegetation, therefore the visual absorption capability of this landscape would be considered as low.

Visual Effect

The visual effect is the degree of change/contrast that occurs in the appearance of the landscape as a result of the development.

Onshore Barrow Island Pipeline(s)

The degree of visual effect involved with the pipeline will generally be associated with how the landscape absorbs a linear form within a natural setting. This has most consequence when the corridor parts from an established road easement.

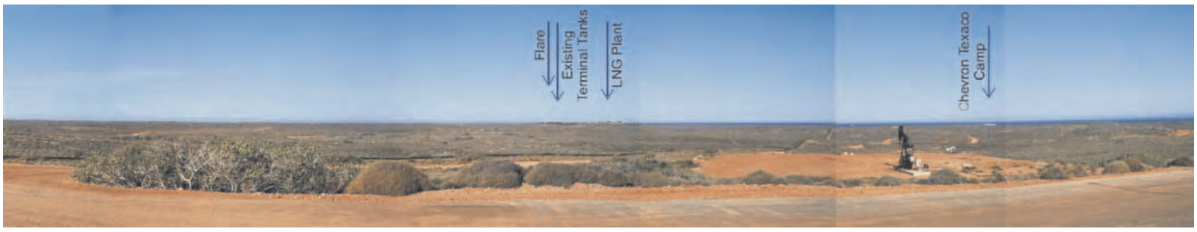
Much regard will be given to construction in particular, the clearance of vegetation and disturbance of the ground surface. Long term visual effects will be negligible, as the alignment design option, rehabilitation and construction management will be carried out in an effective manner.

LNG Plant and Port Facilities

The visual effect of the LNG plant, port facilities and temporary construction camp will depend on the viewer's position within the infrastructure viewshed. If the Plant is viewed beyond the surrounding ridgeline, beyond that which surrounds the drainage line flat (LNG Plant site) the visual effect will range from slight to negligible.

This is due to the screening and integration of Plant mass with the undulating terrain and the softening of distance when high points in the terrain do allow views to the LNG Plant and port facilities (refer Figure 1 below illustrating modelled view from Base Castle, highest viewing point in the central uplands).

Figure 1. Viewing simulation of LNG Plant at completion of construction from Base Castle Communication Tower.



Where the LNG Plant, port facilities and construction camp is viewed within the drainage line flat or upon the nearby surrounding ridgeline (within the 5km viewshed) the visual effect will be moderate to substantial as the structure contrasts with the immediate landscape.

Figure 2. Viewing simulation looking north on ridgeline from Chevron Camp, approximately 4km from LNG Plant and port facilities site.

Onshore Mainland DOMGAS Pipeline

The DOMGAS pipeline will be located underground, in close proximity to the existing Apache pipeline. As the pipeline infrastructure will not be viewed, regard will be given to the construction easement in particular, the clearance of vegetation and disturbance of the ground surface. Apart from a wider clearance easement, long term visual effects will be negligible, as rehabilitation and construction management will be carried out in an effective manner.

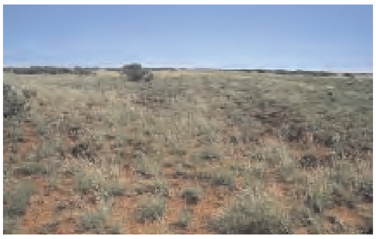


Figure 3. View of existing onshore mainland pipeline corridor, viewing east towards Compressor Station 1.

Visibility of Components

Offshore

The offshore facilities gas collecting facility will not be visible from the ocean's surface or from land.

Onshore Barrow Island Pipeline(s)

The pipeline routes will not be regularly visible until seen from within the road easement or from a road vantage point. The pipeline infrastructure will be most visible on the upland 'Limestone Ridges' landscape unit. Furthermore the pipe infrastructure will be substantially visible when vegetation is sparse in between the shared road corridor or when the pipeline route intersects with the road.

LNG Plant & Port Facilities

The LNG Plant will be moderately visible from within the central eastern area of the island and offshore while approaching the central island mass from the east. Visibility of the plant from the central upland area of Barrow Island will be negligible with views mostly screened by undulating topography and intervening ridgelines.

The viewshed analysis in Figure 4. below, illustrates where the comprehensive height (calculated at 20m above respective ground level) of the proposed LNG Plant will be seen. The flare height is approximately 150m tall and due to its thin structure in contrast to the Plant structure the visual impact is considered negligible (refer chapter 4.6.4 Flare and Illumination).

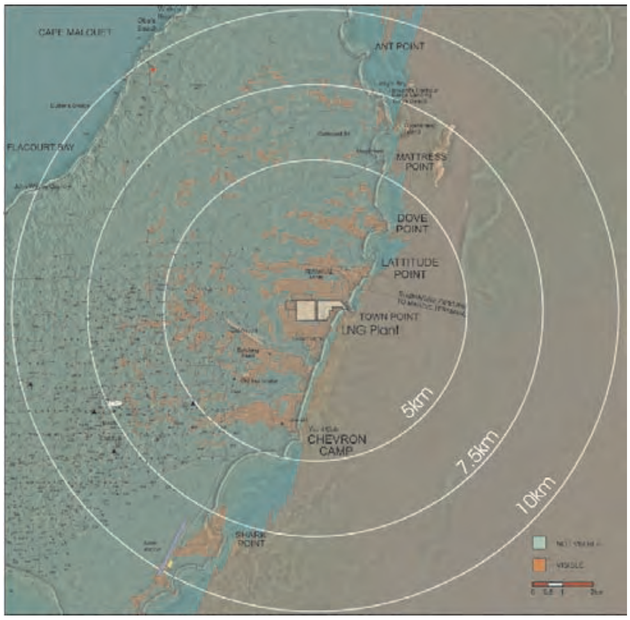


Figure 4. Showing Viewshed of Gorgon LNG Plant

Seven (7) computer generated images from 7 viewpoints in chapter 4 illustrate varying views of the LNG Plant from various distances and viewshed vantage points. These illustrate what components will be seen from person's (workers) from within the viewshed.

Onshore Mainland DOMGAS Pipeline

Once operational, visibility of the pipeline infrastructure will be nil.

Assessment Results - Visual Impact

Detailed findings are included in Chapter 4 of the Report. The following provides a summary of key results.

Onshore Barrow Island Pipeline(s)

The visual impact of the gas pipeline options will be negligible to moderate. Areas of substantial impact will occur in a small number of locations where vegetation is sparse along the central upland 'Limestone Ridges'.

LNG Plant and Port Facilities

The visual impact of the proposed LNG plant and port facilities will be moderate to substantial for views within 5km of the central eastern section of Barrow Island. The anticipated impacts from key viewing locations are summarised in Table 2 and noted in detail in Chapter 4. 6.

Table 2. Indicative Areas of Visual Impact

Viewing Location	Impact*
View 1 – Chevron Camp	Moderate
View 2 – Town Point	Substantial to Severe
View 3 – Communication Tower, Base Castle	Negligible
View 4 – Ocean View at 5km	Moderate to Substantial
View 5 – Road Junction, Old Airport	Substantial
View 6 – New Airport	Negligible to None
View 6 – Ridgeline West of Terminal Tanks	Substantial **Criteria definitions in Methodology Appendices A 1.5*

Within the 5km viewing area the LNG plant will be in stark contrast to the low vegetated nature of the landscape. Given the arid conditions and the lack of substantial indigenous vegetation that may be able to be used to screen the LNG Plant, the impact level would not significantly reduce over time.

Onshore Mainland DOMGAS Pipeline

During construction, the visual impact will be negligible, as there are no human receptors except the construction workers. The visual impacts of completed pipeline corridor will be negligible to none, as rehabilitation and construction management will be carried out in an effective manner.

Visual Impact Mitigation

The landscape of the project area is one of great significance and fragility and already a portion of the Barrow Island has viewed man-made development from a low to moderate extent.

Given the relative scarcity of vegetation of any physical stature due to the environmental conditions of the project area, amelioration methods that rely on the growth of vegetation to hide the visual effects of the LNG plant will be ineffective and therefore inappropriate.

Therefore, where practicable, the components of the proposed pipeline easements and LNG plant will be located to make use of existing infrastructure and topography to minimise visual disturbance and optimise visual blending and screening where possible.

The visual effect of the reinstated pipeline both on Barrow Island/Mainland and the benching works that occur around the LNG Plant pad will depend upon the degree to which it is noticeable due to a contrast occurring between disturbed areas and the surrounding natural ground surface. This may result from observable differences in the colour of the backfilled material or a change in texture and size of the naturally occurring soil or rock on the ground plane.

The dominant colour of the weathered and oxidised surface rock is a light (sun bleached) cream to pink in colour. However, when the rock is fractured or the surface disturbed the colours become deeper and the underlying rust red-ochre earth becomes a dominant contrast. Therefore, it is very important that different soil profiles are stored separately and replaced in the same locations and that excavated rock is reburied where practicable.

Given the difficulty of achieving effective rehabilitation, planning and management should focus on minimising the area of disturbance to vegetation. Experience gained from other revegetated pipelines and benched platforms within the area have demonstrated that the harsh conditions will make revegetation with the same pre-development species difficult.

To assist with this process, revegetation will commence immediately following reinstatement, using direct topsoil placement that matches that of the particular location rather than the broader area. This topsoil contains a local seed pool and from experience is the most effective way of achieving germination. Impact Mitigation and Rehabilitation methods are explained in detail within Chapter 4.4 of this report. In addition, ongoing research into collecting propagation material from the plant site prior to construction to allow stocks of appropriate revegetation species to be grown is to be further investigated.

Environmental Management Objectives:

- To reduce visual impacts to an acceptable level.
- To consider the landscape character in the design, construction, rehabilitation, operation and ongoing maintenance of all facilities and associated infrastructure.

Environmental Management Strategies:

Onshore Pipeline(s) inluding mainland DOMGAS easement

- The extent of vegetation clearing will be minimised.
- Disturbance of soil and rock outcrops will be minimised.
- Construction easement width will be minimised and disturbance to areas outside the easement will be avoided.
- Soil and rock will be replaced to match the existing layers/profiles.
- Revegetation will commence immediately with local direct topsoil replacement or a species mix matching that of the exact location rather than the broader area.
- Infrastructure/easements will be designed and managed to minimise visual impact.

LNG Plant & Port Facilities

- The extent of vegetation clearing will be minimised.
- Propagation material for revegetation will be collected from both the Camp site and LNG Plant site prior to construction.
- Where practicable, the LNG plant components will be located and benched so that they optimise the advantage of the low-lying area and surrounding ridge lines.
- Surface and sub surface material will be stockpiled separately and will be utilised in areas exposed such as terraces, unused roads and as appropriate. Topsoil is not to be stockpiled higher than 1m, and used as soon as practicable.
- Soil and rock will be replaced to match the existing layers/profiles.
- Where practicable, rehabilitation of site benching and unused construction roads/areas will commence immediately with direct topsoil placement that matches that of the exact location rather than broader area.
- Infrastructure surfaces, Port Facilities will be of a colour that minimises visual impact where practicable (non-contrasting colours to vegetation and ocean).

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1 Introduction

Aims

The Gorgon Joint Venture Project Development Team aims to reduce the visual impacts of the proposed works by considering the landscape character of the development area in the design, construction, rehabilitation, operation and ongoing maintenance of all facilities and associated infrastructure.

Objectives

The objectives of the Visual Assessment Report are:

- to assess the visual impacts of the proposed LNG plant and associated infrastructure, from view points within the view shed of the development on and around Barrow Island,

- to assess the impact of the proposed, pipeline(s) and associated infrastructure on the landscape character of the localities through which it runs, and

- to determine a landscape strategy which would help to mitigate significant impacts and to integrate the proposed LNG plant and pipeline(s) into the landscape.

Issues To Be Addressed

Landscape impacts are assessed separately from visual impacts, whereas the receptors of landscape impacts are essentially the elements that comprise the physical environment, such as vegetation, watercourses and built form, the receptors of visual impact are the human users of the physical environment.

As described in the Guidelines for Landscape and Visual Impact Assessment, Spon Press 2nd Edition (GLVIA 2003).

'*The sensitivity of visual receptors and views are dependent on:*

the location and context of the view;

the expectations and occupation or activity of the receptor;

the importance of the view, which may be determined with respect to its popularity or numbers of people affected…'

The Guidelines further state that,

'…the least sensitive receptors are likely to be people at their place of work, or engaged in similar activities… …In this process more weight is usually given to changes in the view or visual amenity.' (GLVIA 2003)

The assessment of the change to, or impact on, the visual amenity of an area involves consideration of two separate but closely interlinked factors:

'Views' are defined as 'what can be seen from an identified location'. However, to interpret views, it is necessary to understand the context of the view.

'Landscape' refers to the context of a view, comprising not only physical appearance, but also population and such factors as built elements, 'naturalness' and scenic beauty. It can be described only up to a point, because the value ascribed to a landscape will vary from person to person and their specific relationship to the land.

Due to Barrow Island's stringent quarantine conditions and isolation to public activity the landscape relationship to human receptors is significantly unique. Workers associated with the oil and gas projects are the only person's to view the development.

Therefore this visual assessment will focus on the visual changes to the landscape in response to the LNG Plant/Port facilities and Pipeline corridor(s) pre-development and construction.

Factors to be considered in assessing the visual impacts of a development are:

- vegetation cover,
- topography,
- degree of existing human modification to the 'natural' landscape and dominance of man-made elements and,
- the proposed developments viewshed (relating to view spread and distance) and specific human vantage points within this viewshed.

The assessment of landscape and visual impacts was undertaken using the following assumptions:

- The parameters of human vision provide some guide in measuring relative visual impacts of the above ground components (ie. LNG Plant and pipeline easement).
- As distance increases, visual impacts are reduced.
- Topography and vegetation can help screen, filter views.
- Perception of beauty and what is visually intrusive can vary.

The visual assessment report is based on interpretation of quantitative assessment (which is based on measurable parameters), and a qualitative assessment, which is based on accurately visualising the proposed works within the existing landscape, and assessing the landscapes ability to absorb that impact.

Methodology

The landscape assessment has been undertaken in accordance with the methodology recommended by the UK Institutes of Landscape and Environmental Management and Assessment. This methodology is consistent with the preparation of Environmental Impact Assessments in accordance with EU Directives and can be applied to the Barrow Island context.

The visual assessment will discuss changes that the proposed development will make to the existing landscape, these being visible from surrounding viewshed locations. The methodology is set out in detail in Appendix A. however in summary the visual assessment is based on the following:

- Determine existing visual Baseline Landscape Character Units and regulatory special values that may apply to this area;

- Within the above description discern the Visual Absorptive Capability of the Baseline Landscape Character Units in the Development - Visual Absorption Capability is a measure of the relative ability of a landscape to absorb visual change. A landscape with a high absorptive capability is able to absorb more visual change than one with a low capability;

- Determine the extent of the viewshed/visual catchment;

- Locate viewpoints within the viewshed where the visual effect (changes to the landscape) can be best described;

- Quantitatively assess the potential visual impact by comparing measurements of viewing size and distance to determine view angles, which relate to the parameters of human vision;

- Qualitatively assess the visual impact by utilising computer simulations to accurately describe and simulate the change to the landscape from identified viewpoints; and,

- Recommend mitigation measures to ameliorate visual impact.

Infrastructure Components

The following components form the Gorgon Gas project.

Offshore Gas Fields

The sub-sea gas-gathering system will be located on the sea floor at the Gorgon gas fields 70 kilometres west of Barrow Island and does not have any visual impact implications above the waterline.

Onshore Gas Pipelines and Corridors

The onshore pipeline will transport gas from the western shore crossing location and head in an easterly direction following closely to an existing road easement, then onto the LNG Plant site. An outgoing gas pipeline will transport gas from the LNG Plant across the eastern shoreline towards the mainland for domestic gas purposes (DOMGAS) and along a 4km jetty to a ship gas loading facilities.

LNG Plant & Port Facilities

The LNG Plant will include a number of structures located above ground associated with the processing and storage of gas. It is expected that the gas plant *(internal infrastructure)* will have a total infrastructure area of approximately 300ha**.** This will include:

- Storage tanks,
- Towers, Pumps and Compressors,
- Offices, workshop and stores,
- Flare and utility systems,
- Racks and Pumps,
- On site turning bays and provisions for vehicle parking.

The Port Facilities include:

- A Material Offloading Facility (MOF) A jetty that extends approximately1km in length directly east of the LNG Plant, and
- A ship gas loading jetty, a smaller thin structure that extends diagonally approximately another 3km from the end of the MOF.

Proposed LNG Plant & Port Facilities detail shown in Chapter 3 Figure 3.4.

Onshore Mainland DOMGAS Pipeline

A sub-sea pipeline from Barrow Island LNG Plant will transport compressed domestic gas to the Western Australian mainland for use in the industrial and domestic gas markets. The pipeline will join existing gas pipeline alignments before crossing the mainland West Coast south of Dampier and will continue east to Compressor Station One.

With regard to the following Visual Impact Assessment report the gas pipeline components on the mainland will be situated underground therefore this pipeline easement will only be referred to in regard to general construction and visual mitigation measures outlined to lesson temporary and long term visual impact.

2 Baseline Landscape Character

2.1 Introduction

The assessment of baseline landscape characteristics discusses the following:-

- A regional assessment to identify landscape character units with similar environmental and geological characteristics, discussing their ability to absorb the impacts associated with the pipeline easement(s) and associated infrastructure;

- Describe the proposed route alignment, and the location and surrounding landscape for proposed shore crossing(s) and proposed onshore pipeline corridor(s);

- Describe the landscape characteristics surrounding the location under consideration for an onshore LNG Plant;

- Identify surrounding viewpoints from where visual changes to the landscape will be noticeable from human vantage points and can be best described.

Project Alignment Plan

The plan (Figure 2.1) on the following page illustrates the proposed options for the alternative shore crossing(s), above ground gas pipeline corridors and LNG Gas Plant location. This plan provides a context for further assessment of the regional landscape character types, local landscape characteristics and surrounding viewpoints associated with:

Island Shore Crossing(s)

- North White's Beach
- Flacourt Bay

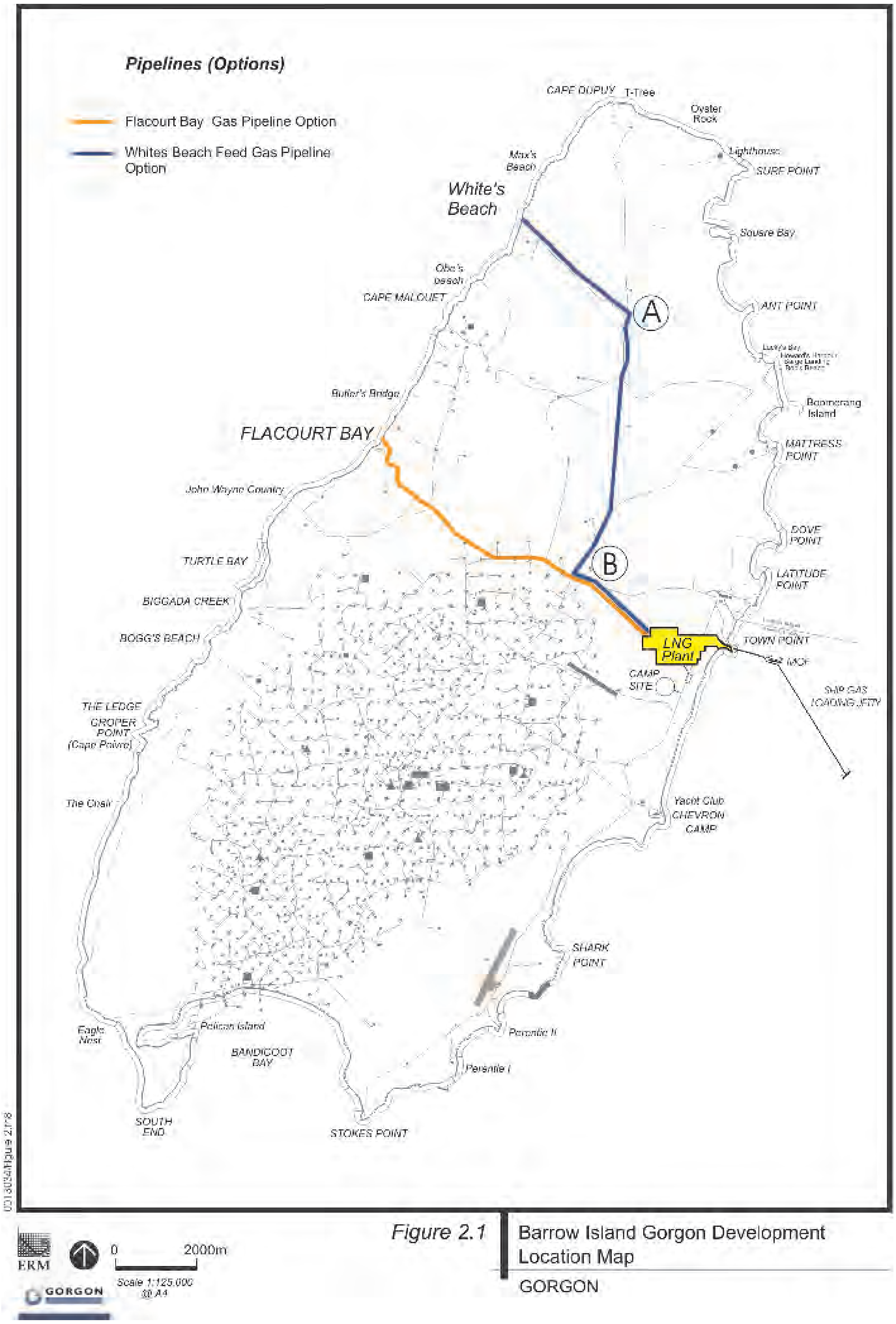
Island Onshore Gas Pipeline Route with possible connections from

- North White's Beach
- Flacourt Bay

Proposed LNG Plant site and Port Facilities

- Mid east point on Island directly west of Town Point.

Figure 2.1 – Barrow Island Gorgon Development Location Map



Onshore Mainland DOMGAS Pipeline

Gas pipeline aligns with existing gas services offshore and crosses the shoreline South of Dampier aligned with existing gas pipeline easements. The pipeline then continues underground to Compressor Station One.

Regional Baseline Landscape Characteristics

Barrow Island Landscape Overview

Barrow Island is elongated oval in shape, 25km in length and 10km in width with total area of about 234km squared. The highest area on the island is 65 metres above sea level. Generally the island can be said to slope toward the sea on the eastern side from higher erosional cliffs and deeply eroded gullies to the west.

An overview of Barrow Islands landscape consists of limestone uplands, dry creek beds, red sands, white dunes, beaches, clay and salt flats and intertidal flats.

The area of the island can increase up to 20% at low tide as a result of shallow offshore conditions and a mean spring tidal range of 2.5m.

Vegetation is low and sometimes sparse due to the arid climate and plant types vary on the island depending on the landform, soil depths and proximity to the sea. Up to 90% of vegetation on Barrow Island are related to three species of spinifex, *Triodia wiseana, Triodia angusta* and *Triodia epactica*.

Oil extraction infrastructure can be sporadically viewed throughout the island with the tallest structure being the communication tower (120m high) situated on the highest central point. The largest visually intrusive man-made structures are the oil terminal tanks situated on the central eastern coastline. These are 5 approximately 25m high by 60m wide bulk oil collection tanks have inturn a relatively low view shed which is contained to the central eastern part of the Island due to Barrow Islands rolling limestone ridges and central upland topography.

More frequently viewed are the less intrusive well heads that are dotted around the central and south central areas of Barrow Island.

Termite mounds, another common vertical element, are spread across much of the Island's landscape. They can sit up to 2m above the vegetation and are ochre red in contrast to the grey green of the spinifex type vegetation.

Four landscape units for Barrow Island have been defined on the basis of dominant plant species, associated landform and soils as a result of flora surveys by Buckley(1983), Trugden(1989) EM Mattiske and Associates (1993;97) and recently expanded by Astron Environmental (1992).

For the purpose of the visual assessment the coastal unit has been further broken down into two separate units due to contrasting visual differences of the West and East Coast to make five landscape   These five landscape units are:

- West Coastal Complex;
- East Coastal Complex;
- Valley Slopes and Escarpments;
- Limestone Ridges;
- Creek or Seasonal Drainage lines.

Figure 2.2 below identifies the location of the various landscape character units within the Island Study area.

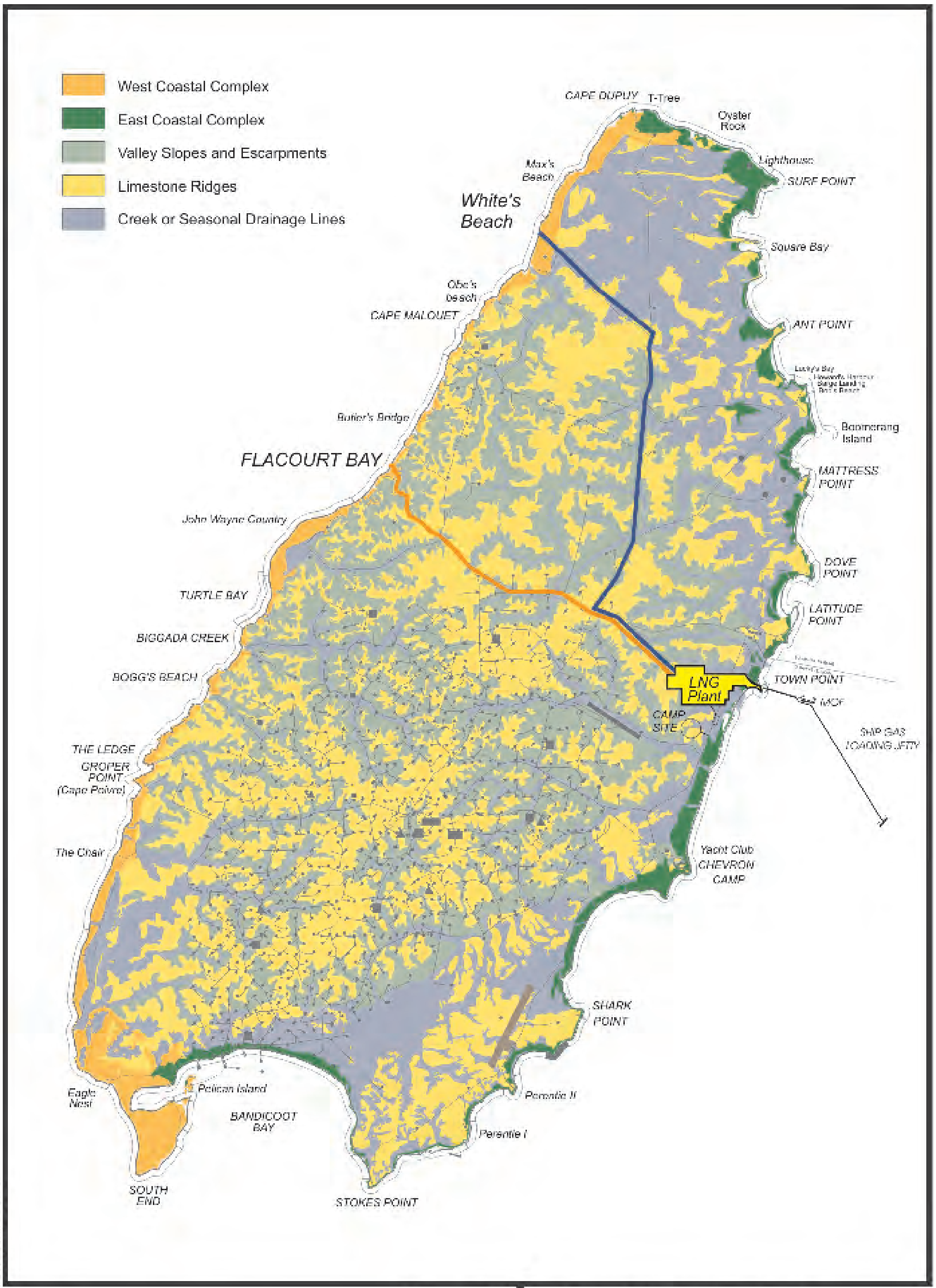


Figure 2.2 Landscape Character Units

GORGON

Baseline Landscape Character Units

This section describes the visual landscape character types within the regional study area. Units are based on areas with similar visual characteristics in terms of their ability to absorb visual change. Often the character units relate to areas with similar environmental, flora and geological features. For the purpose of this Visual Assessment within Barrow Island there have been 5 Landscape Character Units defined and on the Mainland (Mardie Station) there are 4.

Onshore Barrow Island Landscape Character Units

Unit 1 – West Coast Complex

The western ocean coastline absorbs the wind and wave action associated with the open Indian Ocean. The coastline topography varies from rocky weathered steep sheer cliffs to less steep traversable inclines. Typically the existing sandy beaches are narrow and fit between the weathered rocky headlands.

This coastline is a significant feature of Barrow and the western area is highly rated in terms of world significance and accordingly is regarded as sensitive to potential visual disturbance.

Figure 2.3 - View northerly direction of rugged cliffs located along western coastline north of Flacourt Bay towards Butler's Bridge

Except for low priority tracks leading to individual beach's there is no man-made influences viewed in this Landscape Character Unit together with this pristine natural setting this landscape Character is seen to have a low potential to absorb visual change.

Plants in Unit 1 are sparse and cling to the limestone outcrops. The vegetation is described as Low Mixed Shrubland with dominant species of *Frankenia pauciflora* & *Hedyotis crouchiana*.

Figure 2.4 - View southerly direction of western coastline across Flacourt Bay towards John Wayne Country and sheltered reef coral of Turtle Beach beyond

Unit 2 – East Coast Complex

In contrast, Barrow Island's eastern coastline is somewhat more protected and a slight land gradient meets the ocean. Vegetated sand dunes and large tidal flats occur more readily and the 2.5m tidal variance is quite noticeable along this coastline.

Figure 2.5 - View in southerly direction from Town Point with a receding tide.

Figure 2.6 – Same view in southerly direction from Town Point showing high tide.

Vegetation types that occur along this coastline are dominated by the more hardier *Triodia angusta*.

Figure 2.7 – View in northerly direction from Town Point showing oil Terminal Tanks on left and centre right Apache oil rig monopods visible on the ocean horizon.

Existing man-made infrastructure is situated and viewed readily along this coastline (ie. Barge docking infrastructure, 5 large oil terminal yanks, new and old Airports, Well Infrastructure and the Chevron Camp site).

Due to man-made visual disturbance and low-lying nature of the landscape its ability to absorb further development becomes moderate.

Unit 3 – Valley Slopes and Escarpments

Steeper formed valleys and escarpments tend to occur on the western side of the Island that leave exposed limestone ridges, escarpments and relatively deep valleys.

Typical vegetation on the valley slopes and escarpments is described as open low shrubland with dominant species of *Triodia wiseana* with mixed emergent lower growing shrub species such as *Acacia bivenosa/Petalostylis labicheiodes* and *Petalostylis trichodemoides* situated on the southern escarpments.

The hilly terrain within this unit provides views from the elevated areas, however this characteristic may also assist to absorb visual disturbances due to intervening ridgelines therefore the absorptive capability of this landscape unit is considered as being low to moderate.

Figure 2.8 - View easterly towards central uplands showing vegetation on the limestone ridges

Unit 4 – Limestone Ridges

This landscape unit type occurs generally throughout the central north-south upland plateaus of the Island. The terrain ranges from steeper slopes in the west to and flatter more gentle undulations as the ridges continue east.

Typical vegetation on the limestone ridges includes the sensitive Hummock Grassland of *Triodia wiseana* with low mixed shrubs including *Acacia gregorii*.

Figure 2.9 - View easterly from the central uplands towards terminal tanks proposed LNG plant showing vegetation, power poles, and road easement. East-west gas pipeline is proposed to run through this area along side road easement.

This landscape unit has limited capacity to absorb visual impacts especially if low screening vegetation is damaged or removed.

A large proportion of the proposed pipeline corridor is located in this landscape character unit.

Figure 2.10 - View westerly from terminal tanks towards the central uplands showing main oil distributor pipe. Views along the pipe easement are in contrast to views adjacent the pipeline easement where low vegetation can screen pipeline views.

Unit 5 – Creek or Seasonal Drainage Lines

This landscape unit occurs generally in the broad valleys and flats of limestone ridges and is located slightly in from the coastal fringes. This landscape has deeper alluvial soil structure and in conjointly a denser, taller vegetation character. The vegetation in this unit type is described as Mixed Hummock Grassland of *Triodia angusta* with pockets of dense shrubs along major creek lines.

Figure 2.11 - View easterly in the vicinity of the proposed LNG Plant showing taller vegetation communities within the drainage line landscape.

Out of the earlier landscape character units discussed this has the greatest capacity to absorb visual impacts due to the following factors:

- Low-lying topography in an undulating landscape may assist in lessoning a structures potential view shed;
- Vegetation height will potentially be the greatest in this landscape unit making it easier to absorb above ground pipe infrastructure.
- Due to greater soil depth and vegetation type rehabilitation has the best opportunity to be achieved.
- The local vegetation community has a greater capacity for rehabilitation using the 'Direst Topsoil Placement' procedure.
- The proposed LNG Plant is located within this Landscape unit.

Onshore Mainland Landscape Character Units

Unit 1 – Coastal Mangrove Zone

Unlike the western exposed shoreline of Barrow Island, the mainland shoreline has a low-lying approach. Adjacent the shoreline a wide spreading zone of Mangroves inhabit the shallow coastal waters.

Figure 2.13. illustrates rehabilitation technique (fenced structure) used to shelter and encourage new Mangrove growth. This break in the Mangrove stand has occurred due to the existing gas easement.

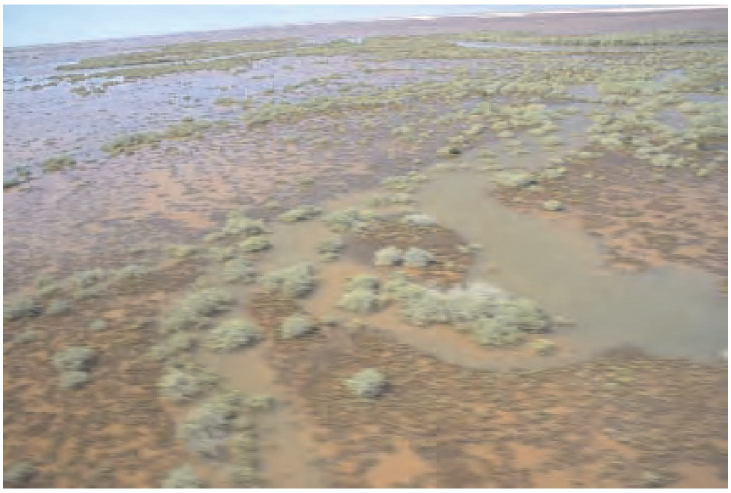


Figure 2.12 – Aerial view east towards shoreline showing extent of mangrove zone.

Figure 2.13 - View west showing existing pipeline easement through the shoreline vegetation and rehabilitation works involved with mangrove re-establishment.

Unit 2 – Red/Grey Non–vegetated Salt Flats

These salt flats are tidal and occur directly adjacent the shoreline and traverse east into the mainland to eventually dissolve into the slightly higher lying shrub and grasslands.

While this landscape has no capacity to absorb above ground structure in contrast it has a great capacity to disguise ground disturbance due to the moving tidal sands and sediment.

Figure 2.14 – Aerial view showing expanse of non-vegetated salt flats adjacent and west of shoreline.

Unit 3 – Vegetated Hummocks within Salt Flats

Increasingly as you move east from the shoreline vegetated hummocks are dispersed within the salt flats. These hummocks are vegetated with low sparse grassland/spinifex vegetation. This hummock landscape unit has limited capacity to absorb visual impacts especially if low screening vegetation is damaged or removed.

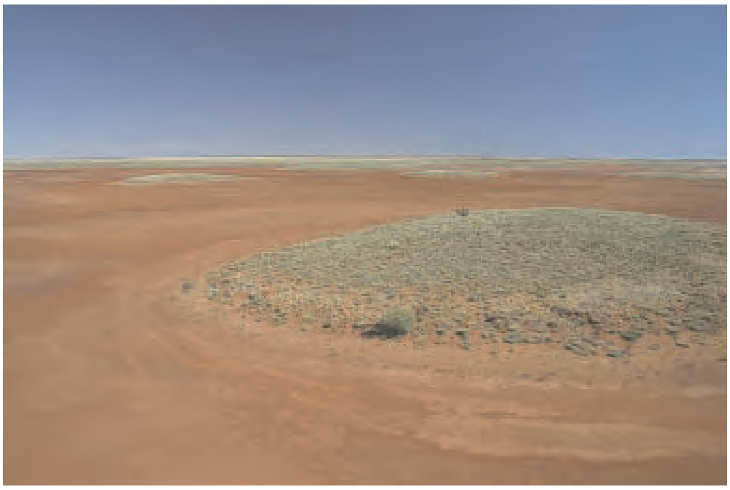


Figure 2.15 – Aerial view of vegetated hummocks within the salt flats.

Figure 2.16 – Aerial viewing west near Compressor Station One. This view shows existing pipeline easement within the low lying shrub and grassland landscape.

Unit 4 – Low Lying Shrub and Grasslands

As the pipeling easement moves east towards Compressor Station One, the vegetated hummocks join to develop a low lying shrub and grassland plain.

This landscape unit has limited capacity to absorb visual impacts especially if low screening vegetation is damaged or removed and the underlying red soil is exposed.

On the mainland a large proportion of the proposed pipeline corridor is located in this landscape character unit.

Baseline Landscape Character – Shore Crossing Options

This section describes the visual landscape character within the Barrow Island proposed Gorgon components local study area.

North White's Beach - Option

The proposed pipeline shore crossing at this site enters at right angles to the coastline. Steep cliffs with limestone rocky headlands occur to the south and north of the corridor. To the east, the grade reduces as the land approaches a sandy beach.

Fig 2.17 Viewing north across the headlands of White's Beach

Apart from the coastal fringe and limestone headlands the area east leading into the shoreline could be described as a 'Valley Slope and Escarpments' landscape unit.

Fig 2.18 Viewing westerly down a slight grade into White's Beach showing typical landform leading to shore line.

From this point in the landscape, with exception an existing red dirt track that falls in and out of view as it winds its way through the undulating limestone ridges, no man-made structures or 'unnatural' disturbances can be viewed.

Vegetation in this unit type is described as open low shrubland with dominant species of *Triodia wiseana* .

Also mixed emergent lower growing shrub species such as *Acacia bivenosa/Petalostylis labicheiodes* as shown in Figure 2.18 previous page.

Flacourt Bay - Option

The proposed shore crossing would also enter at right angles to the shoreline. High steep sided headlands occur to the south and north of the beach corridor as shown in Figure 2.19 below.

Figure 2.19 Viewing southerly across Flacourt Bay.

To the east, the grade reduces through a windy, relatively narrow, steep sided valley and as indicated in earlier Figure 2.8, the land drainage line snakes its way to an open sandy beach.

Views into the bay remain 'natural' with no man-made visual disturbance.

The sandy beach line is larger at Flacourt Bay, however as noted before, the dominant landscape snaking from the east into the shore line can be described as a 'Valley Slope and Escarpments' landscape unit with the common species being *Triodia wiseana*.

Baseline Landscape Character – Pipeline Corridor Options

North White's Beach Gas Pipeline Option – Barrow Island

An overview of North White's Beach Gas pipeline option indicates that after the shore crossing the corridor continues south east to meet the north-south T-Tree Road & Howards Harbour Barge Landing Service roads. The pipeline then continues due south to meet up with the main east-west road. At this point the pipeline would join the Flacourt Bay proposed route and continue due east to the LNG Plant. The overall distance from shore crossing to LNG Plant Site is approximately 10.5km.

In more detail, upon leaving the beach line, the pipeline corridor climbs a gentle drainage line and valley slope for approximately 600m to ascend to the western upland area. From this point until meeting up with the major east west road, the landscape character that the pipeline corridor runs through is gently undulating as it dips into thickly vegetated creek and seasonal drainage lines and rises over the sparsely vegetated stony limestone ridges as shown below in Figure 2.20.

Ascending from the western beach complex the pipeline corridor runs approximately 3km to meet up with the north-south road that gives access the north Island T-Tree area (Indicted as point A on Figure 2.1 Location Map). The North White's Beach pipeline option then changes course to continue due south along this road.

Figure 2.20 Showing typical limestone ridge landscape.

This feeder pipeline corridor option follows adjacent to this road for approximately 1.7km upon where the road and pipeline corridor divert. The road detours east to service Howards Harbour and the barge landing.

For 3.2km the easement crosses south over natural ground, apart from any road easement, until it joins the Howards Landing service road again on its southern approach.

From this point the easement runs adjacent with the road another 1.8km until meeting up with the major east-west access road that links with Town Point, The Terminal Tanks and the LNG Gas Plant site (Indicated as point B on Figure 2.1 Location Map).

Not until approaching this east-west road to Town Point has the pipeline corridor shared other main existing infrastructure easements. Whereas in this area there are a number of existing oil pipe and power easements snaking there way through the landscape often visually obstructed by slightly undulating land or existing vegetation. It is not until the viewer is aligned with one of these easements that a clear view of the infrastructure corridor is apparent as seen in Figure 2.22.

Flacourt Bay Gas Pipeline Corridor – Barrow Island

Flacourt Bay is due west of the LNG Plant Site and is the option with the least travel distance being approximately 9km from coast to LNG Plant.

An overview of this pipeline option indicates that following the shore crossing the gas pipeline corridor continues west mostly adjacent the east/west road to terminate at the LNG Plant Site.

In more detail, upon leaving a wide beach line, the easement climbs approximately 500m up a gentle sloped drainage line, which then narrows into a winding valley for approximately 2km to ascend to the limestone uplands as indicated in Figure 2.21 below.

Fig 2.21 Viewing west from shore line into Flacourt Bay Showing drainage line and winding valley beyond.

As discussed earlier in the Barrow Islands Landscape Overview, valleys and ridgelines tend to be more defined on the western coastline. Views from within the valleys are restricted whereas once ascending upon the ridgeline it is possible to view west across the headlands to the Indian Ocean, also down through tight winding valleys with glimpses of sandy beaches and the shore line beyond.

Continuing along the pipeline corridor oil well heads appear irregularly as you approach the central uplands. The well structures meld into the landscape and only at a reasonable close distance, approximately 1-1.5km, possibly a little further with the sun angle behind the viewer, can this structure be visually discerned from the surrounding landscape. Oil well infrastructure stands out as a small black vertical T-shape when viewed on a ridgeline with a blue sky background. Scattered oil, power and water pipeline infrastructure intersects the ground plane in the upland area. Assuming a pipeline easement is viewed from a vehicle on a service road these low infrastructure easements are visually prominent in the following instances:

- when a long lineal intrusion contrasts the natural landscape visual norm.

- when the pipeline is aligned with the road and there is a break in vegetation easement between the alignments or the vegetation becomes particularly low and sparse;

- when the pipeline angle is misaligned with the viewer on relatively flat ground the visual obtrusion becomes greater the further you can see along the easement. This is mostly experienced when the pipe easement crosses the road as seen in Figure 2.22 below;

Fig 2.22 Viewing south showing typical pipeline and power easement at junction of north south and east west roads

Fig 2.23 Viewing east along the east west road showing proposed pipeline corridor and existing power easement in a typical 'Limestone Ridges' landscape unit.

The roadside vegetation on the uplands becomes increasingly sparse on the limestone ridges this allows filtered views to the aligned corridor as the viewer travels along the east west road.

The alignment continues in a westerly direction adjacent to the east west road where the landscape unit type of the upland 'Limestone Ridges' are typical from this point on until terminating at the seasonal drainage flat of the LNG Plant site.

The rolling topography in the west becomes more gradual as it moves east from the uplands and wide views to Barrow Islands central east lands and coastline open up as the landscape levels towards the eastern coast and terminates at the lowland level of the LNG Plant Site.

Baseline Landscape Character – LNG Plant Site & Port Facilities

The LNG Plant Site & Port Facilities are located on the central eastern coastal flank of Barrow Island approximately 1km west of Town Point and 3.5km north of the Chevron Camp. The proposed plant will be located on the land sloping away to the right of the image below and will be visible from this location.

From the existing Chevron Camp looking north as indicated in Figure 2.24 below, the LNG Plant Site sits within a 'Creek or Existing Drainage Line' landscape unit. Limestone ridges to the north, south and west border the broad low-lying flat, with the land sloping gently down to the shoreline bordering to the east.

The landscape continues to be characterised by gently undulating topography. Expansive views across the landscape can be gained from the fringing ridgeline, however your views are limited within the drainage line flat.

Fig 2.24 Viewing north from Chevron Camp towards proposed LNG Plant Site
The view shows a large open flat bordered by the Chevron Camp ridgeline and the Terminal Tank ridgeline to the north.

Vegetation on this flat is relatively tall (1-1.5m) and there is a dense cover of spinifex, *Triodia pungens*.

Man made structures that are shared within this view shed are the five large Terminal Tanks to the north, the Communication Tower to the south west and the Chevron Camp accommodation buildings, nestled into the ridge due south.

3 Visual Assessment

3.1 Statements, Policy And Planning Guidelines

Environment Protection and Biodiversity Conservation Act (EPBC Act)

Barrow Island is classified under EPBC Act since 1910 as a Class A Nature Reserve.

In relation to visual amenity The Environmental Protection Authority (EPA) issued a statement on the principal of locating a gas processing complex on Barrow Island. Visual significance is not specifically mentioned, although concern was raised for,

'…adequate attention be given to plant design, appropriate stack heights, avoidance of building effects…'

It should be noted that these recommendations have been incorporated into the amelioration measures recommended for the proposed gas plant and pipeline locations.

Visual Assessment Objectives

This part of the report assesses the visual impact of the:-

- onshore components of the 2 gas pipeline options:
  - North White's Beach
  - and Flacourt Bay
- mainland onshore components of gas pipeline
- LNG Plant, Port Facilities and temporary construction camp site

The proposed methodology for this visual assessment is set out in Appendix A.

The objectives of this report are to:

- Describe how the proposed development would alter the landscape character of the immediate area;
- Examine the visual impacts associated with the pipeline and associate infrastructure from adjacent road easements and road vantage points;
- Examine the visual impact of the LNG Plant from identified viewpoints;
- Assess the visual impacts during the phases of construction and completion and present visual optimisation and impact mitigation recommendations.

Assumptions

Assumptions are made when assessing visual impact. These include:

- The parameters of human vision provide some guide in measuring relative visual impacts.

- Natural landscape characteristics (ie. topography, vegetation cover) and degrees of disturbance (man-made built form) influence the capacity to absorb visual changes.

- As distance increases, visual impacts are reduced, to a point where the visual impact is insignificant. This physical distance can be calculated and defines the extent of the view shed for a particular development.

- Vegetation can screen or filter views (in relation to pipeline easements).

- Topography can screen views.

- Perception of beauty and what is visually intrusive can vary.

Visual Impact Mitigation

Visual impact can be lessoned through vegetative and topographic screening, maximising the separation distance to viewpoints and by selecting environments that are capable of absorbing visual changes in the context of surrounding viewpoints. For pipeline easements the strategic alignment of the route is the most important consideration in minimising visual impacts.

Strategic mitigation measures include:

- Alignment of the route to minimise adverse visual impacts associated with easement clearance;

- Minimal visibility of the easements and associated infrastructure from surrounding viewpoints;

- Selection of the most appropriate infrastructure sites for particular circumstances.

On occasions it is not possible to avoid sensitive viewpoints and it is necessary to balance visual impacts with other conflicting issues such as ecological impacts and cost. On such occasions it is necessary to consider tactical methods of mitigation to reduce visual impact. Tactical mitigation measures are applied at visually critical points in order to reduce visual impact to the practical minimum and include:

- adjusting the route alignment and positioning of infrastructure;

- blending infrastructure colour, materiality to match surrounding landscape character;

- vegetation retention;
- rehabilitation.

Tactical mitigation measures provide a degree of amelioration but rarely provide immediate relief from visual impacts and may not always be appropriate or practical. For example, screen planting can be effective in many landscape characters, however given the height and density of existing vegetation and the unique character of this natural Reserve, the introduction of screening species for the large infrastructure becomes inappropriate.

These limitations reinforce the point that infrastructure integration and route selection for pipeline easements are the most important factor in minimising landscape and visual impact.

Tactical mitigation measures available to further ameliorate impacts are discussed below.

Adjusting the Alignment

Minor modifications of the final alignment may make a major difference to the visual impact of the surrounding landscape. These need to be examined on a case by case basis but are generally readily achieved subject to technical suitability.

Colour Integration

The use of sympathetic colours, which blend with the surrounding landscape or are neutral (not contrasting) can assist to visually merge the infrastructure components with the surrounding landscape particularly when viewed from a distance. Colour also can be appropriated in the design and construction of the port facilities.

Vegetation Retention

The retention of vegetation as close as possible to the pipeline easements and LNG Plant site works will reduce exposure of the visually contrasting red soils and rock associated with this area.

Rehabilitation

Rehabilitation should reflect the landscape characteristics of surrounding areas. The removal and replacement of soil, rock and indigenous planting is to be implemented as follows;

Vegetation

- Before removing vegetation from an area that is to be substantially cleared, ensure local seed collection viability and stockpiling techniques have been explored and implemented if required (at present seed viability in the Pilbara region is as little as 1%).
- Vegetation removed is to be buried in appropriate landfill areas.
- Topsoil, not more than 100-50mm (200mm max.) from top of soil profile, at Barrow Island has been known to contain a viable seed pool and if direct

topsoil placement (without storage stockpiling) from one local area to another is practised there is the highest probability for regenerating vegetation cover.

- If stockpiling of topsoil is to occur and maintain seed viability it has to be stockpiled at a depth of 1.5m, not more than 2m high and ripped monthly for aeration. Stockpiles stored longer than a few years will cease to have viable seed stock.

- When roadways are being rehabilitated one technique used with satisfactory results is called ‘equalisation’ ripping, the dragging of topsoil containing seed from both sides of the road in a staggered pattern. As well as transporting seed this treatment allows a less uniform disturbance line in the natural landscape setting and in consideration of the soil profile.

Soil Profile

Visual disturbance in the Barrow Island natural setting is most noticeable when the soil profile is altered or new cap rock is brought to the surface. Topsoil has a different colouring and texture to hidden subsoils and rocks. With this in mind when excavation occurs it is important to maintain topsoil and subsoil layers in separate stockpiles and for these to be replaced in their respective soil profiles.

The soil profile on gorgon apart form the sandy coastal fringes generally consists of the following levels:

1. Topsoil (to 200mm, mostly shallow);
2. Granuled Subsoil (approx 200mm to 1m);
3. Limestone Gravel (approx. 1m to 2m); and
4. Cap Rock (at approx 2m).

This profile is a general across the Barrow Island Landscape. There are many instances especially in the Limestone ridges where the cap rock is exposed. However newly exposed rock has a different hue to existing weathered rock.

Ripping

- When ripping or equalising for road revegetation the prevention of bringing up submerged rocks can be avoided by only shallow ripping to150mm, no greater than 200mm depth. This is to be monitored on site.

Note: The implementations of specific tactical mitigation measures are discussed in association with the assessment of individual viewpoints.

Visual Impact Assessment – Shoreline Crossings

North White's Beach

The options of directional drilling or digging in of the pipeline through the narrow beach foredune achieves a none to negligible visual impact shore crossing.

An access road passes a few hundred metres adjacent on the ridgeline east of North White's Beach as seen in Figure 3.1 below. A track would need to be developed to allow construction equipment access down a moderate gradient to the site.

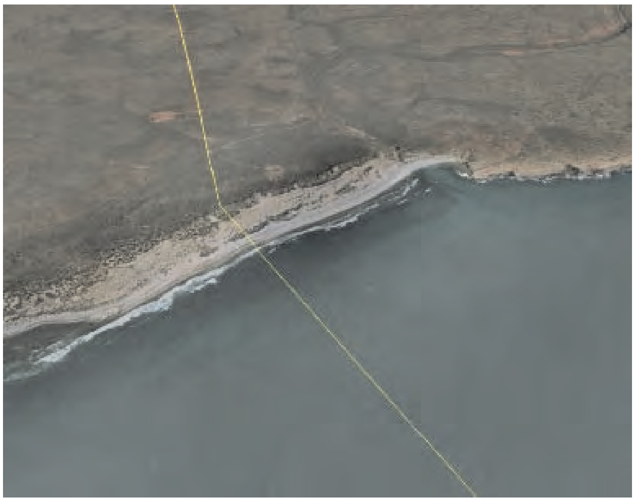


Fig 3.1 Aerial viewing east towards White's Beach showing proposed pipeline corridor and existing road running adjacent to shoreline.

The temporary disruption to the landscape at this location will be visible from vantage points within the surrounding western coastal ridgeline, however this coastal crossing has a viewshed of less than 0.5km.

Reinstatement of sand, soil, exposed rock and vegetation, as soon as practicable will prevent long-term visual impacts. Refer to chapter 3.4 on Visual Mitigation and rehabilitation for recommended reinstatement procedures.

Flacourt Bay

Again, the options of directional drilling or digging in the pipeline through the wide 100m beach have also been discussed to achieve an undersurface, none to negligible visual impact.

The existing road terminates on a ridgeline to the south of Flacourt Bay as seen in Figure 3.2 following page. A track would have to be developed down a steep sided valley to allow construction equipment access to the site.

The temporary disruption to the landscape at this location will be highly visible from vantage points within the surrounding western coast headlands, however this coastal crossing has a viewshed of less than 1km when approached from land.

Suitable reinstatement of sand, soil, exposed rock and vegetation, as soon as practicable will prevent long-term visual impacts. Refer to chapter 3.4 on Visual Mitigation and rehabilitation for recommended reinstatement procedures.

Fig 3.2 Aerial viewing east towards Flacourt Bay showing proposed pipeline corridor and existing road terminating on ridgeline south of beach.

Visual Impact Assessment – Onshore Pipeline Corridors

The majority of the land traversed by the pipeline corridors will follow close to existing road or other pipeline easements. Visual impacts associated with all options are very similar. This is based on visual intrusion of pipeline and for the construction works phase.

Apart from the coastline crossing's all proposed easements pass through gently undulating landscape that has mostly sparse vegetation coverage of low spinifex.

It is therefore possible to align the gas pipeline close to the adjacent road easement and existing pipeline corridors to ensure that there is little vegetation removal required for construction.

It could be argued that a pipe easement adjacent to the road and low in the drivers/passengers visual horizon has a far less visual impact than an alignment that is seen cutting through and contrasting with the open natural setting.

Some visual impacts will be of a temporary nature with vegetation clearing for construction access. Refer to chapter 3.4 on Visual Mitigation and Rehabilitation for recommended reinstatement procedures.

The local visual characteristics, development impacts and mitigation recommendations are summarised for each of the landscape character units within Table 3.1 - Visual Assessment Overview of Onshore Pipeline Options.

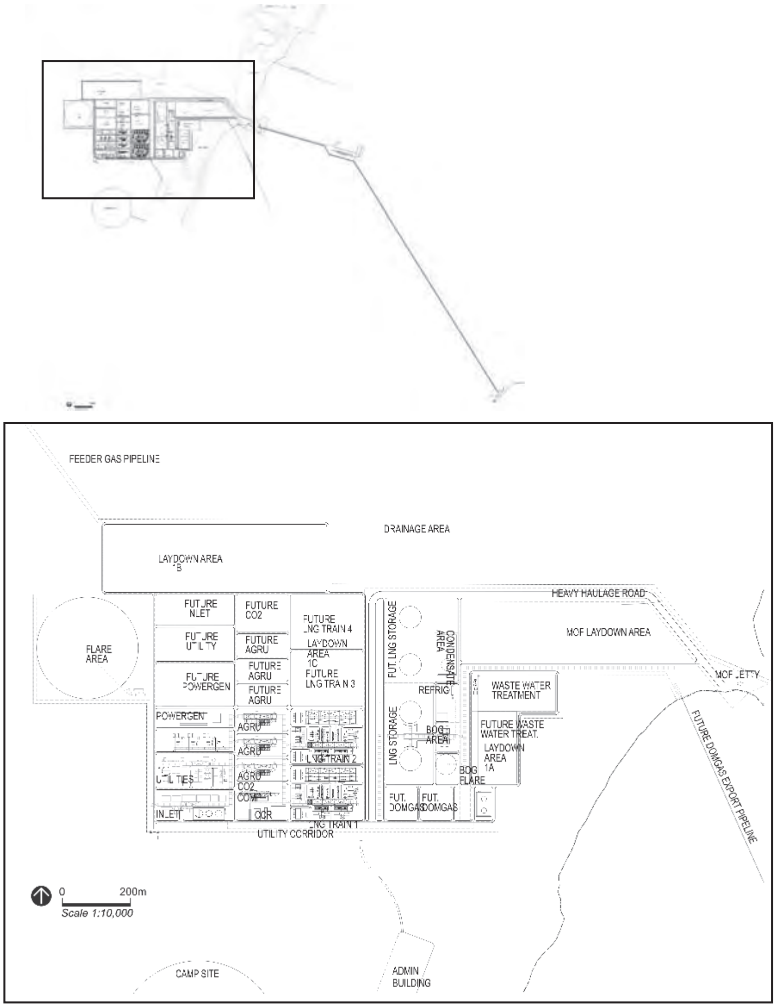
Table 3.1 - Visual Assessment Overview of Barrow Island Onshore Pipeline Corridors.

LANDSCAPE UNITS	LOCAL LANDSCAPE CHARACTERISTICS	POTENTIAL VISUAL IMPACTS	MITIGATION MEASURES AND RECOMMENDATIONS
UNIT 1 West Coastal Complex Western Shoreline crossing	Coastal cliffs Sandy beaches with high rocky headlands Open sandy beach line Gentle to medium slopes behind sandy beach line	Negligible to nil* visual impact on shoreline crossing moderate* visual impact from beyond beach line Disturbance of soil profile, possible exposure of rock on sandy beach and behind shoreline Possible views to pipeline from higher vantage points (rocky headlands)	Directional drilling to minimise damage to the foreshore Rectification of works sites and access roads with vegetation rehabilitation, sand, soils and rock profile to match existing Align pipeline easement to take advantage of topography with screening from vantage point views when climbing escarpment within the valleys
UNIT 3 Valley Slopes and Escarpments Most prominent between West Coast and Central Limestone Ridges	Low shrubland with dominant species of *Triodia wiseana* with mixed emergent lower growing shrub species such as *Acacia bivenosa/Petalostylis labicheiodes* and *Petalostylis trichodemoides* situated on the southern escarpments	Slight* visual impact Ground disturbance and vegetation clearance during the construction of access roads and pipeline easement Permanent pipeline easement with vegetation removal within the easement. Possible screening of easement from ridgelines and in contrast overlooking of pipeline easement into valleys Low to Moderate visual impact from adjacent roads	Rectification of works sites and access roads with soil and rock profile to match existing. Align pipeline easement to take advantage of topography with screening vantage point views when pipeline is not adjacent to road easement Align pipeline easement as close to and adjacent to road easement as practicable Reinstate local vegetation with local direct topsoil placement.
UNIT 4 Limestone Ridges Landscape Character Type most dominant in central development area	The terrain ranges from steeper slopes in the west to flatter more gentle undulations as the ridges continue east Typical vegetation on the limestone ridges include the sensitive Hummock Grassland of *Triodia wiseana* with low mixed shrubs including *Acacia gregorii* Planting is sparse and has limited rehabilitation capacity	Moderate* visual impact Ground disturbance and vegetation clearance during the construction of access roads and pipeline easement Permanent pipeline easement with vegetation removal within the easement Little screening from adjacent road easement	Align pipeline easement as close to and adjacent to road easement as practicable Rectification of works sites and access roads with soil and rock profile to match existing. Reinstate indigenous vegetation with local direct topsoil placement. Retain as much vegetation as practicable

LANDSCAPE UNITS	LOCAL LANDSCAPE CHARACTERISTICS	POTENTIAL VISUAL IMPACTS	MITIGATION MEASURES AND RECOMMENDATIONS
UNIT 5 Creek or Seasonal Drainage Lines Landscape Character Type that occupies the open valleys between the limestone ridges with large open flats situated on the east side of Barrow Island	The vegetation in this unit type is described as Mixed Hummock Grassland of *Triodia angusta* with pockets of dense shrubs along major creek lines. Low-lying topography in an undulating landscape Vegetation height will potentially be the greatest in this landscape unit making it easier to absorb above ground pipe infrastructure.	Negligible* visual impact Ground disturbance and vegetation clearance during the construction of access roads and pipeline easement Permanent pipeline easement with vegetation removal within the easement Due to soil depth and vegetation type rehabilitation has a greater opportunity to be achieved. **Criteria definitions in Methodology Appendices*	Rectification of works sites and access roads with soil profile to match existing. Align pipeline easement as close to and adjacent to road easement as practicable Reinstate indigenous vegetation with local direct topsoil placement.

LNG Plant Layout & Port Faciliy Layout

Figure 3.3 below illustrates the proposed LNG Plant that is to be located at Barrow Island. The elements listed are common for all plants, however their configuration varies relative to site constraints.



The major visual components of the gas plant are:

- The LNG Trains which are made up of columns, pipes and steel platforms, and has a mass height of approximately 20m above ground level; and

- The bulk Compressor and Storage tanks. Each tank is approximately 20m high and 20 metres in diameter. Therefore the comprehensive height of the LNG Plant can be ascertained at 20m above bench level (approximately 38.5m AHD).

The Emergency flare height at 150m high contrasts with the other Plant structures. This structure is tall and thin and although has potentially a wide viewshed it can be argued to have a negotiable visual impact on the surrounding landscape. (Refer Cha. 3.5.4 – Flare & Illumination).

Although the development area on whole will be approximately 300 hectares the LNG Plant is not constructed or viewed as a single mass. The Plant will be viewed as a mixture of steel structural elements of varying size, width and height combining to give the development an "airy" feeling.

In general the development has been sited in a low-lying are to minimise visual impact within the surrounding landscape.

The Port facilities consist of a larger Materials Offloading Ramp (MOF) approximately 1km in length and a lighter structured offshore ship gas loading jetty of approximately 3km in length. While these facilities will protrude for a substantial distance from the eastern coast these forms will tend to blend into the seascape due to their low lying and light structured nature.

Appropriate measures will be taken to neutralise the colouring of these port facilities to blend with the seascape while night lighting will be minimal and will not have a high visual impact in this coastal area.

LNG Plant Viewshed

The viewshed for the LNG Plant site has been calculated assuming radii's of 5km, 7.5km and 10km.

A viewshed diagram (Figure 3.4 below) has been created using Global Positioning System (GPS) combined with 3D topographic information (ArcView) to determine their visibility from surrounding areas.

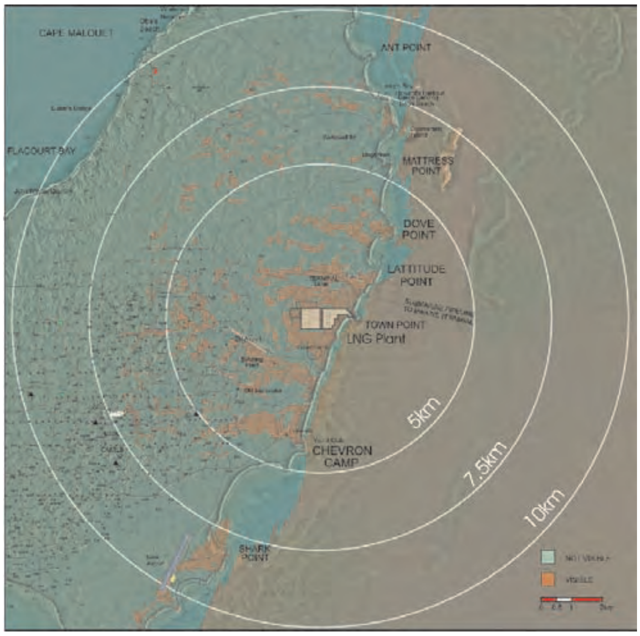


Figure 3.4 - Viewshed of LNG Plant site

The heights of the various infrastructure components have been identified to determine the extent of the viewshed. The viewshed analysis shown in Figure 3.4 above considers structures, which range in height from 10m to 20m and form the comprehensive bulk of the development. It is recommended that Individual stacks and flares may protrude above the comprehensive LNG Plant structure height but their impact is insignificant due to their narrow construction width.

The viewshed quantitative assessment also recognises that the emergency flare exceeds 150m in height, however given its narrow columnar appearance, the disturbance to the field of view is insignificant especially when viewed at a distance. The visual impacts are further tested as part of the qualitative assessment and simulations.

The topography of the LNG Plant Site immediate surrounds is low-lying, flat to gently undulating. This is reflected in the viewshed analysis with the plant being visible from a significant area within the central eastern segment of the Island. The LNG Plant would be visible from the ocean approaching from the east. Viewpoints

The viewpoints identified in the Figure 3.5 below are located within the LNG Plant viewshed. These viewpoints have been selected to illustrate both typical and worst case visual impacts of the proposed development.

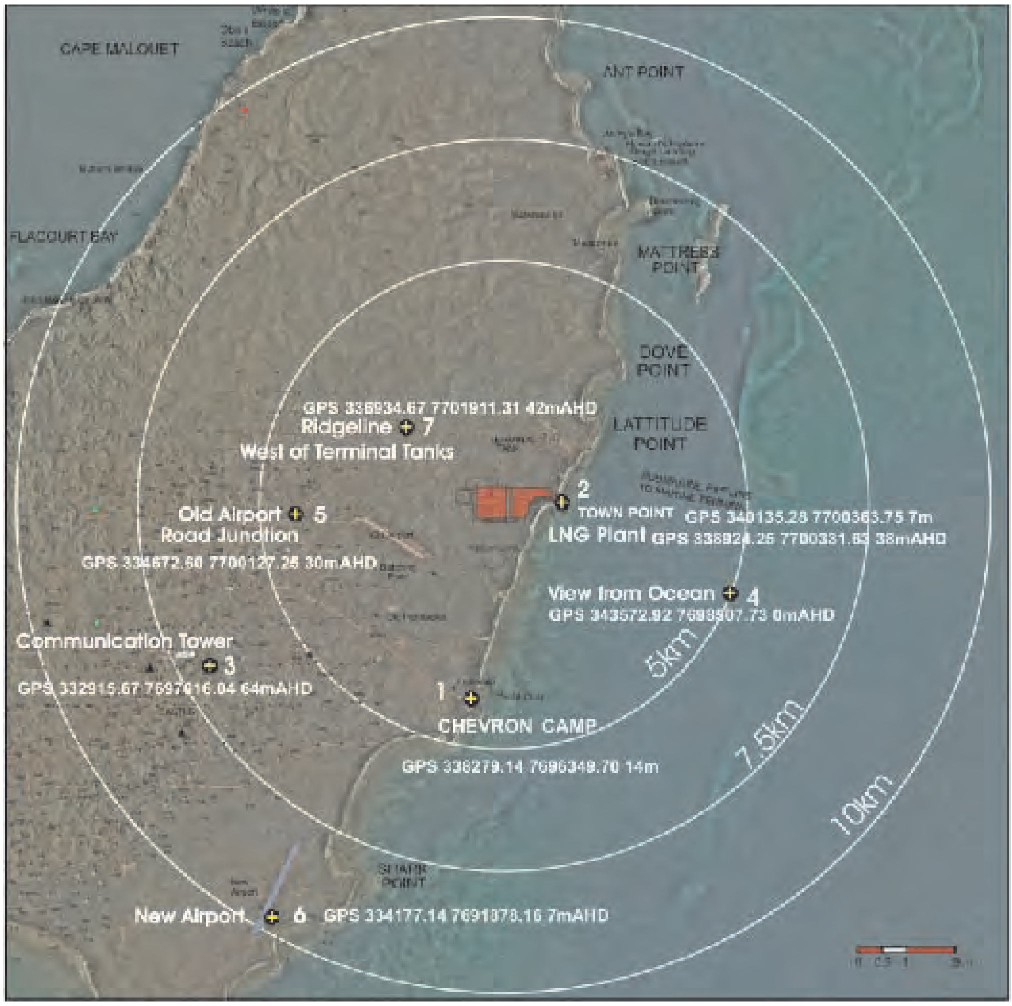


Figure 3.5 – Chosen Viewpoints around the LNG Plant site

Viewpoint 1 – Chevron Camp

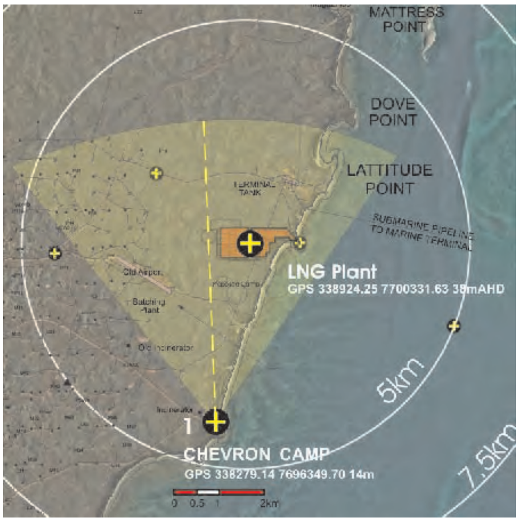


Figure 3.6 – Viewpoint 1

The view is looking north from the Chevron Camp carpark on the southern ridgeline overlooking the drainage line and broad flat. This viewpoint is located due south of the Terminal Tanks and Town Point, approximately 4.3km from the proposed LNG Plant.

Figure 3.7 – Simulation of LNG Plant & Port Facilities at completion of works from Viewpoint 1 – Chevron Camp

This viewpoint was chosen to show the common viewing point for the Chevron Camp workers and as a good overview of the LNG Plant, Port Facilities (MOF) within its landscape character.

The LNG Plant is moderately visible from this viewpoint and continues a low built skyline from the existing terminal tanks as seen situated on the right of the LNG Plant model.

From this distance the flare structure and low lying port facilities become of negligible visual impact and has very little effect on the overall scene.

Viewpoint 2 – Town Point

The view is looking west from Town Point. This viewpoint is located south east approximately 1.8km of the Terminal Tanks and approximately 1.2km due east from the centre of the proposed LNG Plant.

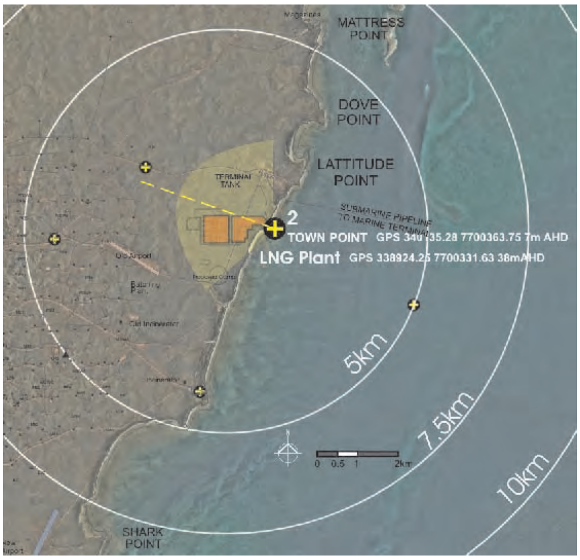


Figure 3.8 – Viewpoint 2

Figure 3.9 – Simulation of LNG Plant at completion of works from Viewpoint 2 – Town Point

This viewpoint was chosen to illustrate an immediate view of the development and to contrast the existing terminal tanks shown on the far right of photo.

The LNG Plant is substantially visible from this close viewpoint and adds to the built skyline of the existing terminal tanks.

This model simulation also shows proposed earth benching that contrasts the natural landscape this is before vegetation rehabilitation of the bench slopes.

Viewpoint 3 – Communication Tower, Base Castle

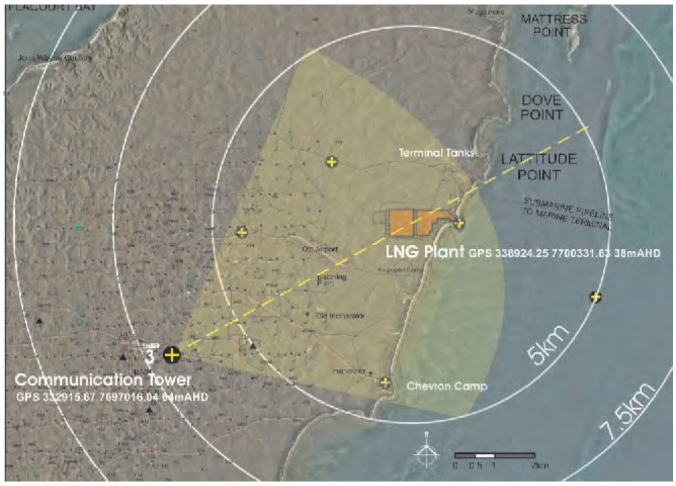


Figure 3.10 – Viewpoint 3

The view is looking north east from the Communication Tower, at 63m the highest central point on Barrow Island. This viewpoint is located 5.2km due west of the Chevron Camp site and approximately 6.8km south west of the proposed LNG Plant.

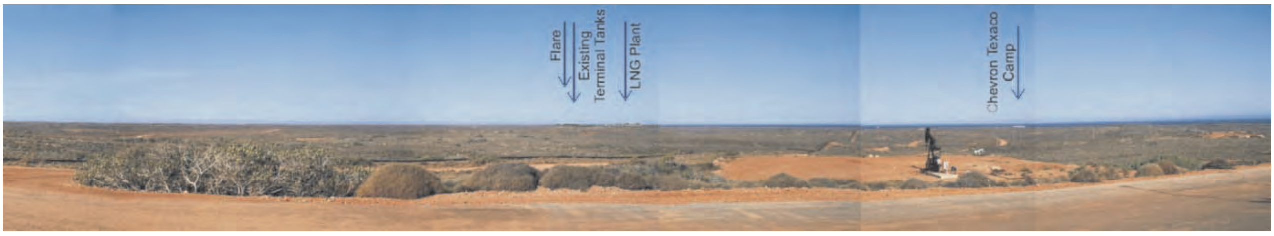


Figure 3.11 – Simulation of LNG Plant at completion of works from Viewpoint 3 – Communication Tower, Base Castle

This viewpoint was chosen to illustrate views from the highest central point in the island (63m AHD). From this view the Plant site is partially hidden due to a ridgeline and its position on a low-lying flat.

The LNG Plant has negligible visual impact and the view indicates how the LNG Plant at this distance melds into the landscape.

The flare structure at this point becomes less discernible and has virtually no visual impact to the broader scene.

Viewpoint 4 – Ocean View at 5km East of LNG Plant

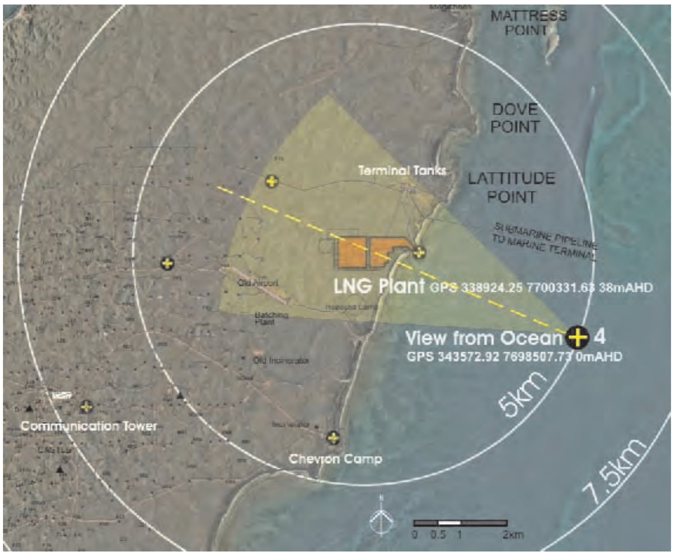


Figure 3.12 – Viewpoint 4

The view is looking west from 5km east of the proposed LNG Plant.

This viewpoint was chosen to account for the view while approaching the development site within a water vessel.

Figure 3.13 – Simulation of LNG Plant at completion of works from Viewpoint 4 – Ocean View at 5km east of LNG Plant. View at left of figure shows extent of Ship Gas Loading facility.

From this viewpoint the LNG Plant has a moderate to substantial visual impact and the view indicates how the LNG Plant and Port Facilities form a recognisable new element within the landscape.

Viewpoint 5 – Road Junction near Old Airport

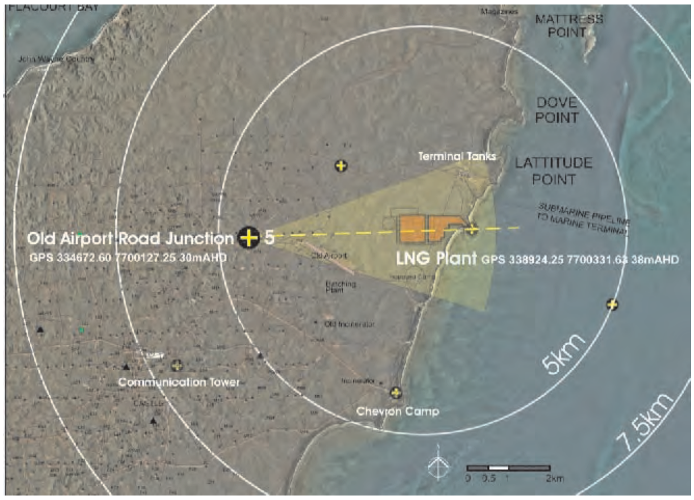


Figure 3.14 – Viewpoint 5

This view is looking due east from a major road junction 1.5km west of the old Airport and 4.9km due west of the Proposed LNG Plant site.

Figure 3.15 – Simulation of LNG Plant at completion of works from Viewpoint 5 – Road Junction, Old Airport

This viewpoint was chosen to illustrate one of the few visible views beyond the development sites low-lying, drainage flat landscape. The junction is situated in a shallow east west valley that aligns, when looking east, with the proposed Plant site.

From this viewpoint the Plant bulk is partially hidden due to a ridgeline however the development dominates the skyline and is seen to have a substantial change to the natural landscape.

Viewpoint 6 – Passenger Terminal, New Airport

This viewpoint was chosen to illustrate the only ground view passengers would

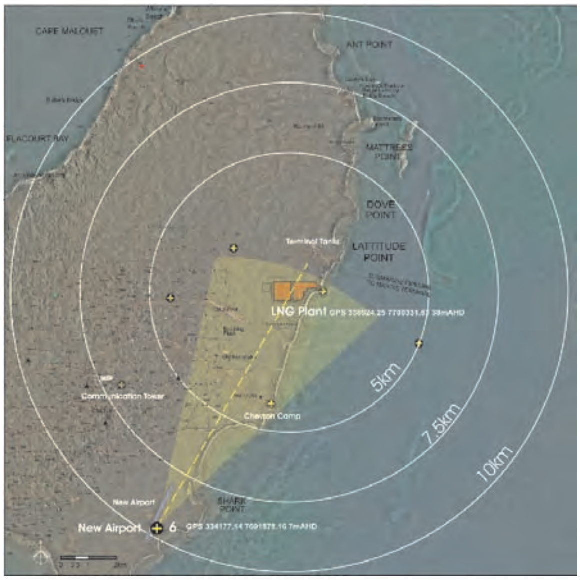


Figure 3.16 – Viewpoint 5

Figure 3.17 – This view is looking north north-east from the New Airport passenger terminal at Barrow Island 9.7km south west of the of the Proposed LNG Plant site.

have of the development site. From this viewpoint the bulk of the development sits behind the helicopter hanger and the flare is the only structure that can be faintly seen. The bulk of the plant sits below a ridgeline and structures that sit above form, from this distance, part of the landform.

The visual impact of the development from the New Airport passenger terminal would be described as negligible to none.

Viewpoint 7 – Ridgeline West of Terminal Tanks

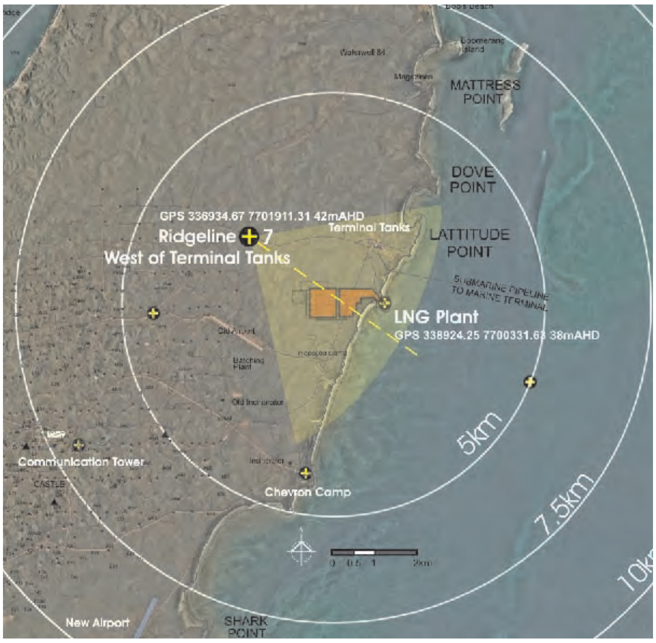


Figure 3.18 – Viewpoint 7

This view is looking south east from a main road that leads west from the existing Terminal Tanks. This view is from the highest point of the ridgeline that surrounds the development site. It is situated 3km west of the Terminal Tanks and 2.5km north west of the development site.

Figure 3.19 – Simulation of LNG Plant at completion of works from Viewpoint 7 – Ridgeline West of Terminal Tanks

This viewpoint was chosen to illustrate a worse case scenario of the highest and closest point that a worker will view the entire development.

From this viewpoint the Plant bulk is totally exposed and the development will dominate the landscape and skyline. Within this broad flat and surrounding ridgeline the development is seen to have a substantial change to the natural landscape.

Flare and Illumination

Foreground active activity is more prominent.

Bench marking 5 – 9km integrate with the landscape

The emergency flare stack of the gas plant is 150 metres in height and has an internal diameter of 0.5m. It is proposed for emergency discharges only, which will be of short duration and infrequent occurrence. The emergency flare will normally operate a pilot flame only, automatically igniting when required for pressure relief. If an emergency situation arises and the flare needs to be used the flame of the flare will extend approximately 30-40 metres above the top of the stack.

The flare will be visible from long distances. However due to the relative infrequency (due to the design of the plants shutdown system) of the purge, the visual impacts are not considered significant.

The lighting of this facility would be designed to ensure that light levels are minimal required for safety and plant operations. Plant and Port Facility lighting will be visible from adjacent ridgelines and roads' where vegetation and topography does not screen or filter views.

Quantitative Assessment – LNG Plant Site

The following Table 3.2 following page show the distances to the proposed gas plant from nominated viewpoints. Also measured are the developments horizontal and vertical line of sight angles (vertical bulk height of 20m). Further described is the likely visibility of the ancillary lighting at night.

Table 3.2 - Distances and viewing angles from identified viewpoints to Centre of Proposed LNG Plant **Note: LNG Plant Site Centre GPS 338924.24 – 7700331.63 38m AHD**

VIEWPOINTS	Distance to gas plant	Horizontal angle of view	Potential impact	Vertical angle of view	Potential impact	Night time Lighting
1. Chevron Camp GPS 338279.14 – 7696349.70 14m AHD	4033m	14°	Potentially noticeable	0.3°	Insignificant	Noticeable glow
Town Point GPS 340135.28 – 7700363.75 7m AHD	1100m	40°	Potentially visually dominant	1.5°	Potentially noticeable	Glow in foreground
Coms. Tower GPS 332915.67 – 7697016.04 64m AHD	6862m	6°	Potentially visually dominant	0.24°	Insignificant	Dull glow in distance
Ocean View GPS 343572.92 – 7698507.73 2m AHD	4993m	10°	Potentially visually dominant	0.5°	Potentially noticeable	Noticeable glow
Old Airport GPS 334672.60 – 7700127.25 30m AHD	4256m	26°	Potentially noticeable	0.11°	Insignificant	Noticeable glow
New Airport GPS 334177.14 – 7691878.16 7m AHD	9695m	5°	Insignificant Disregarding view screened by helicopter hanger	0.02°	Insignificant Disregarding view screened by helicopter hanger	Dull glow in distance
Ridgeline GPS 336934.67 – 7701911.31 7m AHD	2540m	40°	Potentially visually dominant	0.5°	Potentially noticeable	Glow in foreground

The quantitative assessment recognises that isolated structures within the gas plant exceed 20m, however their dimensions are such that their narrow columnar appearance will not provide a significant visual impact when viewed at a distance providing the remaining structure is hidden from view. The visual impacts are further tested as part of the qualitative assessment and simulations.

4 Conclusion

4.1 Pipeline Corridor - Shoreline Crossings

The **Visual Impact** of the alternative shoreline crossings at 'North White's Beach' and 'Flacourt Bay' are considered as none to negligible due to their underground construction and works temporary nature.

Reinstatement of sand, soil, exposed rock and vegetation, as soon as practicable will prevent long-term visual impacts. Refer to chapter 3.4 on Visual Mitigation and rehabilitation for recommended reinstatement procedures.

Onshore Pipeline Corridor(s)

The construction and form of the proposed pipeline easements for Barrow Island will have similar visual implications for all landscape character units with the exception of the underground shoreline crossings. The visual impacts can be summarised as follows:

- When viewed, a long lineal form that will contrast with natural environment;
- Visual gaps in landscape from removal of vegetation and soil;
- Colour change in soil profile disturbance; and
- Additional access roads.

Achieving the following will reduce visual impact for all the proposed pipeline easements on Barrow Island and the Mainland:

- Limiting the removal of vegetation within the pipeline easement;
- Limiting duration of disturbance;
- Replacing disturbed areas as soon as practicable with local direct topsoil replacement;
- Replacing disturbed soil and rock back to existing soil profile;
- Limiting construction access roads;
- Aligning pipeline corridors adjacent and as close to existing road easements as practicable; and
- When a pipeline corridor is not adjacent to road easement designing the pipeline to fit into the topography of the landscape where practicable.

LNG Plant Site

The siting of the LNG Plant has the potential to significantly alter the landscape character without appropriate siting and mitigation treatment applied.

The visual assessment recognises that the regional landscape character surrounding the proposed LNG Plant has the greatest **Landscape Absorptive Capability** ability to incorporate the visual impact of this type of infrastructure.

The **Visual Amenity** of the proposed LNG Plant site adjacent Town Point would be considered negligible to human visual perception and significance.

However, according to the viewers position within the LNG Plant's viewshed the **Visual Impact** ranges from negligible to substantial as the development bulk height is screened from most of Barrow Island by surrounding ridgelines and its tactical positioning within a low-lying landscape.

Visual Impact Mitigation

Given the lack of substantial indigenous vegetation and inappropriate within this landscape character to use exotic species, the visual impact level of the LNG Plant or ancillary and other lighting would not significantly reduce over time.

It is important that the lower infrastructure to 20m (including the temporary construction camp) is coloured not to contrast surrounding spinifex vegetation where practicable and benching slopes (unused roads, benches) are revegetated to blend effectively into the landscape. The extent of vegetation removed is to be minimised and rehabilitation by direct soil placement is to take place as soon as practicable.

Figure 4.1 – Proposed aerial view simulation of LNG Plant at completion of works. View shows LNG Plant & extent of Port Facilities. Chevron Camp can be viewed on the lower right hand corner of the simulation.

5 Appendices

5.1 Methodology

Quantitative Assessment

An analysis of the parameters of human vision makes it possible to establish guidelines for defining the viewshed within which potential visual impacts associated with a development may occur. Within this viewshed it is possible to identify specific locations with potential views to the infrastructure or easement clearing associated with the gas pipeline.

The visual impact of a development can be quantified by reference to the degree of influence on a person's field of vision. The diagrams on the following pages illustrate the typical parameters of human vision. These provide a basis for assessing and interpreting the impact of a development by comparing the extent to which the development would intrude into the central field of vision.

These parameters also allow a comparative analysis of the visual impacts relative to other elements within the landscape such as tall trees.

It should be noted that the quantitative assessment determines the relative scale of a development from a viewpoint. The quantitative assessment assumes that distance is the only modifier of visual impact, and if considered in isolation, does not allow for local landscape characteristics, which may influence the visibility of a development. As such the quantitative assessment should be interpreted in association with the qualitative assessment.

Horizontal Line of Sight

The central field of vision for most people covers an angle of between 50° degrees to 60°. Within this angle, both eyes observe an object simultaneously. This creates a central field of greater magnitude than that possible by each eye separately. This central field of vision is termed the 'binocular field' and within this field images are sharp, depth of perception occurs and colour discrimination is possible.

The visual impact of a development will vary according to the proportion in which a development impacts on the central field of vision. Being evaluation on this measurable parameter allows the rating of potential impact.

These physical parameters are illustrated in Figure A1.1

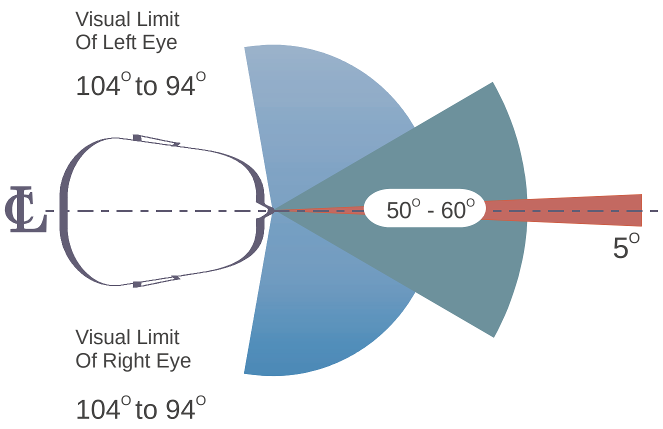


Figure A1.1 Horizontal Field of View

Table A1.1 below list assumptions, which determine whether the impact of a development is:

- Insignificant;
- Potentially noticeable; or
- Potentially visually dominant.

Once potential visual impacts are rated one may direct remedial action to those viewpoints that are most impacted.

Horizontal Field of View	*Impact*
<5^{O} of view	Insignificant The development will take up less than 5 percent of the central field of view. The development, unless particularly conspicuous against the background, will not intrude significantly into the view. The extent of the vertical angle will also affect the visual impact.
5^{O} – 30^{O} of view	Potentially noticeable The development may be noticeable and its degree of visual intrusion will depend greatly on its ability to blend in with its surroundings.
>30^{O} of view	Potentially visually dominant Developments that fill more than 30 percent of the central field of vision will always be noticed and only sympathetic treatments will mitigate visual effects.

Table A1.1 Impact within the horizontal field of view

Vertical Line of Sight

A similar analysis can be undertaken based upon the vertical line of sight for human vision.

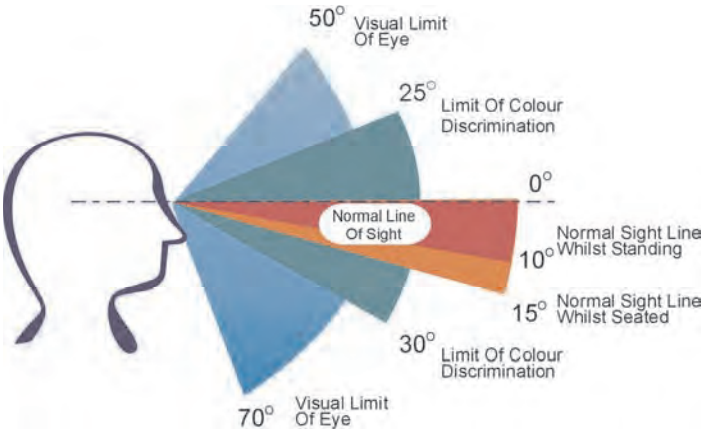


Figure A1.2 Vertical Line of Sight

As can be seen in Figure A1.2, the typical line of sight is considered to be horizontal or 0°. A person's natural or normal line of sight is below the horizontal. It varies slightly from person to person and depends on whether they are standing or sitting. If standing, the normal line of sight is approximately 10° below the horizontal and if sitting, approximately 15°

This situation is similar when looking across a disturbed landscape. Objects, which take up a small proportion of the vertical field of view, are visible when one focuses on them directly. However, they are not dominant, nor do they create a significant change to the existing environment when short objects are placed within a landscape.

Table A1.2 Shows the relationship between the impact and the proportion that the development occupies within the vertical line of sight.

Vertical Line of Sight	Impact
<0.5° of vertical angle	Insignificant A thin line in the landscape.
0.5° – 2.5° of vertical angle	Potentially noticeable The degree of visual intrusion will depend on the development's ability to blend in with the surroundings.
>2.5° of vertical angle	Visually evident Usually visible, however the degree of visual intrusion will depend of the width of the object and its placement within the landscape.

Table A1.2 Impact within the Vertical Line of Sight

Qualitative Assessment

The qualitative analysis is achieved by observation, description of existing conditions (supported by simulations, photographs, sketches etc.) and interpretation of the changes to the landscape associated with the proposed development

Computer Simulations

Computer imagery makes it possible to accurately simulate the visual changes associated with the proposed development. The visual modelling process enables people to observe the typical changes to the landscape associated with the construction of the proposed gas pipeline from particular viewpoints at the completion of construction and once mitigation measures such as trees have established.

- Photographs were taken from the selected viewpoints towards the proposed corridor, using a 50mm lens to most accurately simulate the human eye. GIS Co-ordinates (satellite positioning) were recorded to determine the location at which the photographs were taken;

- 3-D models were constructed of the infrastructure to accurately represent their form in terms of height and construction;

- A 3-D, wire frame model of the terrain was then created from digital contour information. The 3-D models of the infrastructure were accurately positioned within this terrain model, again using GIS Co-ordinates to determine their location and height;

- Cameras were created within the 3-D model to simulate the camera used on site. The simulated camera view was then overlayed onto the original photos;

- The visual modelling software then rendered the proposed alignment over the scanned site photo to demonstrate how the infrastructure would appear along the corridor;

- Photo-montaging techniques were utilised to modify the final view to represent proposed view in its' altered condition

The accuracy of simulations is dependent on the available base information and may be subject to change during the development of the project.

In the first instance, the digital wire frame simulation is overlaid on the photograph to demonstrate the accuracy of the modelling process. By relating the 3-D contours with the terrain and landscape features within the photograph, it is possible to accurately position the infrastructure in the landscape. The pipeline alignment and infrastructure are clearly identified in yellow so that they clearly stand out from the landscape.

The final visual simulation is intended to accurately reflect the colours and form of the gas plant or associated infrastructure and easement clearing.

Interpretation

The existing landscape character plays an important role in determining the impact of a proposed development. The background setting and surrounding natural/built environment can help to absorb changes brought about by developments such as linear infrastructure developments. Alternatively, a development may contrast significantly with the existing environment making its integration more difficult.

There are four major elements of landscape character, which affect the extent to which the proposed developments impact on a landscape. These are:

- Vegetation cover;
- Topography;
- Degree of human modification to 'the natural' landscape and dominance of man made elements; and
- Distance

Vegetation Cover

The height and density of vegetation can contribute to the visual quality of the landscape. However the removal of vegetation to accommodate infrastructure in the Barrow Island Landscape presents a significant change to the landscape character by exposing the contrasting red soils and in some cases contrasting unexposed rock that is deeper in colour to the sun bleached extracted rock. The visual impact is relative to the significance of the viewpoints.

Topography

Topography can play an important role in determining the visibility of a development within the landscape, depending on elevation of viewpoints and their relationship with the proposed development, and surrounding vegetation and structures.

Flat Landscapes

Changes in the vertical field of view may not be apparent within flat landscapes if foreground vegetation screens views. If views are not screened, vertical development above the scale of the surrounding landscape becomes very apparent from longerdistances.

Undulating Landscapes

Landscapes with topographical variations have greater capacity to partially screen views to a development, however, this is largely dependent on the viewing location. At lower elevations topography may help to screen foreground views, whereas at higher elevations views may be exposed.

Degree of Human Modification

The potential impact of the proposed pipeline easement and associated infrastructure is less when man modifies the surrounding landscape. Viewers perceive the first change to a natural landscape with greater sensitivity than subsequent changes.

Distance

As distance increases, the impacts associated with development decrease due to the relative reduction in scale. As the scale of a development reduces, the capacity for screening is increased.

Sensitive Viewpoints

The location and frequency of viewing are important considerations when assessing visual impact. As the Barrow Island Visual Assessment is unique due to the lack of sensitive human receptors visual impact within the context of this study, will be assessed from a number of viewpoints that are considered important to represent the potential changes in the landscape character. These viewpoints are from:

- the Chevron Camp site;
- Town Point;
- The base of the Communication Tower highest land point located centrally on the Island;
- from 5km offshore looking towards the LNG Plant site;
- A main road junction directly west of the development site;
- The new Airport, in regard to passengers passing through; and
- Worst case scenario of highest closest point to view whole of construction (Ridgeline directly west of Terminal Tanks.

Major, Secondary Roads and Access Tracks

In regard to the Barrow Island, workers alone will be viewing changes to the landscape from roads. Roads themselves are part of man-modified landscapes.

Generally, the visual impact of easement clearing and infrastructure construction on motorists varies according to distance and surrounding landscape character. In vegetated areas, changes to the landscape resulting from easement clearing or construction works may be seen for only a short period in the context of a journey. Therefore vegetated areas easement clearing is preferable at right angles to existing roads, as the view along the easement may be visible for only a very short period.

When easement clearing occurs adjacent to the road edge, the change to the landscape character is more apparent for longer periods to the motorist.

However in the Barrow Island context, as stated earlier, this structure will be inspected and viewed by gas and oil workers, a pipeline easement that becomes part of the road easement would be in this scenario viewed in favour of an easement cutting through the natural landscape.

Easement clearing can be viewed at a further distance on Barrow Island due to the to low and sparse vegetation habit and as noted with the existing seismic lines.

Visual Impact Definitions

Table A1.3 explains the visual impact definitions used within this study.

Visual Impact	Definition
None	No part of the development, or work or activity associate with it, is discernible.
Negligible	Only a very small part of the proposals is discernible and/or they are at such a distance that they are scarcely appreciated, Consequently they have very little effect on the scene.
Slight	The proposals constitute only a minor component of the wider view, which might be missed by the casual observer or receptor. Awareness of the proposals would not have a marked effect on the overall quality of the scene.
Moderate	The proposal may form a visible and recognisable new element within the overall scene and may be readily noticed by the observer or receptor.
Substantial	The proposals form a significant and immediately apparent part of the scene that affects and changes its overall character.
Severe	The proposals become the dominant feature of the scene to which other elements become subordinate and they significantly affect and change its character.

Table A1.3 Visual Impact Definitions

Note: That these definitions can apply to either existing or proposed situation and that visual impacts need not be necessary detrimental. For example, a proposed prominent group of trees might have a 'substantial' impact, however the effect on the landscape and views would be beneficial.

Landscape Visual Assessment - Glossary

Analysis	(Landscape) The process of breaking the landscape down into its component parts to understand how it is made up.
Assessment	(Landscape) An umbrella term for description, classification and analysis for landscape.
Enhancement	Landscape improvement through restoration, reconstruction or creation.
Environment	Our physical surroundings including air, water and land.
Landform	Combinations of slope and elevation that produce the shape landform of the land.
Landscape	Human perception of the land conditioned by knowledge and identity with a place.
L. absorptive capacity	The degree to which a particular landscape character type or area is able to accommodate change without unacceptable adverse affects on its character. Capacity is likely to vary according to the type and nature of change being proposed.
Landscape character	The distinct and recognisable pattern of elements that occur consistently in a particular type of landscape, and how this is perceived by people. It reflects particular combinations of geology, landform, soils, vegetation, land use and human settlement. It creates the particular sense of place of different areas of the landscape.
L. character type	A landscape type will have broadly similar patterns of geology, landform, sols, vegetation, land use , settlement and field pattern discernible in maps and field survey records.
Landscape effects	Change in the elements, characteristics, character and qualities of the landscape as a result of development. These effects can be positive or negative.
Landscape perception	The psychology of seeing and possibly attaching value and/or meaning to landscape.
Landscape sensitivity	The extent to which a landscape can accept change of a particular type and scale without unacceptable adverse effects on its character.
Landscape value	The relative value or importance attached to a landscape which expresses national or local consensus, because of its quality, special qualities

	including perceptual aspects such as scenic beauty, tranquillity or wildness, cultural associations other conservation issues.
Receptor	Special interest of viewer group that will experience the landscape effect.
Sense of place	The essential character or spirit of an area. The *genius loci* meaning the spirit of a place.
Visual amenity	The value of the landscape character, a particular area in terms of what is seen.
Visual effect	Change in appearance of the landscape as a result of development. This can be positive(ie. beneficial, improvement) or negative (ie. adverse or a detraction).
Visual impact	The measure of visual effect in the landscape being quantitative or qualitatively assessed.
Visual Mitigation	Measure, including any process, activity or design to avoid, reduce remedy or compensate for adverse landscape and visual effects of a development project.
Viewshed	Extent of potential visibility to or from a specific area or feature.
Methodology	The specific approach and techniques used for a given study.

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Technical Appendix E3

Public Risk Assessment

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CHEVRONTEXACO

GORGON DEVELOPMENT

PUBLIC RISK ASSESSMENT TECHNICAL APPENDIX: E3

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REVISION	**:**	**2**
DATE	**:**	**09/11/04**

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REVISION RECORD

Rev	Date	Description	Prepared	Reviewed	Approved
0	8/07/04	Issued to client	S Robertson	K Cheney	K Berry
				Ken Cheney	
1	29/09/04	Aircraft Hazard included	S Robertson	G Penno	K Berry
2	09/11/04	BOD Rev 1 incorporated	S Robertson	G Penno	K Berry
Title		**CHEVRONTEXACO AUSTRALIA, GORGON DEVELOPMENT, PUBLIC RISK ASSESSMENT**	**QA Verified**	M Grosvenor	

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ABBREVIATIONS

^oC	degrees Celsius
^0F	degrees Fahrenheit
/kmy	per kilometre year
AGRU	Acid Gas Removal Unit
aMDEA	Activated Methyldiethanolamine
APCI	Air Products and Chemicals Inc
AS	Australian Standards
bara	bar atmosphere
barg	bar gauge
BLEVE	Boiling Liquid Expanding Vapour Explosion
CASA	Civil Aviation Safety Authority
C3MR	Propane Mixed Refrigerant
CO_2	Carbon Dioxide
CS1	Compressor Station 1
CVX	ChevronTexaco
Dom Gas	Domestic Gas
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme
EPA	Environmental Protection Authority
ERS	Environmental Risk Solutions
FEED	Front End Engineering Design
GRE	Glass Reinforced Epoxy
GV	Gorgon Venture
H_2S	Hydrogen Sulphide
HAT	Highest Astronomical Tide
Hg	mercury
HHV	High Heating Value
HP	High Pressure
HW	High Water
ID	inside diameter
kg/s	kilograms per second
km	kilometre
KP	Kilometre Point
Kv	Kilovolt
LAT	Lowest Astronomical Tide
LNG	Liquefied Natural Gas
LOC	Loss of Containment
LP	Low Pressure
m^3	cubic metres
m^3/h	cubic metres per hour

m	meter
mm	millimetre
MCHE	Main Cryogenic Heat Exchanger
MEG	Monoethylene glycol
MOF	Materials Offloading Facility
MR	mixed refrigerant
MTPA	million tonnes per annum
MW	megawatt
NSW	New South Wales
NWS	North West Shelf
pa	Per annum
PJ/a	Peta-joule per annum
QRA	Quantitative Risk Assessment
R1	Rural Land Use
STP	Standard Temperature and Pressure
T1	Suburban
T2	High Rise
t	tonnes
TEG	triethylene glycol
TJ	terrajoule
TJ/d	terrajoules per day
T/T	tangent to tangent
v	volts
WA	Western Australia
WAPET	Western Australian Petroleum
wt	weight
y	year

1. SUMMARY

The Gorgon Venture (GV) proposes to construct and operate a number of pipelines and onshore gas plant as part of the Gorgon Development which is located off North Western Australia. A gas processing facility (i.e. a Liquefied Natural Gas Plant) (LNG) of two trains each with a nominal capacity of five million tonnes per annum (MTPA) and Domestic Gas (Dom Gas) plant) with a 60PJ/a to 100PJ/a capacity, located on the central-east coast of Barrow Island would process the gas. Reservoir carbon dioxide would be removed and re-injected into deep saline reservoirs beneath the island. The liquid hydrocarbon product would then be transported by ship to international markets. Compressed domestic gas would be delivered via a sub-sea pipeline to the Western Australian mainland for use in the industrial and domestic gas markets.

The scope of this study includes the five pipelines and the onshore plant facilities for the Gorgon Development. The pipelines include:

- Sub–sea flow lines from well clusters via four manifolds and Export Flowline to onshore facilities on Barrow Island
- LNG Export Pipeline from LNG tanks to ship loading facility
- Condensate Export Pipeline from condensate storage tanks to existing crude export loading line
- Carbon Dioxide Pipeline for the re-injection of carbon dioxide from the on-shore plant to north end of Barrow Island
- Domestic Gas (Dom Gas) Export Pipeline from the Barrow Island onshore plant to Compressor Station 1 (CS1) which is located on the mainland.

The plant, located on Barrow Island, consists of:

LNG

- Inlet Separator
- Acid Gas Removal
- Carbon Dioxide Reinjection
- Dehydration and Mercury Removal
- Liquefication
- Condensate Handling
- Storage

Domestic Gas

- Acid Gas Removal
- Carbon Dioxide Reinjection
- Dehydration
- Compression

The scope of the study is to determine the level of offsite risk to human life that would be imposed on surrounding environs of the proposed Gorgon Development Barrow Island

plant. It is recognised that at this early stage of the Gorgon Development, the plant's detailed design has not been undertaken. Therefore the risk assessment will reflect the current design stage. No consideration is given to pipeline ancillaries such as compressor stations, valve pits and branch/lateral lines it is considered unwarranted at this stage of an Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP).

The risk assessment aims to:

- demonstrate that the offsite risks resulting from the Gorgon Development Onshore Plant are tolerable and meet the EPA criteria for industrial developments (Reference 2); and
- assess the risks and identify the safeguards associated with the operation of the proposed pipelines for the Gorgon Development. The focus of this study is on public risk and assessment of the level of risk to the public will be made against the criteria provided by AS2885 and EPA Public Risk Criteria (References 15 and 3 respectively).

The methodology used in this study is outlined in the NSW Department of Planning's Hazardous Industry Planning Advisory Paper No.6 (Reference 7), which is a classical risk assessment, a systematic approach to the analysis of what can go wrong in hazardous industrial facilities. This approach is consistent with that provided in AS4360 (Reference 1).

One approach to establish the likelihood of a hazardous event occuring is to review generic data that is published in the public domain in various data bases. One such data base is the E & P Forum; as reported by CMPT, that provides frequencies for leaks from pipelines and process equipment based largely on UK offshore experience but combined with onshore data where necessary. Therefore it is appropriate for this study to determine applicable frequencies. This data source has been augmented by other publically available documents such as PARLOC which is prepared for the UK Health and Safety Executive. Although it is practicable for the failure cases to be dependant on the major equipment items, other smaller plant items such as pipework, pumps, valves, fittings etc; together with their contribution to offsite risk are excluded. To address this issue, and to ensure that a true representation of the level of offsite risk is determined, a conservative approach of increasing all onshore plant failure case frequencies by a factor of 5 was applied. Jet and pool fires have been assumed to represent wost case off-site effects for the materials of methane and condensate.

The QRA modelling was undertaken using "TNO's Effects 4" and "Riskcurves" packages. The TNO tools are internationally recognised by industry and government authorities, including WA's Department of Industry and Resources.

There have been two methodologies used in undertaking the pipelines risk assessment; AS2885 and QRA. The AS2885 risk assessment was undertaken for:

- Export Flowline – both Flacourt Bay and North White's Beach route options:
- LNG Export Pipeline for both the Jetty and Cryogenic options;
- Condensate Export Pipeline; and
- Dom Gas Pipeline.

The level of risk for the above was determined to be acceptable given the surrounding land use and the number of physical and procedural controls incorporated into the pipeline's design, construction and operation complying with or exceeding the controls criteria specified by AS2885 (Reference 15).

The CO_2 Reinjection Pipeline will be located above ground on Barrow Island with little, if any, obstructions to natural ventilation. A release of CO_2 from the worst case scenario of catastrophic failure of the pipeline would not displace the oxygen content within the air to a degree where asphyxiation could occur. Therefore this hazard was not considered further.

The applicable risk criteria as published by the EPA (Reference 6) is the level of individual risk in residential areas of one in a million per year is not exceeded by the pipeline routes. The applicable residential area on Barrow Island are deemed to be the Gorgon Development Construction Village (due to personnel being housed in this village during commissioning and plant start-up) and the existing Chevron Village, both of which are not affected by individual risk levels greater than one in a million per year due to the pipelines.

The results of the risk assessment for the plant are provided in Appendix E as iso-risk contours that reflect the current stage of the plant's design. The one in a million per year individual risk contour extends 150m outside the site's southern boundary. This iso-contour does not encroach on the proposed for the Construction Village with the contour being approximately 250m from the Construction Village. The major risk contributor being the propane and ethane storage vessel BLEVEs and jet fires from plant equipment. Therefore, compliance with the EPA Criteria for residential areas (Reference 2) is expected.

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2. INTRODUCTION

2.1 Background

The Gorgon Venture (GV), the participants being ChevronTexaco Australia, Shell Developments Australia and Exxon Mobil Australia Resources Pty Ltd, proposes to construct and operate an onshore gas plant and a number of pipelines as part of the Gorgon Development which is located off North Western Australia. A gas processing facility (ie a Liquefied Natural Gas (LNG) and Domestic Gas (Dom Gas) plant) located on the central-east coast of Barrow Island would process the gas. Reservoir carbon dioxide would be removed and re-injected into deep saline aquifers beneath the island. The LNG product will then be transported by ship to international markets. Compressed domestic gas would be delivered via a sub-sea pipeline to the Western Australian mainland for use in the industrial and domestic gas markets.

Environmental Risk Solutions Pty Ltd (ERS) has been commissioned to undertake a public risk assessment on the proposed facilities and pipelines as an element of the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) for the Gorgon Development. This document reports the findings of the risk assessment.

2.2 Study Scope

The scope of this study includes the five pipelines and the onshore plant facilities for the Gorgon Development. The pipelines are:

- Sub–sea flow lines from well clusters via four manifolds and Export Flowline to onshore facilities on Barrow Island
- LNG Export Pipeline from LNG tanks to ship loading facility
- Condensate Export Pipeline from condensate storage tanks to existing crude export loading line
- Carbon Dioxide Pipeline for the re-injection of carbon dioxide from the on-shore plant to north end of Barrow Island
- Domestic Gas (Dom Gas) Export Pipeline from the Barrow Island onshore plant to Compressor Station 1 (CS1) which is located on the mainland.

The plant, located on Barrow Island, consists of:

LNG

- Separator
- Acid Gas Removal
- Carbon Dioxide Reinjection
- Dehydration and Mercury Removal
- Liquefication
- Condensate Handling
- Storage

Domestic Gas

- Acid Gas Removal
- Carbon Dioxide Reinjection
- Dehydration
- Compression

The scope of the study is to determine the level of offsite risk to human life that would be imposed on surrounding environs of the proposed Gorgon Development Barrow Island plant and the level of risk to human life due to the pipeline. It is recognised that at this early stage of the Gorgon Development, the plant's detailed design has not been undertaken. Therefore the risk assessment will reflect the current design stage. No consideration is given to pipeline ancillaries such as compressor stations, valve pits and branch/lateral lines it is considered unwarranted at this stage of an EIS/ERMP.

The risk assessment is to consider the risks due to pipeline and plant operations including storage and unloading of export shipments.

2.3 Objectives

The risk assessment aims to:

- demonstrate that the offsite risks resulting from the Gorgon Development Onshore Plant are tolerable and meet the EPA criteria for industrial developments (Reference 2); and
- assess the risks and identify the safeguards associated with the operation of the proposed pipelines for the Gorgon Development. The focus of this study is on public risk and assessment of the level of risk to the public will be made against the criteria provided by AS2885 and EPA Public Risk Criteria (References 15 and 3 respectively).

3. METHODOLOGY

3.1 General

The methodology used in this study is outlined in the NSW Department of Planning's Hazardous Industry Planning Advisory Paper No.6 (Reference 7), which is a classical risk assessment, a systematic approach to the analysis of what can go wrong in hazardous industrial facilities. This approach is consistent with that provided in AS4360 (Reference 1). The normal conditions of operation of the system are defined and then the following questions asked:

- What accidental events can occur in the system?
- How frequently would each event occur?
- What are the consequences of each event?
- What are the total risks (frequencies x consequences) from the system?
- What is the significance of the calculated risk levels?

These questions correspond to the basic components of a risk assessment. Once a system has been analysed, if the risks are assessed to be too high according to some criteria, the system can be modified in various ways to attempt to reduce the risks to an acceptable level, and the risk levels recalculated. The process may therefore be viewed as iterative, where the design of the system may be changed until it complies with the needs of society. By objectively quantifying the risks from each part of the system, the QRA enables the most effective measures to reduce risks to be identified. Figure 3.1 illustrates all these tasks in the context of QRA methodology.

Figure 3-1 QRA Methodology

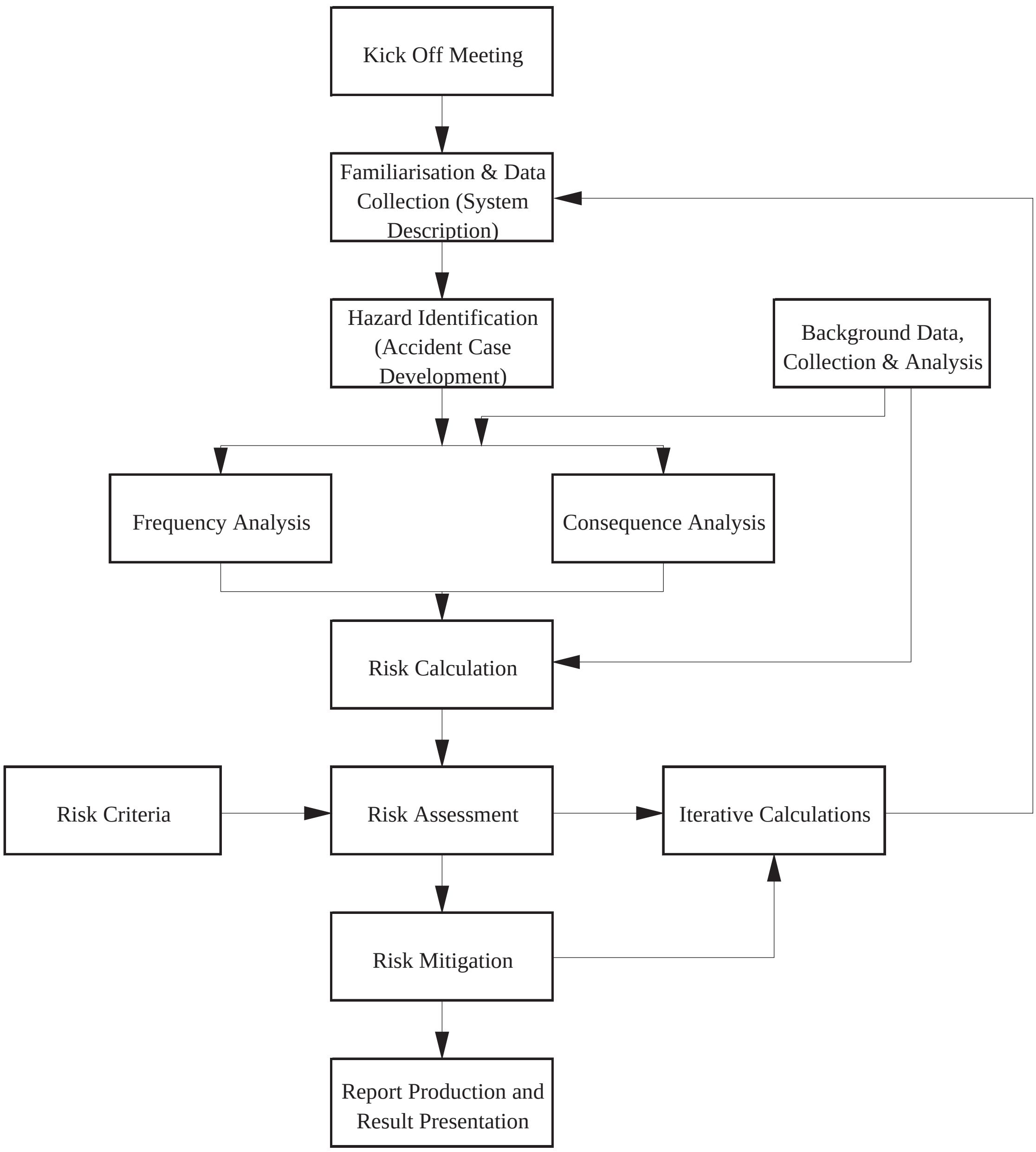


Table 3.1 reproduces the EPA's risk criteria that are detailed in their publication 'Risk Assessment and Management: 'Offsite Individual Risk from Hazardous Industrial Plant No. 2 Interim' (Reference 2).

Table 3-1 WA EPA Individual Fatality Risk Criteria

"a)	A risk level in residential zones of one in a million per year or less, is so small as to be acceptable to the Environmental Protection Authority.
b)	A risk level in "sensitive developments", such as hospitals, schools, child care facilities and aged care housing developments of between one half and one in a million per year is so small as to be acceptable to the Environmental Protection Authority. In the case of risk generators within the grounds of the "sensitive development" necessary for the amenity of the residents, the risk level can exceed the risk level of one half in a million per year up to a maximum of one in a million per year, for areas that are intermittently occupied, such as garden areas and car parks.
c)	Risk levels from industrial facilities should not exceed a target of fifty in a million per year at the site boundary for each individual industry, and the cumulative risk level imposed upon an industry should not exceed a target of one hundred in a million per year.
d)	A risk level for any non-industrial activity located in buffer zones between industrial facilities and residential zones of ten in a million per year or lower, is so small as to be acceptable to the Environmental Protection Authority.
e)	A risk level for commercial developments, including offices, retail centres and showrooms located in buffer zones between industrial facilities and residential zones, of five in a million per year or less, is so small as to be acceptable to the Environmental Protection Authority."

3.2 Pipeline Risk Assessment

The overall purpose of this risk assessment is to determine the level of risk to the public from the external pipelines associated with the Gorgon Development. To this end, two methods of assessment has been used to determine the overall level of risk.

The method in accordance with AS2885 is applicable for hydrocarbon pipelines, i.e.:

- Export Flowline;
- LNG Export Pipeline;
- Condensate Export Pipeline; and
- Dom Gas Export Pipeline.

Details of this method are provided in Section 3.2.1.

All pipelines will be the subject of a QRA whose results will include individual risk contours to address the EPA's Public Risk Criteria (Reference 3). Details of the QRA Methodology are provided in Section 3.1. The results from both risk assessment methodologies have been used to determine if compliance with government authorities' risk criteria is achieved.

3.2.1 AS 2885 Risk Assessment

For hydrocarbon pipelines, public risk and safety has been addressed using the guidance provided by AS2885.1 – 1997 (Reference 15) . The definitions of terms and categorisations used in those documents have been used in this study.

In undertaking this assessment, the following parameters have been considered:

- Location Analysis – the purpose of which is to provide the basis for the identification of the areas that are appropriate to the land use and activities along the pipeline route.
- Threat Analysis which develops a list of threats to the pipeline at each location. It should be noted that not all threats are location specific.
- External Interference Protection provides controls for many of the threats and is a combination of physical and procedural measures.
- Threats prevented by Design and/or Procedures apply to those threats that are not controlled by external interference protection
- Failure Analysis is undertaken for those threats that cannot be controlled by design and/or procedures. Failure analysis determines the potential damage that an identified threat may cause to the pipeline and allow assessment of the consequence.
- Hazard Events use those threats that cannot be effectively controlled by either external interference protection or by design or by appropriate procedure, and which are determined by the failure analysis to result in a loss of integrity. Each hazardous event is carried through to risk evaluation.

The risk assessment methodology provided in AS2885.1 (Reference 15) combines an estimate of the frequency of occurrence of each hazardous event with the estimated severity of the hazardous event to produce a risk class. The relevant tables in AS2885.1 (Reference 1) are reproduced below.

Table 3-2 Frequency of Occurrence for Hazardous Events

Frequency of Occurrence	Description
Frequent	Expected to occur typically once per year or more.
Occasional	Expected to occur several times in the life of the pipeline.
Unlikely	Not likely to occur within the life of the pipeline, but possible.
Remote	Very unlikely to occur within the life of the pipeline.
Improbable	Examples of this type of event have historically occurred, but not anticipated for the pipeline in this location.
Hypothetical	Theoretically possible, but has never occurred on a similar pipeline.

Table 3-3 Typical Severity Classes for Pipelines for use in Risk Matrix

Severity Class	Description
Catastrophic	Applicable only in location classes T1 and T2 where the number of humans within the range of influence of the pipeline would result in many fatalities.
Major	Event causing few fatalities or loss of continuity of supply or major environmental damage.
Severe	Event causing hospitalising injuries or restrictions of supply.
Minor	Event causes no injuries and no loss or restriction of supply.

Note: T1 and T2 refers to the classificationof locations where T1 is Suburban which is areas developed for residential, commercial or industrial use, and T2 is High Rise which is areas as per T1 with the majority of buildings having four or more floors.

Table 3-4 Risk Matrix

	Risk Class			
Frequency of occurrence	Severity Class			
	Catastrophic	Major	Severe	Minor
Frequent	H	H	H	I
Occasional	H	H	I	L
Unlikely	H	H	L	L
Remote	H	I	L	L
Improbable	H	I	L	N
Hypothetical	I	L	N	N

Legend: H = High risk, I = Intermediate risk, L = Low risk, N = Negligible

For each hazardous event, the risk class determines the risk management actions that are required (see Table 3.5).

Table 3-5 Risk Management Actions

Risk Class	Action Required
High	Modify the hazardous event, the frequency or the consequence to ensure the risk class is reduced to intermediate or lower.
Intermediate	Repeat the risk identification and risk evaluation processes to verify and, where possible to quantify, the risk estimation. Determine the accuracy and uncertainty of the estimation. Where the risk class is confirmed to be intermediate, modify the hazardous event, the frequency or the consequence to ensure that the risk class is reduced to low or negligible.
Low	Determine the management plan for the hazardous event to prevent occurrence and to monitor changes which could affect the classification.
Negligible	Review at the next review interval.

4. LOCATION DESCRIPTION

4.1 General

The Gas Fields are located approximately 70km north west of Barrow Island in North Western Australia. Barrow Island is approximately north of Onslow. Figure 4.1 provides an indication of the location of the Gorgon Gas Fields and Barrow Island to the North West Australian Mainland. Figure 4.2 provides the general map for Barrow Island.

Petroleum interest in Barrow Island dates back to June 1947 when the first exploration permit was issued The Barrow Island oilfield was originally envisaged to have a 30 year life but as a result of proper reservoir management, the field life is expected to last through until the 2020's.

A strict environmental program, which protects the island's unique flora and fauna, has enabled the petroleum activities to successfully coexist with the island's Class A Nature Reserve status. This successful coexistence is world renowned.

Figure 4-1 Location of Barrow Island from Mainland, Western Australia

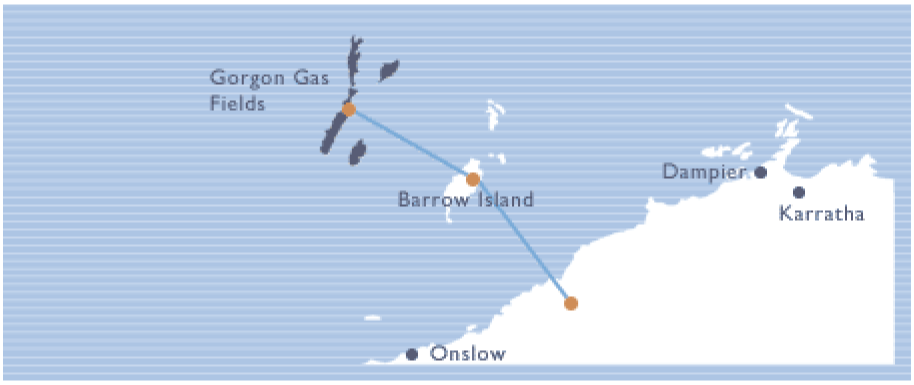


Figure 4-2 Barrow Island

4.2 Climate

4.2.1 General

The sea surrounding Barrow Island provides a moderate influence on the harsh climate generally experienced in the north-west of Australia, characterised by a mild to dry winter (June to August) and a mild to hot summer with cyclonic activity (October to March).

Prevailing summer winds are typically from the south west due to the heat low over the Pilbara region lingering into the night. The normal winter wind patterns are more variable with northerly through easterlies to southerlies predominating. The autumn months of April and May indicate a transitional period, where the winds are more variable in direction and lighter in speed, while the Spring month of September shows a pattern similar to Summer.

4.2.2 Meteorological Conditions

Barrow Island is located in a region considered to have the highest wind risk in Australia (Region D – AS 1170.4) (Reference 10). This is primarily influenced by the occurrence of tropical cyclones in the area, which occur at an average of about twice per year. Maximum wind conditions are tabulated in Table 4.1. Figure 4.3 provides wind roses for Barrow Island.

Table 4-1 Maximum Wind Speeds for Barrow Island

Condition	1 YEAR (non-cyclonic)	50 YEAR (extreme)
3 - second gust	28.6 m/s	68.2 m/s
1 minute mean	24.0 m/s	57.3 m/s
10 - minute mean	20.0 m/s	48.4 m/s

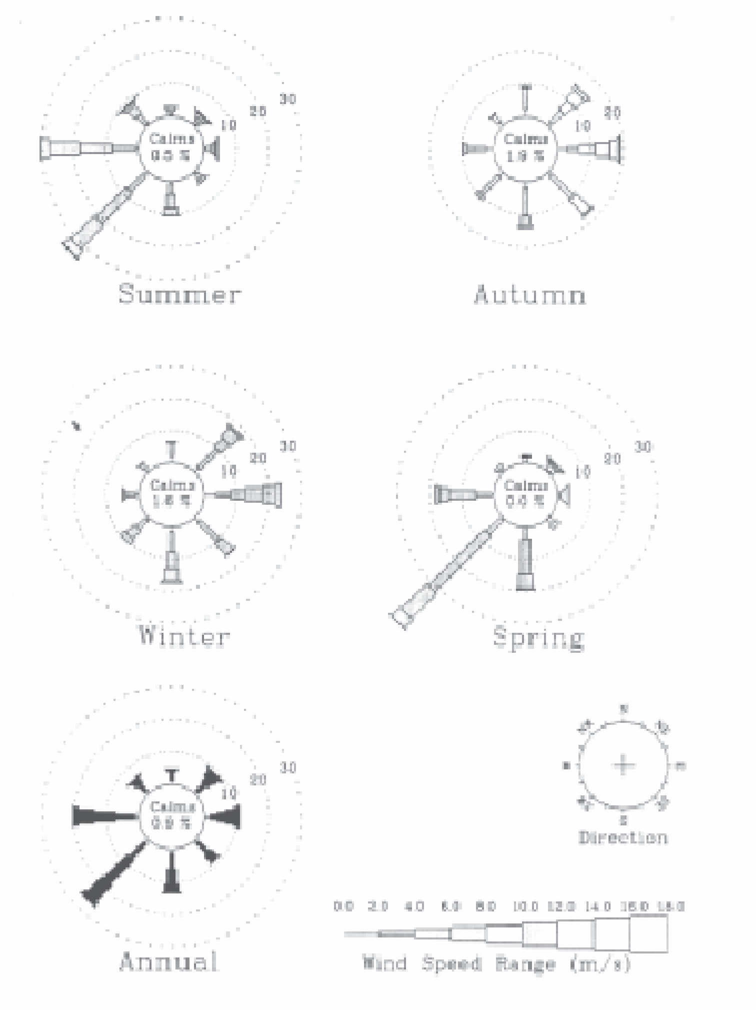
Air temperatures at Barrow Island typically vary between 15.8 ^{o}C and 42.0 ^{o}C. In 1994, there were 228 days where the temperature rose above 30 ^{o}C and 2 days where the temperature rose above 40 ^{o}C.

Table 4.2 provides a summary of rainfall and humidity statistics for Barrow Island.

Table 4-2 Rainfall and Humidity Statistics for Barrow Island.

Condition	Value
Rainfall (mm)	
Mean Annual	329 mm
Median Annual	312 mm
Mean Raindays	27 per year
Humidity	
Maximum	100 %
Maximum (monthly average)	72.2 %
Minimum (monthly average)	55.9 %

Figure 4-3 Wind Rose Diagrams for Barrow Island



4.2.3 Oceanographic Conditions

The seawater temperature varied between 19^{0}C and 31^{0}C. Tables 4.3 and 4.4 show the annual minimum, maximum and mean significant swell wave heights and the maximum wave heights and return periods for 2 year non cyclonic return periods and 50 year extreme at the Barrow Island Marine Terminal.

Table 4-3 Significant Swell Wave Heights for Barrow Island.

	Minimum	Maximum	Mean
Swell Wave Height (metres)	0.00	0.29	0.07
Swell Wave Period (seconds)	9.37	19.06	13.44

Table 4-4 Maximum Wave Heights and Return Periods

	Height (m)	Period (sec)
1 year storm	4.7	7.4
50 year storm	11.4	12.9

The highest astronomical tide (HAT) is 3.68m above the lowest astronomical tide (LAT) measured at WAPET landing. The directions of the tidal stream is approximately 245º on flood and 065º on ebb and attains a rate of 1.0 knot during Spring tides.

Due to the shallow water depth (less than 10 m), channelled bathymetry and strong semi diurnal tides, all the current data is dominated by tides and direction is dominated by bathymetry.

4.2.4 Seismic Activity

Barrow Island is located in an area which is considered to have a 10% probability of experiencing an earthquake resulting in ground acceleration in excess of 0.11g (AS 1170.4).

Tsunamis have previously not been considered important for the North West Shelf (NWS) due to the long distance from significant earthquake risk areas and the barrier provided by the NWS. Furthermore, the shallow reef area surrounding the island provides better protection than for other areas on the NWS.

However, recent incidents on the NWS, one involving sudden lateral movement of a moored tanker, have raised the possibility of Tsunami effects also on the NWS. The Bureau of Meteorology is currently managing a research program on Tsunamis in the NWS area.

5. FACILITIES DESCRIPTION

5.1 Pipeline Description

The details of each of the five pipelines are provided in this section.

A Kilometre Point (KP) system has been used to indicate the length of pipelines, and the location of features that may influence the pipelines design or operation. The KPs begin at 0.00 at a point which is 2m hihg water (HW) mark on Barrow Island, and positively increase as the Pipeline traverses offshore. Negative KPs are used for pipelines on Barrow Island. The exception to this is the CO_2 Pipeline which does not have a shore crossing, and therefore, the KP 0.00 is at the isolation valve at the Plant. For the Dom Gas Pipeline, the KP0.00 is defined as a point 2m above the HW mark on Barrow Island, and the KPs increase positively towards the mainland, and onto CS1.

5.1.1 Export Flowline

As the pipeline's identity suggests, this is the export flow line from the subsea wells and manifolds to the on-shore plant facilities located on the east side of Barrow Island.

The flow line consists of two lines, each of an internal diameter of 697 mm, and an outlet pressure of 77 bara. There are two route options for the flow line, i.e.:

- Flacourt Bay; and
- North White's Beach.

The submerged Export Flowline will be designed and constructed in accordance with international standards and the onshore section will be above ground with the line supported on purpose built supports.

The Export Flowline is a gas gathering system that is used for the transport of production fluids and gases from the well heads and manifolds to the onshore plant facilities on Barrow Island.

Option A – Flacourt Bay

A 66km submerged line from the field subsea manifold to Barrow Island with shore crossing at Flacourt Bay. From Flacourt Bay, Export Flowline will traverse in a easterly direction across Barrow Island towards the plant facilities for a distance of 9.2km. At KP13.5, the Export Flowline will cross the existing East Spar pipeline.

The onshore route will be selected to minimise environmental impact by following an existing road where feasible. It includes seven road crossings at KP -2, -3.7, -4, -4.9, -5.7, -6 and –6.3. It is proposed that the Export Flowline will be buried and protected at the seven road crossings.

There are five locations where the Export Flowline crosses ephemeral water crossings at KP -1, -3, -4.2, -5.3 and -6.9. These ephemeral waterways are dependant on large quantities of rainfall, is typical of extreme cyclones.

The route passes 6 existing wells that are within 100 m of the Export Flowline route, and are located at KP -3.1, -4, -4.9, -5.3, -5.7 & -6.4.

The route includes the following crossings, all of which are constructed above ground. It is proposed that the Export Flowline will be protected at these crossings.

- 5 crossings of existing flowlines at KP -3.6, -3.9, -4.6, -6.3, and -6.5;
- 3 crude pipeline crossings at KP-5.9 and -6.6 (known on site as Glass Reinforced Epoxy (GRE) highways) and -8.5 for the Shipping Line; and
- 2 crossings of the 1000 volt (v) also known as 1 Kilovolt (Kv)) cable at KP -5.8 and -6.9.

5.1.1.1 Option B – North White's Beach

From North White's Beach, the Export Flowline will initially traverse in a easterly direction across Barrow Island towards the carbon dioxide re-injection pipeline; will traverse in a southerly direction parallel with the carbon dioxide re-injection pipeline until it is west of the plant facilities; and then traverse in a easterly direction to the plant facilities, again parallel with the carbon dioxide re-injection pipeline. The onshore section is approximately 12.80 km in length.

The route from North White's Beach will be selected to minimise environmental impact by following an existing road where feasible. This route is parallel with the $CO_{2.}$ Reinjection Pipeline. It includes eight road crossings at KP -0.6, -0.9, -5.1, -6.3, -8.5, -9.1, -10.4 and -10.9. It is proposed that the Export Flowline will be buried and protected at the eight crossings.

There are nine locations where the Export Flowline crosses ephemeral water crossings at KP-2.5, -4.5, -5.2, -6.2, -7.3, -8.3, -8.7, -9.2, and –12.5 These ephemeral waterways are dependant on large quantities of rainfall, is typical of extreme cyclones.

The route passes 3 existing wells that are within 135 m of the Export Flowline route; 2 are located at KP –0.9 and the other at KP-10.4

The route includes the following crossings, all of which are constructed above ground. It is proposed that the Export Flowline will be protected at these crossings.

- 4 crossings of existing flowlines at KP –0.8, -10.2, -10.3, and –10.8;
- 1 crude pipeline crossing at KP-12.2 for the Shipping Line; and
- 2 crossings of the 1Kv cable at KP –10.1 and –10.5.

5.1.2 LNG Export Pipeline

There are two options being considered for the transfer of Liquefied Natural Gas (LNG) from the plant to ship: the Jetty Option and Submerged Cryogenic Pipeline Option. Ship loading will occur approximately every three days, with the day either side of loading being scheduled for ship berthing and other ship activities.

5.1.2.1 Jetty Option

Liquefied natural gas (LNG) from the plant will be transported via a 915 mm diameter pipeline to the LNG ship loading jetty operating at 1.5 bara. The approximate length of this pipeline is 1 km for the onshore section, and 4.2 km for the pipeline running along the jetty.

The onshore route for both options is located within the plant area and there are no crossings of waterways and vehicle access routes.

5.1.2.2 Submerged Cryogenic Pipeline Option

This option consists of 2 x 609 mm internal diameter pipelines operating at 16 bara. The route incorporates a 1 km onshore section, and an 8 km offshore pipeline loop. (i.e. 2 x 8 km)

5.1.3 Condensate Export Pipeline

Condensate recovered from the production wells will be loaded onto ships for export. The loading will be effected by a pipeline that is 508 mm internal diameter and operating at 19 bara. This pipeline will traverse from the plant to the existing Barrow Island Oil Pipeline for product transfer to ship loading.

The new 1.45 km pipeline will be constructed from the storage tank to the load out pump used for current operations. This will connect to the 9.8 km pipeline with 300,000 bbls shipments of condensate scheduled 1 per month with ship loading requiring 24 hours.

The 1.45 km pipeline route between the storage site tank and load out pump is located as follows:

- Within the plant area the pipeline traverses northerly for 300 m from the storage tank and then for 400 m in a easterly directions; and
- From the plant area, the pipeline will traverse 750 m in a north easterly direction towards the existing load out pumps, and will be located within a designated plant area in a pipeline corridor.

Both sections do not cross any vehicle access routes and waterways.

5.1.4 Carbon Dioxide Re-injection Pipeline

Carbon dioxide (CO_2) from the field stripped at the plant will be piped and reinjected into the Dupuy saline reservoir which is located at the north end of Barrow Island. This pipeline will have an operation pressure of 300 bara, and 305 mm internal diameter.

The pipeline route of 19 km has been selected to minimise the impact to the environment and for much of the route, the pipeline follows existing vehicle access ways. The pipeline crosses fourteen ephemeral water crossings at KP 0.6, 0.9, 2.4, 2.7, 3.1, 3.9, 5.9, 6.6, 7.6, 8.7, 9.7, 10.1, 10.6, and 13.9. These ephemeral waterways are dependant on large quantities of rainfall that is typical of extreme cyclones.

The pipeline route includes eleven road crossings at KP1.0, 2.7, 3.2, 6.1, 6.4, 10.6, 11.8, 14, 14.6, 15.9, and 16.4. It is proposed that the pipeline will be buried and protected at these crossings.

The route passes 3 existing wells that are within 100 m of the Export Flowline route, and are located at KP 0, 4.4, and 12.

The route includes the following crossings, all of which are constructed above ground. It is proposed that the Export Flowline will be protected at these crossings.

- 4 crossings of existing flowlines at KP 6.3, -15.7, 15.8, and 16.3;
- 1 crude pipeline crossing at KP17.7 for the Shipping Line; and
- 2 crossings of the 1000 volt (v) cable at KP 15.6 and 16.

5.1.5 Dom Gas Export Pipeline

The Dom Gas will be supplied to the Western Australian mainland via a 430 mm internal diameter pipeline. It is envisaged this pipeline will connect to the existing Dampier to Bunbury Natural Gas Pipeline at CS1. The outlet pressure of the pipeline will be 65 bara, and consists of 3 sections:

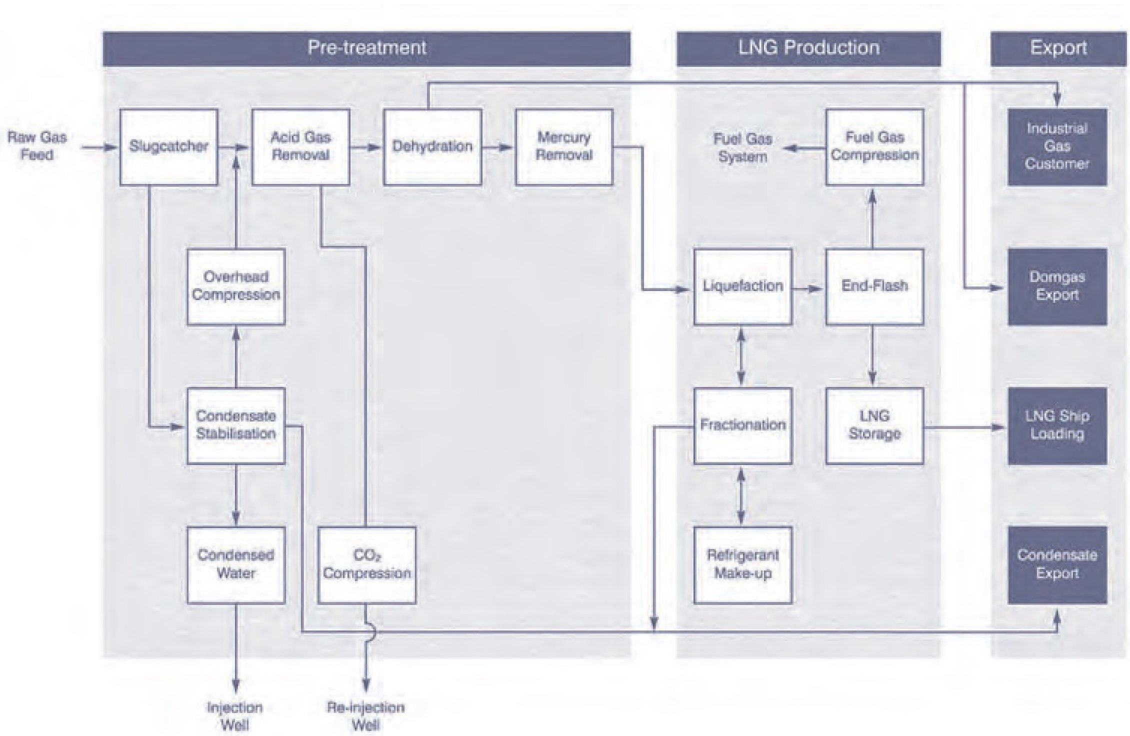
- Barrow Island onshore section where the pipe will run from the Dom Gas Plant for 1.11 km to the shore crossing. This pipeline will be within the plant boundary and there are no crossings with vehicle access routes and waterways;
- A 61.32 km submarine pipeline between Barrow Island and the mainland; and
- A 29.64 km buried pipeline from the mainland shore crossing to CS1. The shore crossing is approx 150 km south west of Karratha and this route will follow the existing gas pipeline operated by Apache Energy, with a 30 m separation distance being established between the two pipelines. This route incorporates the crossing of:
    - a wet land area between KP 61.32 and 72.0 that is typical of the North Western Australian mainland consisting of tidal flats and mangroves;
    - ephemeral water crossing at KP 76.12 ;
    - 3 minor road crossings at KP 76.2, 77.76 and 84.77;
    - an ephemeral water lake is passed between KP 85.15 and 85.34 (note that this is not crossed by the pipeline); and
    - 2 crossings of Seismic Survey Information Lines at KP 73.22 and 74.92.

5.2 Description

5.2.1 Processing Facilities Overview

The facility would separate gas and condensate (light oil) received from the gas fields. After separation from the gas, the condensate will be stabilised prior to shipping to market. The gas component of the stream will then be treated to remove carbon dioxide (CO_2), hydrogen sulfide (H_2S), trace amounts of mercury (Hg) and water vapour. At this point the gas can be either liquefied for export as LNG, compressed and exported as domestic gas (once the domestic gas export pipeline is installed) or utilised as feed gas for other gas processing facilities. An illustration of the process is provided in Figure 5.1.

Figure 5-1 Plant Process Summary



The configuration of the onshore plant in terms of major equipment is summarised in Table 5.1. The following sections provide an overview of the proposed plant.

Table 5-1 Plant Configuration Summary

Area	Train Configuration	Comments
Inlet Separator	1 x 100%	1 x 100% handles Gorgon feed for LNG and Dom Gas production.
Acid Gas Removal Unit (AGRU)	2 x 50%	Size limited by proven amine licensor experience. Each Gorgon absorber handles half of the combined LNG /Dom Gas production.
Liquefaction trains	2 x 50%	5 MTPA each. Includes Dehydration and Hg removal.
LNG Storage Tanks	2 x 50%	135,000 m^3 per tank.

5.2.2 Gas Reception and Liquid Stabilisation

Raw production is received from the Export Flowline by 1 x 100% Inlet Separator approximately 74 barg. There is one separator for each of the 2 Export Flowlines. The overhead vapour from the separator is sent to the Feed Gas Separator; a Knockout drum which protects downstream units from liquid and solids carry-over. Inlet Separator liquids pass to the three phase Stabilisers Feed Separator (6.5 m ID x 32.7 m long) at 25 barg where the aqueous water/MEG phase is separated and sent to MEG recovery. The MEG regeneration and reclamation package is designed for 120 m^3 of rich MEG (40% MEG by wt.) and produces lean MEG (80% by wt.) for reuse. MEG is used in upstream operations to assist in the control of hydrates formation.

The hydrocarbon stream from the three phase Stabiliser Feed Separator is sent to the Stabiliser process. Stabilised condensate (RVP:11 psia at 100 F) is sent to condensate storage.

5.2.3 Acid Gas Removal

Wet gas at 70 barg is passed to 2 x 50% AGRU trains for CO_2 and H_2S removal via the aMDEA process. Each AGRU train contains an amine absorber column (5.5 m ID x 25 m T/T), flash drum (6.1 m ID x 14 m T/T), amine regenerator column (6.8 m ID x 25 T/T) and four shell and tube reboilers. The reboiler duty is 144 MW per train, or 432 MW for the total which represents approximately 80% of the heating medium load for the plant. All of the AGRU sweetened gas is recombined before being split again to feed the 2 x 4.88 MTPA LNG trains.

5.2.4 CO2 Reinjection

The wet CO_2 from the AGRU trains is compressed to 45 barg, dehydrated by TEG, further compressed to approximately 135 barg, cooled, then compressed supercritically to 300 barg and exported to the reinjection wells. This unit comprises of 2 x 50% compression/dehydration trains and a single 100% accumulator/supercritical liquid pump set. Each 37 MW compressor operates on a single shaft, has four stages and a fixed speed electric motor driver. The interstage pressures, export pressure and pipeline size are to be optimised during FEED. The CO_2 will be reinjected down several wells in the Dupuy reservoir. The wells are to be located in the north of Barrow Island, approximately 15 km from the LNG Plant.

5.2.5 Dehydration and Mercury Removal

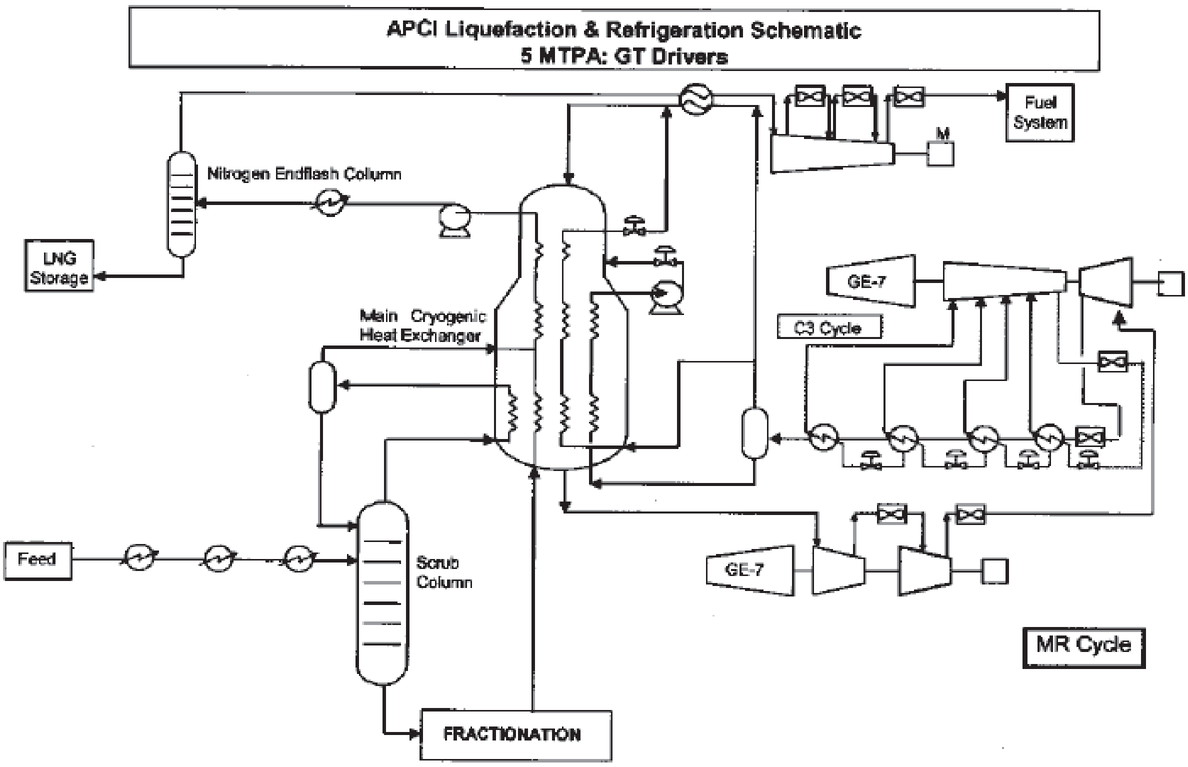
Prior to entering the liquefaction trains, the process gas is dried by 3 x 50% mole sieve vessels (each, 4m ID x 5.5 m T/T). Regeneration of the mole sieve beds is a batch process. Typically, two of the vessels are in service while the 3rd vessel is being regenerated. The mole sieve material is regenerated at approximately 55 barg and 290^{0}C by heated dry gas from downstream of the mercury removal beds. Regeneration gas is heated by waste heat from the refrigerant compressor gas turbine drivers. The spent regeneration gas is recompressed and recycled to the onshore plant inlet feed stream. The dry gas is passed through 2 x 50% mercury absorbers (3.5 m ID x 4.2 m T/T) to remove mercury.

5.2.6 Liquefaction

Each 5 MTPA liquefaction train is based on "Split C3MR APCI technology (See Figure 5.1 of the APCI train configuration). The design is based on achieving the desired cooling and liquefaction of natural gas with two refrigerant circuits, propane and mixed refrigerant. The summary is as follows:

- The feed gas from the mercury absorbers is cooled by the propane refrigerant to minus 34°C and passed to the scrubber column (4.3m ID x 20m T/T) at approximately 67 barg.
- Recovered liquids from the scrub column are sent to fractionation.
- Overhead gas from the scrub column is further cooled to minus 148°C and partially condensed in the Main Cryogenic Heat Exchanger (MCHE) (4.6m ID x 54m high).
- 3 mol% nitrogen in the LNG is removed in the nitrogen endflash column (4.3 ID x 15m T/T)
- Final condensation and chilling is achieved by the liquids expander and nitrogen endflash. LNG leaves the bottom of the nitrogen column at minus 158°C and 1.3 barg. Rundown pumps repressurize the stream to 6.3 barg to move the LNG to the storage tanks.
- Endflash gas is recompressed and used for HP fuel gas.

Figure 5-2 APCI 5 MTPA Refrigeration Cycle



Pre-cooling duty and cooling of mixed refrigerant is provided by the propane circuit which consists of a 4 stage, single casing compressor and 10 propane kettles operating at 2 to 17.6 barg and down to -36 ^{o}C. The propane refrigerant compressor flowrate is 2.1 million kg/hr of propane. Major equipment in the propane circuit includes the propane condender (aircooler, 173 MW, 15.5 m x 203 m long) and LLP Propane suction drum (7.4 m ID x 9.8 m T/T).

The Mixed Refrigerant (MR) circuit is a 3-casing compressor, LP, MP and HP, over cover 5 to 65 barg and down to -160 ^{o}C. 1.2 million kg/hr of MR is circulate through the compressors and the MCHE. Major equipment includes the MP MR suction drum (7.8 m ID x 9.8 m T/T). The LP MR suction drum (6.5 ID x 8.7 m T/T) has been sized with vane pack internals. Without internals the calculated diameter required exceeds current manufacturing limits of 8 m (24ft).

The MR and propance compressor drivers in each train will be Frame 7 gas turbines configured as follows (refer to Figure 5.2).

All LPGs extracted by fractionation will be injected back into the condensate except as required to supply make-up refrigerant. Due to the low LPG content of inlet gas it is not economically attractive to store and sell LPGs separately. LPG fractionation includes a deethaniser, depropaniser and debutaniser columns.

5.2.7 Product Storage and Loading

LNG storage consists of 2 x 135,000 m^3 tanks with double containment design. Each tank contains 4 submerged loading pumps and the design loading rate is 10,000 m^3/h. Storage tank boil off gas will be compressed and sent to HP fuel gas. Boil off gas from loading operations will be separately compressed and recombined with dry feed from Mercury removal. Loading will be via two loading arms.

Condensate will be stored in 2 x 35,000 m3 floating roof tanks. 2 x 50% loading pumps have been assumed. Pumps will tie into existing oilfield loadout subsea pipelines.

5.2.8 Domestic Gas

Domestic gas (Dom Gas) facilities are incorporated into the plant design based on 300TJ/d derived from Gorgon feed gas. The Dom Gas processing facilities are integrated with LNG gas through the AGRUs. At this point, a stream of sweetened gas is sent to stand alone facilities including:

- Dehydration
- Dew Point Control
- Export Compression.

6. ASSUMPTIONS

The following is a list of the assumptions made in undertaking this risk assessment, together.

1. The LNG Plant is designed to operate an average of 336 days per year, with the other days being for shutdowns and maintenance. It is assumed that the Dom Gas plant will have a similar operating philosophy. However, it is unlikely that both LNG trains and/or the Dom Gas plant will be shutdown simultaneously. Therefore a conservative approach is adopted where it is assumed the plant will operate continually throughout the year.

2. In undertaking the AS2885 risk assessment, it is assumed that internal corrosion is not a valid threat for the LNG and Dom Gas pipelines as water moisture is removed in the plant by the Mole Sieves and therefore the gas is considered to be dry. Internal corrosion for the Condensate Export Line is not considered in the AS2885 risk assessment as the pipeline contents do not include water (i.e. condensate only).

3. Although it is recognised that additional safety mechanisms are likely to be included in the plants' design, they have not been incorporated into this risk assessment as the details of such options are not available at the time of this study.

4. A risk assessment, probably in the form of a Hazard Identification Study, will be undertaken for the construction of the plant and pipelines. It is assumed that this construction risk assessment will cover all the hazards to the environment, the plant and other infrastructure such as roads, and other pipelines. Therefore these hazards are not included in this risk assessment.

5. It is assumed that the plant will be provided with a system whereby any losses of containment of gas and liquid hydrocarbons and other hazardous materials such as CO_2 and H_2S will be detected. The detection system will activate mechanisms that will place the section of plant and/or the entire plant if warranted, in a safe condition (e.g. vent to flare) and isolate inventory so as to minimise the level of risk. It is assumed that detection and isolation within the plant will require up to 15 minutes for the inventory to be isolated by high integrity devices such as Emergency Shutdown Valves. It is also assumed that the inventory for a failure case will be the maximum inventory.

6. Given that the ship loading of LNG and Condensate will take place at a considerable distance from the shore line (i.e. the shortest distance is for the LNG Export Pipeline via the Jetty Option that has the ship loading approximately 4.2km from the shoreline), then it is assumed that the risks from these activities will not influence the onshore risk levels due to the plant. This risk level will not be determined.

7. The operation of the 3 Mole Sieves in the Dehydration and Mercury Removal circuit is assumed to be one on line, one being regenerated, and one on standby. Therefore in determining the frequency of failure cases, it is assumed that 2 Mole Sieves are in operation mode (i.e. at operating pressure and temperature) and one is on standby. This is a conservative assumption that is in line with good practice.

8. The size and operating conditions for equipment in the Dom Gas circuit is assumed to be the same as that in the LNG trains. This assumption is made in lieu of plant specific data being available at the time of this study.

9. There will be 338.1 operating days per year for the LNG and Dom Gas Plants. Therefore, the CO_2 pipeline will not be required to operate at full capacity for 365 days per year. It is unlikely that both plants will be shut down simultaneously, and therefore, the CO_2 pipeline will be required for a reduced duty. A conservative approach is taken in this risk assessment for the duty of the CO_2 pipeline is that it will be assumed and assessed at full duty of 365 days per year.

10. In the immediate vicinity of the mainland shore crossing for the Dom Gas Export Pipeline, it is assumed that an isolation valve will be provided.

11. Where pipelines enter and/or exit the plant area, an isolation valve will be provided to isolate the pipeline.

12. The onshore sections of LNG Export Pipelines, Condensate Pipelines and the Dom Gas Pipe (i.e. Barrow Island) are assumed to be located within the on shore gas plant area.

13. Regular visual inspections of the above ground sections of the on-shore pipelines will be undertaken.

14. Although both the condensate export and LNG export pipelines (both options for the latter) are scheduled to operate monthly and every 3 days respectively, it is assumed that continuous operation will occur. This conservative approach accommodates the potential scenario when the pipeline is rested with product, albeit at a lower pressure

15. The Dom Gas pipeline located on the mainland will be buried with a minimum depth of cover of 1200mm.

16. The time to affect the closure of isolation valve for all pipelines in this study will be dependant on their location. For those pipeline sections with the plant and operating areas including the jetty, it is expected that detection and closure for leaks will be effected within 120 seconds. For other valve locations, such as shore crossing isolation valves, the time interval will vary. A conservative approach is adopted for modelling a loss of containment, in that all releases will be modelled as a continuous leak instead of a decaying leak.

17. The end of the existing runway for Barrow Island Airport is between 7.1 and 8.5 km from the proposed Gorgon Development. The northern extension of the runway centreline is aligned with the proposed LNG Process Plant and there is a potential for aircraft to over-fly the Plant and flare area. The operation of the flare is non-continuous. There exists the possibility of an aircraft on the flight path overflying the flare simultaneously as the activation of the flare. Further, there is the risk to aircraft due to tall structures. Both of these hazards could result in damage to the aircraft and a possible impact with ground and/or the on-shore plant.

    Given the low frequency of scheduled flights (i.e. a maximum of 2 flights per day or 14 flights per week at peak), it is considered that the contribution to the overall level of risk from/to aircraft approaching or taking off from the BWI airfield during construction, is negligible. Once operation commences the number of flights will diminish to a very low frequency, until or unless further construction is planned. However, this potential risk will be incorporated into the Safety Case risk assessment that will be undertaken during the detailed design phase of the project. All risks will be revisited during detailed design to validate original assumptions, to obtain Civil Aviation Safety Authority (CASA) approval to implement aerodrome design changes or to publish safety notifications.

18. Barrow Island is located in an area whose weather patterns include cyclones. The hazards to facilities due to cyclones are acknowledged and as such, engineering design incorporates a number of safeguards and as such these hazards are not considered further.

    CASA has established regulations for the safety of aircraft movements, some of which pertain to the flight path of aircraft in the vicinity of aerodromes. In particular, CASA advisory circular AC 139-05(0) (Reference 20) provides guidelines for conducting Plume Rise Assessments, and draft advisory circular AC130-08(0) (Reference 21) provides guidelines for Reporting Tall Structures

    The need to assess potential hazards to aviation where tall obstructions and gas efflux may cause damage to airframes and/or affect the handling characteristics of an aircraft in flight will be addressed in compliance with CASA requirements. A detailed plume analysis will be undertaken to determine the risk to aircraft. Should CASA consider that safety is compromised, risk will be mitigated by any one of a number of methods including deviation of the approach path, re-alignment of the runway or possibly relocation of the flare. Therefore, this hazard will not be considered further in this study.

7. HAZARD ID

7.1 Material Hazard Identification

7.1.1 LNG

Natural gas is composed primarily of methane, with some ethane and minor quantities of other light hydrocarbons and CO_2. Liquefied natural gas (LNG), when released to the atmosphere, condenses moisture from the air and thus appears as a white cloud or fog, at the point of discharge. A litre of liquid methane will vapourise at an expansion ratio of about 600 to 1 at standard temperature and pressure (STP) atmospheric pressure. Natural gas is lighter than air and may travel long distances to a point of ignition and flash back.

Natural gas is largely composed of methane, with the balance being mainly higher alkanes and inerts such as carbon dioxide. In terms of this analysis the properties of methane are assumed to represent the natural gas.

Methane is a colourless and odourless gas. It is not toxic but is flammable and may form mixtures with air that are flammable or explosive. Methane is violently reactive with oxidisers, halogens, and some halogen compounds. The combustion products of methane and air are water and carbon dioxide. Under some conditions, carbon monoxide may also be produced.

Methane is an asphyxiant and may displace oxygen in a workplace atmosphere. The concentrations at which flammable or explosive mixtures form are much lower than the concentration at which asphyxiation risk is significant.

The principal hazard associated with a release of methane to the atmosphere from pipelines or vessels is the potential for fire and explosion if ignited. The molcular weight of methane is 16.04, its boiling point is -161.5°C, its auto ignition temperature is 537°C, and the flammable limits in air are 5.3% - 15%.

7.1.2 Dom Gas

Dom Gas is the natural gas that is used in the domestic market. It is primarily composed of methane, with some ethane and minor qualities of other light hydrocarbons and CO_2. Dom Gas is compressed and transported via a pipeline. Natural gas is lighter than air and is flammable.

7.1.3 Condensate

This is a volatile liquid consisting of the heavier hydrocarbon fractions that condense out of the gas as it leaves the well. It is a mixture of pentanes and higher hydrocarbons and is flammable. Condensate is a light crude oil which condenses from natural gas with temperature and pressure changes. Condensate is primarily used in oil refineries as it is rich in gasoline (naptha), diesel and kerosene (middle distillate).

7.1.4 Export Flowline Contents

The contents of the Export Flowline will be the production fluids and gases from the production wells. This includes water, sand, CO_2, gases which are primarily methane and ethane with minor quantities of other light hydrocarbons, and condensate. The material is flammable.

7.1.5 Carbon Dioxide

Carbon Dioxide (CO_2) is an inert gas that is widely used in the chemical, food and beverage, petrochemical and metal industries. CO_2 is normally present in the air at a concentration of 340ppm by volume. Where the quantity of CO_2 dilutes the oxygen concentration below the level that can support life, then CO_2 can act as an asphyxiant. Concentration in the order of 10% can cause respiratory paralysis.

The CO_2 facilities are located on Barrow Island in the open air with little, if any, obstructions to natural ventilation. Therefore it is unlikely that a release of CO_2 from the worst case scenario of catastrophic failure of the facilities would displace the oxygen content within the air to a degree where asphyxiation would occur without alarms and visual effects being obvious to personnel. Therefore this hazard will not be considered further.

7.2 Frequency Analysis

One approach to establish the likelihood of a hazardous event occurring is to review generic data that is published in the public domain in various data bases. One such data base is the E & P Forum as reported by CMPT (Reference 9); that frequencies for leaks from process equipment based largely on UK offshore experience but combined with onshore data where necessary. Therefore it is appropriate for this study to determine applicable frequencies.

In determining the failure case for this study, the focus is on major plant equipment that is identified at this stage of the Gorgon Development i.e. slug catchers, feed separators, Absorber Columns, flash drums, reboilers, compressors, scrubber columns, heat exchangers, tanks, etc. The failure cases where by offsite risk will be incurred is expected to originate from significant leaks (i.e. not pinhole type leaks). Therefore two hole sizes of 50 mm and 150 mm have been selected as representatives of holes between 10 mm and 80 mm, and greater than 80 mm including rupture, respectively. These hole sizes are appropriate, and can be viewed as conservative in terms of effects of a Loss of Containment (LOC), given the size of plant equipment.

The leak frequencies and the hole distribution as reported by CMPT (Reference 9) were used to develop the generic failure case frequencies.

The material involved in any LOC has been taken to be the dominant material for that section of plant. The selection of materials has adopted a conservative approach in that the material that has the potential to incur the worst-case effects has been selected. For example, the separator will contain a mixture of gases primarily methane, ethane and minor quantities of other light hydrocarbons, condensate, water, sand, some CO_2 and Hydrogen Sulphide (H_2S). It is expected that 80% to 90% of the material will be gas-predominantly methane. Methane, in terms of off site effects has the potential to cause personal injury. Therefore, for the failure case of the slugcatchers, methane is the selected material to be modelled. A similar process was applied to the other failure cases, which provides for a conservative model.

Although it is practicable for the failure cases to be dependant on the major equipment items, other smaller plant items such as pipework, pumps, valves, fittings etc; together with their contribution to offsite risk are excluded. To address this issue, and to ensure that a true representation of the level of offsite risk is determined, a conservative approach of increasing all failure case frequencies by a factor of 5 was undertaken.

One failure case scenario that is applicable to gas storage (ie propane and ethane) is a Boiling Liquid Expanding Vapour Explosion (BLEVE). Work undertaken by Sooby & Tolchard (Reference 12) considered a vessel population of the exposure of an estimated 2,113,000 vessel years up to 1998 and determined the frequency of a BLEVE to be 5×10^{-7} per vessel year. Given that a BLEVE involves the ancillary pipework and fittings in the incident and the determination of the frequency, then the frequency will not be ammended by a factor of 5.

With regards to pipelines the E & P Forum QRA Data Directory (Reference 19) and its reference studies for onshore gas and oil pipelines in Western Europe for the periods 1970-92 and 1984-88 respectively provides generic data. The likelihood of a LOC is expressed in terms of per kilometer year (/kmy) and the E & P Forum data provides the total leak frequency from all causes as 0.58×10^{-4} /kmy for both gas and oil pipelines.

The E&P Forum also reports data for onshore pipelines within the US as compiled by the US Department of Transport. The failure rates for all causes for the US Pipelines is 5.52×10^{-4} /kmy, however this does not differentiate between gas and oil pipelines.

The E & P Forum data does not differentiate between pipeline sizes such as the PARLOC data (Reference 11) which report offshore pipeline incidents and indicates pipeline leak frequencies in the order of 10^{-5} and 10^{-6} kmy.

For this study, a conservative approach, was used given the early stage of this Gorgon Development, and the number of unknown parameters such as corrosion, sand content of production fluids, etc; the most conservative data is adopted (5.52×10^{-4} /kmy).

PARLOC does provide guidance for various hole sizes distribution for different pipe sizes, and is the only publically available reference that does. However the population for this data is relatively small with only 6 recorded LOCs for the size pipes used in the Gorgon Development. This is likely to be due to the comparative recent introduction of large diameter pipe that have included inherent safety within their design. Although PARLOC is foccussed on submarine pipelines, which by their location are remote, the Gorgon Development pipelines are equally remote. Therefore this data will be used to determine the distribution of hole sizes.. The hole distribution reflects small, medium and large holes with the latter including total pipeline rupture.

Table 8.1 provides the details of the failure cases, the materials and operating conditions to be modelled, and the frequency used in the risk assessment.

7.3 Ignition Probabilities

There are a number of potential sources of ignition including:

- welding, cutting, grinding;
- engines and exhausts;
- hot surfaces other than engines and exhausts;
- electrical, including lights, instrumentation, switch gear motors, mobile phones, radios;
- static;
- lightning strikes;
- flames, e.g. fuel fired equipment, matches, cigarette lighters, bushfires;
- arson.
- drilling, and
- blasting

Most potential ignition sources are controlled by engineering and management procedures. Therefore, in a plant area, the probability of ignition as provided by CMPT (Reference 9) are relevant and are provided in Table 7.1. For this study, medium size release as per the failure cases are equivalent to the Minor and Major Release Rate Categories, and large release are equivalent to Massive Release Rate Category.

Table 7-1 Ignition Probabilities

Release Rate Category	Release Rate (kg/s)	Gas Leak	Oil Leak
Minor	< 1	0.01	0.01
Major	1 to 50	0.07	0.03
Massive	> 50	0.3	0.08

In developing failure cases, another aspect to be considered is delayed ignition which could be caused by:

- The drifting of a gas cloud towards and ignition source. In the Longford Incident, it took the gas cloud 30-60 seconds to reach an ignition source (Reference 11).
- Intermittent ignition sources whereas ignition is most likely from a constant source.
- Delayed ignition can be cased by an introduced ignition source.
- The change in gas concentration towards the gases flammable limits.

CMPT Report (Reference 9) that process leak experience as documented by the UK Health and Safety Executive (HSE) suggests that most events that ignited did so immediately. However this is in conflict with offshore ignition delay probabilities (as provided by CMPT (Reference 9) which are recognised by CMPT as being judgemental. CMPT (Reference 9) also records that other studies have resolved ignition delay probabilities by means of simple judgements with Technica assuming 50% of ignited events were delayed by approximately 5 minutes or more, but this conclusion was applicable for offshore facilities. Given the standing of the UK HSE and its findings in relation to process leaks, this study will use 90% of ignited events being immediate and 10% being delayed by up to 5 minutes.

With regards to onshore pipelines, the work done by Lees (Reference 12) provides ignition probabilities for massive LPG release and flammable liquids. The reference of LPG is used as the most applicable data for the pipeline gases, LNG and Dom Gas that is available in the public domain. Table 7.2 includes the identification of the pipelines for which these ignition probabilities apply. The LPG data is applied to the LNG pipelines the Export Flowline and the Condensate Export Pipeline as this is most applicable to the materials in these pipelines given that the material is cold and in the event of a LOC would run along the ground.

Table 7-2 Probability of Ignition

MATERIAL	PROBABILITY OF IGNITION	APPLICABLE PIPELINES
Massive LPG Release	0.1	LNG Export Pipeline – both Jetty and Cryogenic options Dom Gas Pipeline for 1.11 km section on Barrow Island Export Flowline on Barrow Island and within 1km of an operating well
Flammable liquid with flashpoint below 110^0F	0.01	Condensate Export Pipeline

For the Export Flowline on Barrow Island, and the Dom Gas Pipeline on the mainland, there is limited infrastructure in the immediate area and activities are limited to a few road vehicles movement per day, resulting in less likelihood of ignition sources to be present. The probability of ignition is reduced by one order of magnitude to reflect these site conditions, and left unchanged where the Export Flowline on Barrow Island, where it passes existing wells and crosses the 1Kv power cables, the ignition probability is not reduced to reflect the increased likelihood of an ignition source being present.

7.4 AS 2885 Risk Assessment

The analysis will be undertaken as per AS2885 Risk Assessment methodology and QRA Methodology, the details of which are provided in Section 3.2.1. This section reports the analysis for each methodology.

This methodology applies to the hydrocarbons pipelines, i.e.:

- Export Flowline;
- LNG Export Pipeline;
- Condensate Export Pipeline; and
- Dom Gas Pipeline.

7.4.1 Location Analysis

The proposed routes for the four pipelines traverse the broad rural land use class. This is typified by location in underdeveloped areas on broadly farmed areas that are sparsely populated where the average allotment is typically greater than 5 hectares.

Barrow Island is a Class A Reserve, and populated areas are controlled and limited to CVX personnel. The areas on the mainland where the route for the Dom Gas Pipeline is proposed is sparsely populated and rural in development. For the onshore areas where a pipeline route is proposed, there are no sensitive developments such as schools, hospitals and aged and child centres.

Where the pipelines are submarine, there could be fishing activities undertaken – predominantly recreational. Therefore, a land use of R1 which is used for broad rural land use, is applicable.

For each pipeline, a Location Analysis is provided in:

- Appendix A – Export Flowline;
- Appendix B – LNG Export Pipeline;
- Appendix C – Condensate Pipeline; and
- Appendix D – Dom Gas Pipeline.

7.4.2 Threat Analysis

For the four pipelines, the common threats are:

- Seismic event;
- Internal Corrosion;
- Overpressure;
- Design defects;
- Material defects; and
- Construction defects.

Other threats that are location specific (e.g. road crossings) are included in the Threat Analysis Tables.

The Threat Analysis undertaken for each pipeline (see Appendix 1 to 4) includes details on the controls that will be applied to each pipeline to address each of the threats. These controls are a combination of physical and procedural controls that will be implemented during design, construction and operation of each pipeline. Given the location class of R1 for all four pipelines, at least one physical and two procedural controls are required for each threat.

For each of the four pipelines, the number of physical and procedural controls that are incorporated into the pipelines design, construction and operation, comply or exceed the controls criteria required by AS 2885. Therefore, further analysis as per AS2885 is not warranted.

8. CONSEQUENCE ANALYSIS

8.1 Effects Modelled

Consequence analysis was undertaken using the TNO Quantitative Risk Assessment program “Riskcurves”.

Potential consequences associated with high pressure gases (methane), LNG and condensate include:

- jet fires;
- pool fires;
- vapour cloud explosions;
- flash fires; and
- BLEVEs.

Jet fires tend to have relatively small areas of impact. Pool fires are where the liquid (i.e. condensate) forms a pool in the immediate vicinity of the LOC. These are modelled as unconfined circular pool. Given the topography of the plant, the condensate would flow as per the local gradient and streams would be more likely to form. Ignition of a stream of flammable materials would flow back to the source of the LOC. Vapour cloud explosions may result in overpressure effects that become more significant as the degree of confinement increases. Flash fires result from the release of flammable gas and formation of a vapour cloud, and possibly from a pool of flammable liquid. Flash fires have the potential for offsite impact as the vapour clouds can travel downwind of the source. However, these tend to be instantaneous in terms of effects and in terms of fan field effects, are considered not to incur fatalities given the high probability for dispersion by weather conditions. Therefore, flash fires are not considered further. Instead pool and jet fires are modelled. A BLEVE can occur when the vessel wall surrounding the vapour space is subject to extreme heat radiation, normally as a result of a jet fire. BLEVE failure cases are modelled for the ethane and propane storages. A BLEVE is not considered to be a credible scenario for any of the pipelines as there is no storage above the pipeline routes.

For the materials that are processed by this plant there is potential for a combination of effects to occur; for example, a LOC of condensate can result in either a pool or jet fire. A jet fire's effect are limited to the immediate area of the jet fire, whereas the effects are greater with a large diameter pool fire as would be expected to occur given the operating conditions of this equipment. Therefore, a pool fire is modelled for failure cases of condensate.

For most of the plant, the material that is being processed is methane. At each stage of the process, the concentration of methane increases from the slug catchers. A conservative approach is adapted in that all failure cases are modelled as 100% methane. In terms of off-site effects, jet fires from LOCs are modelled as the worst case as other effects such as vapour cloud explosions for methane are highly unlikely.

Similarly, with regards to the failure cases with propane and ethane as the material, the jet fire effects are modelled although there is an increased likelihood of vapour cloud explosions. However these are considered to have minimal effect on the off-site risk levels given the small inventories and the plant layout not being congested.

Table 8.1 summarises the failure cases, together with their frequency and the effects to be modelled.

Table 8-1 Failure Cases and Model Effects

Failure Case ID	Failure Case Description		Volume (m3)	Hole Size (mm)	Failure Case Frequency	QRA Failure Case Frequency	Probability of Ignition	Material	Pressure	Temp ºC	Location North	Location East
ISC01M	No 1 Inlet Separator	medium leak		50	1.34E-04	6.68E-04	0.08	Methane	74 barg	26	7700000	338425
ISC01L	No 1 Inlet Separator	large leak		150	1.65E-05	8.25E-05	0.3	Methane	74 barg	26	7700000	338425
ISC02M	No 2 Inlet Separator	medium leak		50	1.34E-04	6.68E-04	0.08	Methane	74 barg	26	7700050	338425
ISC02L	No 2 Inlet Separator	large leak		150	1.65E-05	8.25E-05	0.3	Methane	74 barg	26	7700050	338425
SFS01M	Stabiliser Feed Separator	medium leak	1085.09	50	1.34E-04	6.68E-04	0.04	Condensate	25barg	26	7699950	338500
SFC01L	Stabiliser Feed Separator	large leak	1085.09	150	1.65E-05	8.25E-05	0.08	Condensate	25barg	26	7699950	338500
AGR Train 1												
AGR01M	Amine Absorber Column	medium leak	593.96	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700150	338625
AGR01L	Amine Absorber Column	large leak	593.96	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700150	338625
AGR02M	Flash Drum	medium leak	478.97	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700150	338625
AGR02L	Flash Drum	large leak	478.97	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700150	338625
AGR03M	Amine Regenerator Column	medium leak	907.92	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700150	338625
AGR03L	Amine Regenerator Column	large leak	907.92	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700150	338625
AGR04M	Reboilers	medium leak	144MW	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700150	338625
AGR04L	Reboilers	large leak	144MW	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700150	338625
AGR Train 2												
AGR05M	Amine Absorber Column	medium leak	593.96	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700240	338625
AGR05L	Amine Absorber Column	large leak	593.96	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700240	338625
AGR06M	Flash Drum	medium leak	478.97	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700240	338625
AGR06L	Flash Drum	large leak	478.97	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700240	338625
AGR07M	Amine Regenerator Column	medium leak	907.92	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700240	338625

Failure Case ID	Failure Case Description		Volume (m3)	Hole Size (mm)	Failure Case Frequency	QRA Failure Case Frequency	Probability of Ignition	Material	Pressure	Temp ºC	Location North	Location East
AGR07L	Amine Regenerator Column	large leak	907.92	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700240	338625
AGR08M	Reboilers	medium leak	144MW	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700240	338625
AGR08L	Reboilers	large leak	144MW	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700240	338625
AGR Train 3												
AGR09M	Amine Absorber Column	medium leak	593.96	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700300	338625
AGR09L	Amine Absorber Column	large leak	593.96	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700300	338625
AGR10M	Flash Drum	medium leak	478.97	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700300	338625
AGR10L	Flash Drum	large leak	478.97	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700300	338625
AGR11M	Amine Regenerator Column	medium leak	907.92	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700300	338625
AGR11L	Amine Regenerator Column	large leak	907.92	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700300	338625
AGR12M	Reboilers	medium leak	144MW	50	1.34E-04	6.68E-04	0.08	Methane	70 bara	25.2	7700300	338625
AGR12L	Reboilers	large leak	144MW	150	1.65E-05	8.25E-05	0.3	Methane	70 bara	25.2	7700300	338625
LNG Train 1												
Dehydration & Mercury Removal												
DM101M	Mole Sieve	medium leak	69.12	50	4.45E-05	2.23E-04	0.08	Methane	65 bara	20	7700000	338725
DM101L	Mole Sieve	large leak	69.12	150	5.50E-06	2.75E-05	0.3	Methane	65 bara	20	7700000	338725
DM102M	Mole Sieve	medium leak	69.12	50	4.45E-05	2.23E-04	0.08	Methane	65 bara	20	7700000	338775
DM102L	Mole Sieve	large leak	69.12	150	5.50E-06	2.75E-05	0.3	Methane	65 bara	20	7700000	338775
DM103M	Mole Sieve	medium leak	69.12	50	4.45E-05	2.23E-04	0.08	Methane	65 bara	20	7700000	338825
DM103L	Mole Sieve	large leak	69.12	150	5.50E-06	2.75E-05	0.3	Methane	65 bara	20	7700000	338825
DM104M	Mercury Absorber	medium leak	40.41	50	6.68E-05	3.34E-04	0.08	Methane	65 bara	20	7700000	338850
DM104L	Mercury Absorber	large leak	40.41	150	8.25E-06	4.13E-05	0.3	Methane	65 bara	20	7700000	338850
DM105M	Mercury Absorber	medium leak	40.41	50	6.68E-05	3.34E-04	0.08	Methane	65 bara	20	7700000	338875
DM105L	Mercury Absorber	large leak	40.41	150	8.25E-06	4.13E-05	0.3	Methane	65 bara	20	7700000	338875

Failure Case ID	Failure Case Description		Volume (m3)	Hole Size (mm)	Failure Case Frequency	QRA Failure Case Frequency	Probability of Ignition	Material	Pressure	Temp ºC	Location North	Location East
Liquefaction												
LQ101M	Main Cryogenic Heat Exchanger	medium leak	897.43	50	6.68E-05	3.34E-04	0.08	Methane	65 bara	20	7700100	338725
LQ101L	Main Cryogenic Heat Exchanger	large leak	897.43	150	8.25E-06	4.13E-05	0.3	Methane	65 bara	20	7700100	338725
LQ102M	Scrubber Column	medium leak	290.44	50	1.34E-04	6.68E-04	0.08	Methane	67 barg	-34	7700100	338775
LQ102L	Scrubber Column	large leak	290.44	150	1.65E-05	8.25E-05	0.3	Methane	67 barg	-34	7700100	338775
LQ103M	Nitrogen Endflash Column	medium leak	217.83	50	1.34E-04	6.68E-04	0.08	Methane	1.32 bara	-158.3	7700100	338825
LQ103L	Nitrogen Endflash Column	large leak	217.83	150	1.65E-05	8.25E-05	0.3	Methane	1.32 bara	-158.3	7700100	338825
LQ104M	Propane Accumulator	medium leak	421.48	50	1.34E-04	6.68E-04	0.08	Propane	16.04 bara	47	7700100	338850
LQ1O4L	Propane Accumulator	large leak	421.48	150	1.65E-05	8.25E-05	0.3	Propane	16.04 bara	47	7700100	338850
LQ105M	Fuel Gas Compressor	medium leak		50	1.39E-02	6.93E-02	0.08	Methane	1.24 bara	-163.5	7700100	338900
LQ105L	Fuel Gas Compressor	large leak		150	1.40E-04	7.00E-04	0.3	Methane	1.24 bara	-163.5	7700100	338900
LNG Train 2												
Dehydration & Mercury Removal												
DM201M	Mole Sieve	medium leak	69.12	50	4.45E-05	2.23E-04	0.08	Methane	65 bara	20	7700200	338725
DM201L	Mole Sieve	large leak	69.12	150	5.50E-06	2.75E-05	0.3	Methane	65 bara	20	7700200	338725
DM202M	Mole Sieve	medium leak	69.12	50	4.45E-05	2.23E-04	0.08	Methane	65 bara	20	7700200	338775
DM202L	Mole Sieve	large leak	69.12	150	5.50E-06	2.75E-05	0.3	Methane	65 bara	20	7700200	338775
DM203M	Mole Sieve	medium leak	69.12	50	4.45E-05	2.23E-04	0.08	Methane	65 bara	20	7700200	338825
DM203L	Mole Sieve	large leak	69.12	150	5.50E-06	2.75E-05	0.3	Methane	65 bara	20	7700200	338825
DM204M	Mercury Absorber	medium leak	40.41	50	6.68E-05	3.34E-04	0.08	Methane	65 bara	20	7700200	338850
DM204L	Mercury Absorber	large leak	40.41	150	8.25E-06	4.13E-05	0.3	Methane	65 bara	20	7700200	338850
DM205M	Mercury Absorber	medium leak	40.41	50	6.68E-05	3.34E-04	0.08	Methane	65 bara	20	7700200	338875
DM205L	Mercury Absorber	large leak	40.41	150	8.25E-06	4.13E-05	0.3	Methane	65 bara	20	7700200	338875
Liquefaction												
LQ201M	Main Cryogenic Heat Exchanger	medium	897.43	50	6.68E-05	3.34E-04	0.08	Methane	65 bara	20	7700350	338725

Failure Case ID	Failure Case Description		Volume (m3)	Hole Size (mm)	Failure Case Frequency	QRA Failure Case Frequency	Probability of Ignition	Material	Pressure	Temp ºC	Location North	Location East
		leak										
LQ201L	Main Cryogenic Heat Exchanger	large leak	897.43	150	8.25E-06	4.13E-05	0.3	Methane	65 bara	20	7700350	338725
LQ202M	Scrubber Column	medium leak	290.44	50	1.34E-04	6.68E-04	0.08	Methane	67 barg	-34	7700350	338775
LQ202L	Scrubber Column	large leak	290.44	150	1.65E-05	8.25E-05	0.3	Methane	67 barg	-34	7700350	338775
LQ203M	Nitrogen Endflash Column	medium leak	217.83	50	1.34E-04	6.68E-04	0.08	Methane	1.32 bara	-158.3	7700350	338825
LQ203L	Nitrogen Endflash Column	large leak	217.83	150	1.65E-05	8.25E-05	0.3	Methane	1.32 bara	-158.3	7700350	338825
LQ204M	Propane Accumulator	medium leak	421.48	50	1.34E-04	6.68E-04	0.08	Propane	16.04 bara	47	7700350	338850
LQ2O4L	Propane Accumulator	large leak	421.48	150	1.65E-05	8.25E-05	0.3	Propane	16.04 bara	47	7700350	338850
LQ205M	Fuel Gas Compressor	medium leak		50	1.39E-02	6.93E-02	0.08	Methane	1.24 bara	-163.5	7700350	338900
LQ205L	Fuel Gas Compressor	large leak		150	1.40E-04	7.00E-04	0.3	Methane	1.24 bara	-163.5	7700350	338900
LNG Tanks												
TKS01M	LNG Tank	medium leak	135000	50	1.00E-05	5.00E-05	0.08	Methane	1.17 bara	-165	7700180	339090
TKS01L	LNG Tank	large leak	135000	150	6.00E-07	3.00E-06	0.3	Methane	1.17 bara	-165	7700180	339090
TKS02M	LNG Tank	medium leak	135000	50	1.00E-05	5.00E-05	0.08	Methane	1.17 bara	-165	7700300	339090
TKS02L	LNG Tank	large leak	135000	150	6.00E-07	3.00E-06	0.3	Methane	1.17 bara	-165	7700300	339090
TKS03M	Propane Sphere	medium leak	1800	50	1.00E-05	5.00E-05	0.08	Propane	15 bara	43	7700160	339165
TKS03L	Propane Sphere	large leak	1800	150	1.00E-06	5.00E-06	0.3	Propane	15 bara	43	7700160	339165
TKS03B	Propane Sphere	BLEVE	1800		1.34E-07	6.70E-07		Propane	15 bara	43	7700160	339165
TKS04M	Ethane Bullet	medium leak	500	50	1.00E-05	5.00E-05	0.08	Ethane	26 bara	-30	7700250	339165
TKS04L	Ethane Bullet	large leak	500	150	1.00E-06	5.00E-06	0.3	Ethane	26 bara	-30	7700250	339165
THS04B	Ethane Bullet	BLEVE	500		1.34E-07	6.70E-07		Ethane	26 bara	-30	7700250	339165
TKS05M	Condensate Tank	medium leak	35000	50	1.00E-05	5.00E-05	0.04	Condensate	5.89 bara	39.6	7700460	339165
TKS05L	Condensate Tank	large leak	35000	150	6.00E-07	3.00E-06	0.08	Condensate	5.89 bara	39.6	7700460	339165
TKS06M	Condensate Tank	medium leak	35000	50	1.00E-05	5.00E-05	0.04	Condensate	5.89 bara	39.6	7700540	339165
TKS06L	Condensate Tank	large leak	35000	150	6.00E-07	3.00E-06	0.08	Condensate	5.89 bara	39.6	7700540	339165

Failure Case ID	Failure Case Description		Volume (m3)	Hole Size (mm)	Failure Case Frequency	QRA Failure Case Frequency	Probability of Ignition	Material	Pressure	Temp ºC	Location North	Location East
Dom Gas												
DMS1M	Mole Sieve	medium leak	69.12	50	1.34E-04	6.68E-04	0.08	Methane	65 bara	20	7700100	339155
DMS01L	Mole Sieve	large leak	69.12	150	8.25E-06	4.13E-05	0.3	Methane	65 bara	20	7700100	339155
DMS02M	Mole Sieve	medium leak	69.12	50	6.68E-05	3.34E-04	0.08	Methane	65 bara	20	7700100	339180
DMS02L	Mole Sieve	large leak	69.12	150	8.25E-06	4.13E-05	0.3	Methane	65 bara	20	7700100	339180
DGC03M	Compressor	medium leak		50	1.39E-02	6.93E-02	0.08	Methane	65 bara	20	7700000	339200
DGC03L	Compressor	large leak		150	1.40E-04	7.00E-04	0.3	Methane	65 bara	20	7700000	339200

8.2 Modelling

The QRA modelling was undertaken using "TNO's Effects 4" and "Riskcurves" packages. The TNO tools are internationally recognised by industry and government authorities, including WA's Department of Industry and Resources.

9. RISK ASSESSMENT AND CONCLUSIONS

There have been two methodologies used in undertaking the pipelines risk assessment; AS2885 and QRA. The AS2885 risk assessment was undertaken for:

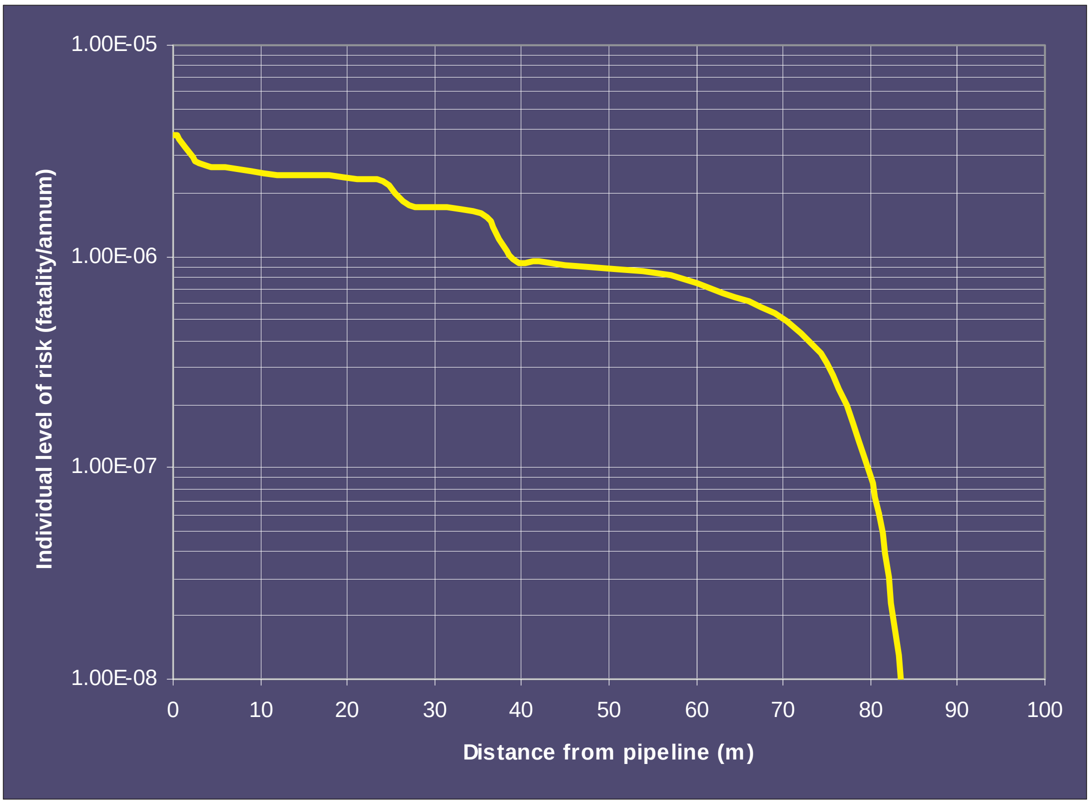
- Export Flowline – both Flacourt Bay and North White's Beach route options:
- LNG Export Pipeline for both the Jetty and Cryogenic options;
- Condensate Export Pipeline; and
- Dom Gas Pipeline.

The level of risk for the above was determined to be acceptable given the surrounding land use and the number of physical and procedural controls incorporated into the pipeline's design, construction and operation complying or exceeding the controls criteria as provided by AS2885 (Reference 15).

The CO_2 Reinjection Pipeline will be located above ground on Barrow Island in the open air with little, if any, obstructions to natural ventilation. A release of CO_2 from the worst case scenario of catastrophic failure of the pipeline would not displace the oxygen content within the air to a degree where asphyxiation would occur. Therefore this hazard was not considered further.

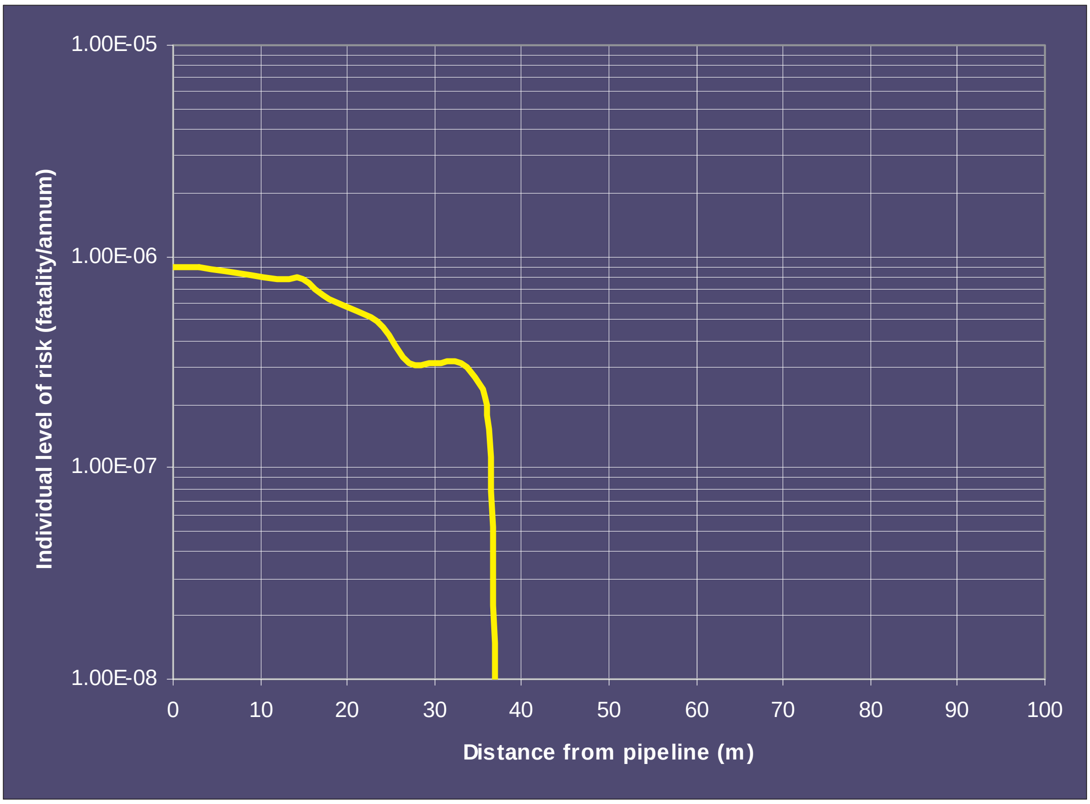
The QRA methodology was applied to all hydrocarbon pipelines with individual risk transects for each pipeline provided in Figures 9.1 to 9.4.

Figure 9-1 Export Flowline Risk Transect



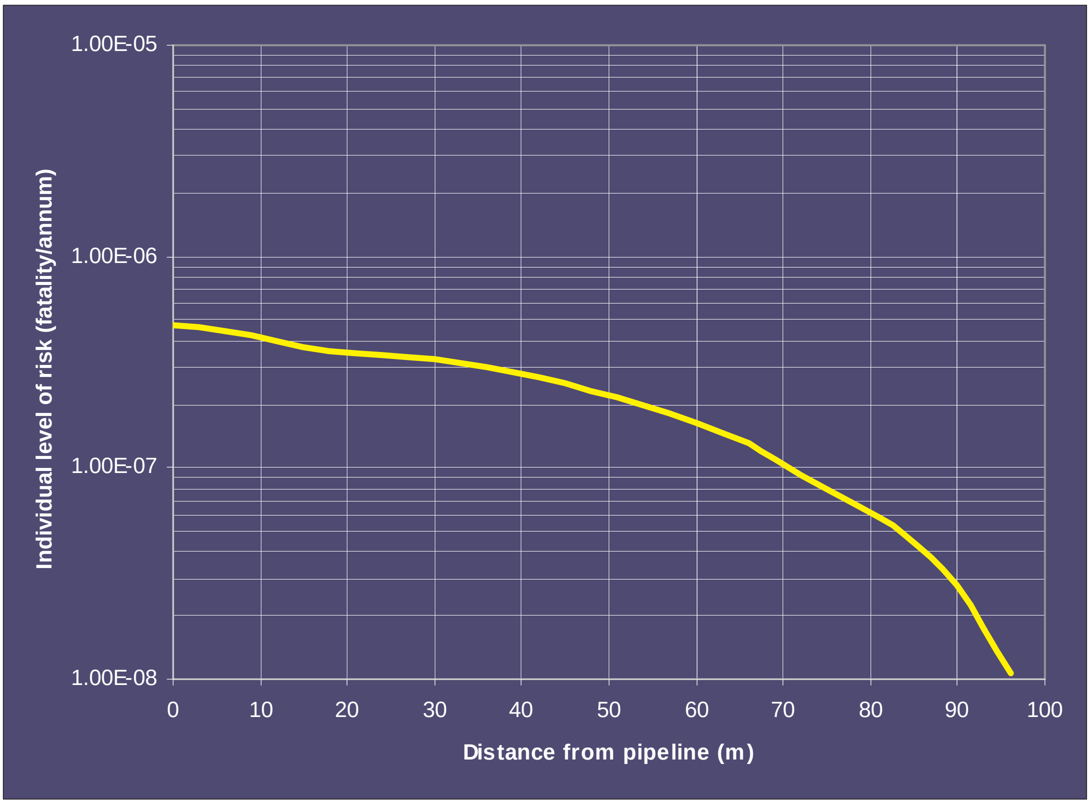
The level of individual risk is approximately 4 x 10^{-6} pa at the centreline for the Export Flowline and decreases to 1 x 10^{-6} pa over a distance of 40m either side of the Export Flowline route. The EPA's individual fatality risk criterion (Reference 2) for residential areas is 1 x 10^{-6} pa. As both routes for the Export Flowline do not pass within 40m of a residential area (i.e. the construction village), then compliance is achieved. These results are indicative for both routes given that the material modelled is methane as jet fires.

Figure 9-2 LNG Export Pipeline Risk Transect



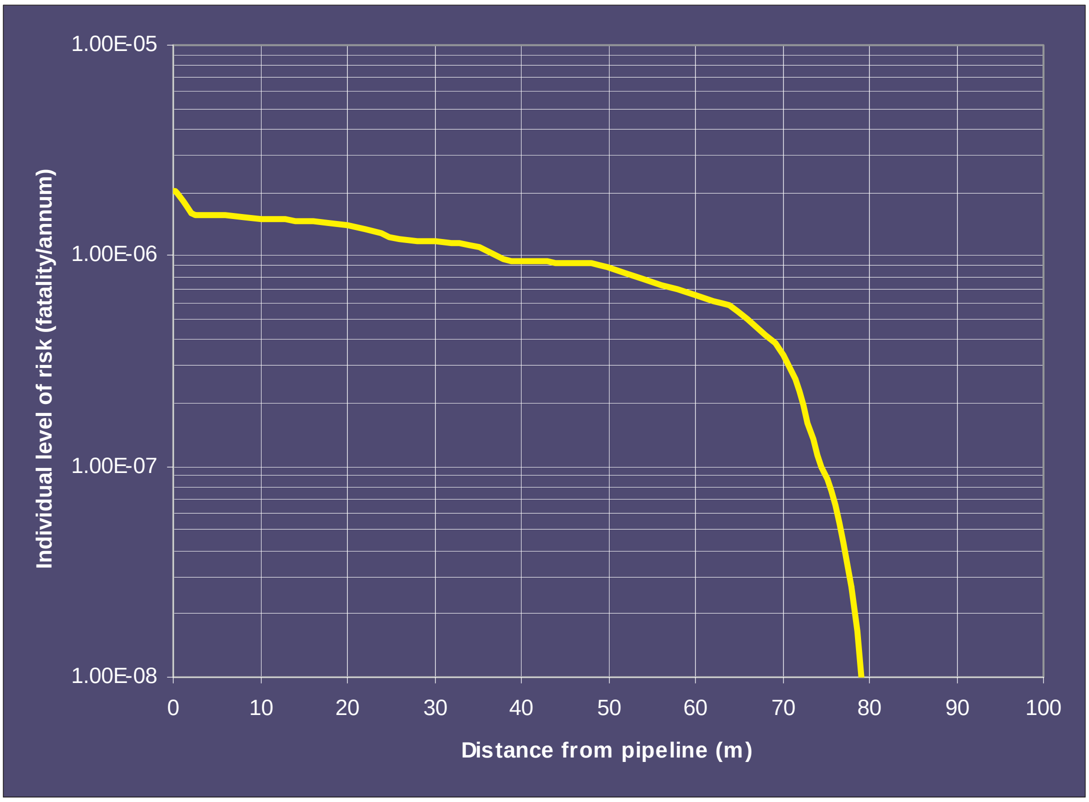
The level of individual risk is approximately 1 x 10^{-6} pa at the centreline for the LNG Export route and decreases to 2 x 10^{-7} pa over a distance of approximately 40m either side of the pipeline. This level of risk is less than the EPA individual fatality risk criteria (Reference 2) and therefore compliance is achieved. These results reflect modelling as methane for jet fires for the Jetty Option. These results are indicative for both options for planning purposes.

Figure 9-3 Condensate Pipeline Risk Transect



The level of individual risk is approximately 4 x 10^{-7} pa at the centreline for the Condensate Export Pipeline and decreases to 1 x 10^{-8} pa over a distance of approximately 100m either side of the pipeline. This level of risk is less than the EPA individual fatality risk criteria (Reference 2) and therefore compliance is achieved. These results are indicative that the material modelled is condensate as pool fires.

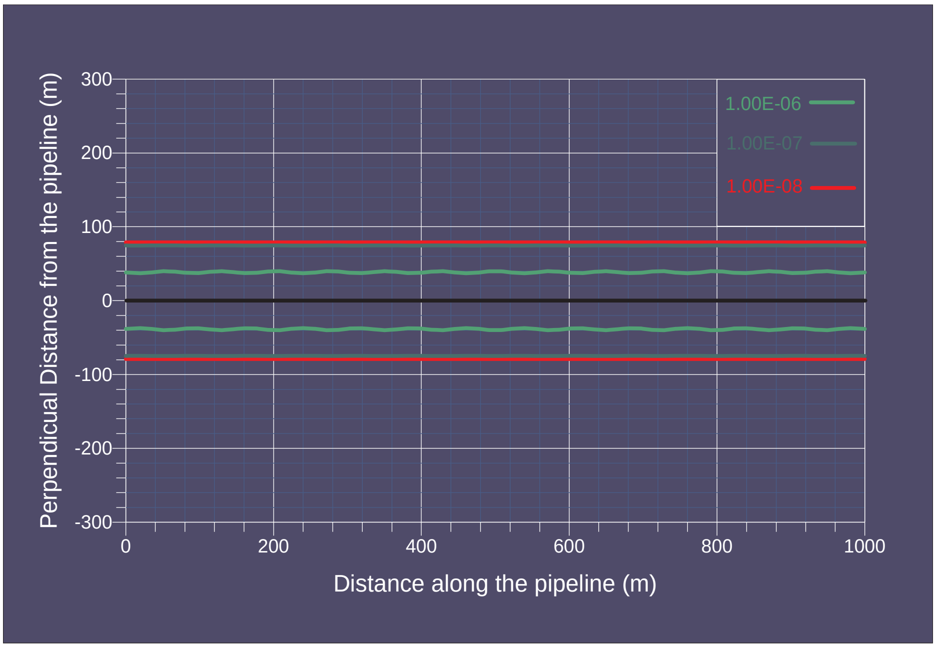
Figure 9-4 Dom Gas Pipeline Risk Transect



The level of individual risk is approximately 2 x 10^{-6} pa at the centreline for the Dom Gas Pipeline and decreases to 1 x 10^{-6} pa over a distance of approximately 40m either side of the pipeline. The EPA's individual fatality risk criterion (Reference 2) for residential areas is 1 x 10^{-6} pa. As both routes for the Dom Gas pipeline do not pass within 40m of a residential area (i.e. the construction village), then compliance is achieved. These results are indicative given that the material modelled is methane as jet fires.

Figure 9-5 provides an illustration of the iso-risk contours for a 1 km section of the Dom Gas Pipeline. The black line in the centre represents the centreline of the pipeline and illustrates the 1 x 10^{-6} per year iso-risk contour is approximately 40m either side of the pipeline.

Figure 9-5 Dom Gas Pipeline Iso-Risk Contours



The applicable risk criteria as published by the EPA (Reference 6) is the level of individual risk in residential areas of one in a million per year is not exceeded by the pipeline routes. The applicable residential area on Barrow Island are deemed to be the Gorgon Development Construction Village (due to personnel being housed in this village during commissioning and plant start-up) and the existing Chevron Village, both of which are not affected by individual risk levels greater than one in a million per year due to the pipelines.

The results of the risk assessment for the plant are provided in Appendix E as iso-risk contours that reflect the current stage of the plant's design. The one in a million per year individual risk contour extends 150m outside the site's southern boundary. This iso-contour does not encroach on any residential areas such as the area that is proposed for the Village with the contour being approximately 250m from the Village. The major risk contributors being the propane and ethane storage vessel BLEVEs and jet fires from process eqipment. Therefore, compliance with the EPA Criteria for residential areas (Reference 2) is achieved.

10. REFERENCES

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APPENDIX A

THREAT ANALYSIS OF PROPOSED EXPORT FLOWLINE – FLACOURT BAY OPTION & NORTH WHITE'S BEACH

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Table AP A.1 : Threat Analysis of Proposed Export Flowline – Flacourt Bay Option

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
-9.2 to 0.00	R1	Class 1 Nature Reserve	Export Flowline runs approximately 8.2 km over gentle undulating plateau, and 1km wide dune foreshore.	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
-2 ,-3.7, -4, -4.9, -5.7, -6, & -6.3	R1	Road Crossings	The Export Flowline intersects several tracks	Potential damage by grading of track and earth movement by heavy vehicles. Potential damage in the event that a vehicle runs of the road/track	Physical: Depth of cover (to 1200mm) in road reserves and in road crossings. Concrete slabs over pipeline under drainage ditches. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly	1 Physical, 2 Procedural	1 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
-1, -3, -4.2, -5.3 & -6.9	R1	Ephemeral Water Crossings	The Export Flowline crosses several ephemeral waterways	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
-3.6, -3.9, -4.6, -6.3, & -6.5	R1	Export Flowline crossings	The Export Flowline crosses existing flowlines associated with current Barrow Island operations	Excessive wear/erosion of Export Flowline wall thickness due to pipe movement	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. All crossings of existing flowlines will be designed and constructed to eliminate contact between Export Flowlines. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly	1 Physical, 2 Procedural	2 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
-3.1, -4, -4.9, -5.3, -5.7, & -6.4	R1	Infrastructure Passing	The Export Flowline passes up to six existing wells	Operating, housekeeping and maintenance activities could cause damage to the Export Flowline.	Physical: Clearance by at least 100m. A coating of either Fusion Binded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	2 Physical, 3 Procedural
-5.9, -6.6, & -8.5	R1	Pipeline crossings	This Export Flowline crosses existing pipelines (i.e. 2 GRE Highways and the Shipping Line) associated with current Barrow Island operations	Excessive wear/erosion of Export flowline wall thickness due to pipe movement	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. All crossings of existing pipelines will be designed and constructed to eliminate contact between the Export Flowlines and pipelines. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route.	1 Physical, 2 Procedural	2 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					The route will be patrolled regularly		
-5.8, & -6.9	R1	1000v power cable crossings	This Export Flowline crosses existing 1000v power cable that are associated with current Barrow Island operations.	Excessive wear/erosion of Export Flowline wall thickness due to pipe movement	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. All crossings of existing power cables will be designed and constructed to eliminate contact between the Export Flowlines and cables. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly	1 Physical, 2 Procedural	2 Physical, 3 Procedural
0.00 to 66.0	R1	Marine	Vessels (ships/boats) crossing submarine Export Flowline	A sinking vessel could impact the Export Flowline, an anchor being dragged or a dropped object (i.e. an anchor) could damage the Export Flowline	Physical: The Export Flowline will be provided with stabilisation that will provide protection to impact. Procedural: Regular pipeline integrity checks.	1 Physical, 2 Procedural	1 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					The Export Flowline location will be included on all admiralty charts will be marked with signs for its entire route.		
0.00 to 66.0	R1	Marine	Fishing	Fishing activities (i.e. trawling) could damage the Export Flowline	Physical: The Export Flowline will be provided with stabilisation that will provide protection to impact. Procedural: Regular pipeline integrity checks. The Export Flowline location will be included on all admiralty charts will be marked with signs for its entire route.	1 Physical, 2 Procedural	1 Physical, 2 Procedural
0.00 to 66.0	R1	Marine	Pipeline crossing	An existing submarine pipeline is to be crossed. Excessive wear/erosion of Export Flowline wall thickness due to pipe movement	Physical: The Export Flowline will be provided with stabilisation that will limit Export Flowline movement This pipeline crossing will be designed and constructed to eliminate contact. Procedural: Regular pipeline integrity checks.	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					The Export Flowline location will be included on all admiralty charts will be marked with signs for its entire route.		
NON-LOCATION SPECIFIC							
All	R1			Design Defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning.	1 Physical, 2 Procedural	2 Physical, 2 Procedural
All	R1			Material defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Steel mill verification of pipe material in accordance with material specification. Pressure testing during	1 Physical, 2 Procedural	2 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					commissioning.		
All	R1			Defects introduced during construction.	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning	1 Physical, 2 Procedural	2 Physical, 2 Procedural
All	R1			Internal Corrosion	Physical: Corrosion inhibitors to be added at well heads Procedural: A comprehensive corrosion analysis will be carried out at the detailed design stage to ensure that the pipeline is protected against corrosion. Regular pipeline integrity checks.	1 Physical, 2 Procedural	1 Physical, 2 Procedural
All	R1			Overpressure	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. Procedural:	1 Physical, 2 Procedural	1 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					Pipeline design pressure is greater than well shut-in pressure. Regular pipeline integrity checks		
All	R1			Seismic activity	Physical Pipeline to be designed and constructed in accordance with Australian Standard 2885. The pipeline lies in a low seismic activity risk area. Procedural: Emergency shutdown systems to close off supply of gas in event of rupture. Regular pipeline integrity checks	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Table AP A.2 : Threat Analysis of Proposed Export Flowline – North Whites Beach Option

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
-12.8 to 0.00	R1	Class 1 Nature Reserve	Export Flowline runs approximately 12.8 km over gentle undulating plateau, and 1km wide dune foreshore.	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
-0.6, -0.9, -5.1, -6.3, -8.5, -9.1, -10.4, & -10.9	R1	Road Crossings	The Export Flowline intersects eight tracks	Potential damage by grading of track and earth movement by heavy vehicles. Potential damage in the event that a vehicle runs of the road/track	Physical: Depth of cover (to 1200mm) in road reserves and in road crossings. Concrete slabs over pipeline under drainage ditches. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly	1 Physical, 2 Procedural	1 Physical, 3 Procedural
-2.5, -4.5, -5.2, -6.2, -7.3, -8.3, -8.7, -9.2, & -12.5	R1	Ephemeral Water Crossings	The Export Flowline crosses nine ephemeral waterways	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural:	1 Physical, 2 Procedural	1 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.		
-0.8, -10.2, -10.3, &-10.8	R1	Export Flowline crossings	This Export Flowline crosses existing flowlines associated with current Barrow Island operations	Excessive wear/erosion of Export Flowline wall thickness due to pipe movement	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. All crossings of existing flowlines will be designed and constructed to eliminate contact between Export Flowlines. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly	1 Physical, 2 Procedural	2 Physical, 3 Procedural
-0.9, & -10.4	R1	Infrastructure Passing	The Export Flowline passes up to three existing wells	Operating, housekeeping and maintenance activities could cause damage to the Export Flowline.	Physical: Clearance by at least 100m. A coating of either Fusion Binded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route.	1 Physical, 2 Procedural	2 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					The route will be patrolled regularly.		
-12.2	R1	Pipeline crossings	This Export Flowline crosses existing pipeline (i.e. the Shipping Line) associated with current Barrow Island operations	Excessive wear/erosion of Export Flowline wall thickness due to pipe movement	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. All crossings of existing pipelines will be designed and constructed to eliminate contact between the Export Flowlines and pipelines. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly	1 Physical, 2 Procedural	2 Physical, 3 Procedural
-10.1, & -10.5	R1	1000v power cable crossings	This Export Flowline crosses existing 1000v power cable that are associated with current Barrow Island operations.	Excessive wear/erosion of Export Flowline wall thickness due to pipe movement	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. All crossings of existing power cables will be designed and constructed to eliminate contact between the Export Flowlines and cables. Procedural: Regular pipeline integrity checks.	1 Physical, 2 Procedural	2 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					The pipeline will be marked with signs for its entire route. The route will be patrolled regularly		
0.00 to 66.37	R1	Marine	Vessels (ships/boats) crossing submarine Export Flowline	A sinking vessel could impact the Export Flowline, an anchor being dragged or a dropped object (i.e. an anchor) could damage the Export Flowline	Physical: The Export Flowline will be provided with stabilisation that will provide protection to impact. Procedural: Regular pipeline integrity checks. The Export Flowline location will be included on all admiralty charts will be marked with signs for its entire route.	1 Physical, 2 Procedural	1 Physical, 2 Procedural
0.00 to 66.37	R1	Marine	Fishing	Fishing activities (i.e. trawling) could damage the Export Flowline	Physical: The Export Flowline will be provided with stabilisation that will provide protection to impact. Procedural: Regular pipeline integrity checks. The Export Flowline location will be included on all admiralty charts will be marked with signs for its entire route.	1 Physical, 2 Procedural	1 Physical, 2 Procedural
0.00 to 66.37	R1	Marine	Pipeline crossing	An existing submarine pipeline is to be crossed. Excessive wear/erosion of	Physical: The Export Flowline will be provided with stabilisation that will limit Export Flowline movement	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
				Export Flowline wall thickness due to pipe movement	This pipeline crossing will be designed and constructed to eliminate contact. Procedural: Regular pipeline integrity checks. The Export Flowline location will be included on all admiralty charts will be marked with signs for its entire route.		
Non-Location Specific							
All	R1			Design Defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning.	1 Physical, 2 Procedural	2 Physical, 2 Procedural
All	R1			Material defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and	1 Physical, 2 Procedural	2 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					design checked. Steel mill verification of pipe material in accordance with material specification. Pressure testing during commissioning.		
All	R1			Defects introduced during construction.	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning	1 Physical, 2 Procedural	2 Physical, 2 Procedural
All	R1			Internal Corrosion	Physical: Corrosion inhibitors to be added at well heads and on corrosion resistant alloys will be used Procedural: A comprehensive corrosion analysis will be carried out at the detailed design stage to ensure that the pipeline is protected against corrosion. Regular pipeline integrity checks.	1 Physical, 2 Procedural	1 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
All	R1			Overpressure	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. Procedural: Pipeline design pressure is greater than well shut-in pressure. Regular pressure testing. Regular pipeline integrity checks	1 Physical, 2 Procedural	1 Physical, 3 Procedural
All	R1			Seismic activity	Physical Pipeline to be designed and constructed in accordance with Australian Standard 2885. The pipeline lies in a low seismic activity risk area. Procedural: Emergency shutdown systems to close off supply of gas in event of rupture. Regular pipeline integrity checks	1 Physical, 2 Procedural	2 Physical, 2 Procedural

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APPENDIX B

THREAT ANALYSIS OF PROPOSED LNG EXPORT LINE – JETTY OPTION & CRYOGENIC SUBMERGED OPTION

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Table AP B.1 : Threat Analysis of Proposed LNG Export Line - Jetty Option

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
-1.00 to 0.00	R1	Plant area	Pipeline runs from plant LNG tanks to marine jetty.	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
0.00 to 4.2	R1	**Marine jetty**	Pipeline runs along jetty above water	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
0.00 to 4.2	R1	Marine jetty	Jetty operations	Jetty operations such as vehicle movements and equipment handling may impact pipeline, leading to damage	Physical: The pipeline will be protected by being located outside the normal work area. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly	1 Physical, 2 Procedural	1 Physical, 3 Procedural
0.00 to 4.2	R1	Marine jetty	Jetty operations	Impact with ships may lead to pipeline damage	Physical: The pipeline route will be outside normal ship movement area. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
Non-Location Specific							
All	R1			Design Defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885.	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning.		
All	R1			Material defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Steel mill verification of pipe material in accordance with material specification. Pressure testing during commissioning.	1 Physical, 2 Procedural	2 Physical, 3 Procedural
All	R1			Defects introduced during construction.	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked.	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					Pressure testing during commissioning		
All	R1			External Corrosion	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
All	R1			Overpressure	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. Procedural: Pipeline design pressure is greater than well shut-in pressure. Regular pressure testing. Regular pipeline integrity checks	1 Physical, 2 Procedural	1 Physical, 3 Procedural
All	R1			Seismic activity	Physical Pipeline to be	1 Physical,	2 Physical,

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					designed and constructed in accordance with Australian Standard 2885. The pipeline lies in a low seismic activity risk area. Procedural: Emergency shutdown systems to close off supply of gas in event of rupture. Regular pipeline integrity checks	2 Procedural	2 Procedural

Table AP B.2 : Threat Analysis of Proposed LNG Export Line - Cryogenic Option

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
-1.00 to 0.00	R1	Plant area	Pipeline runs from plant LNG tanks to marine jetty.	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
0.00 to 8.00	R1	Marine	Vessels (ships/boats) crossing submarine pipeline	A sinking vessel could impact the pipeline, an anchor being dragged or a dropped object (i.e. an anchor) could damage the pipeline	Physical: The pipeline will be provided with stabilisation that will provide protection to impact. Procedural: Regular pipeline integrity checks. The pipeline location will be included on all admiralty charts will be marked with signs for its entire route.	1 Physical, 2 Procedural	1 Physical, 2 Procedural
0.00 to 8.00	R1	Marine	Fishing	Fishing activities (i.e. trawling) could damage the pipeline	Physical: The pipeline will be provided with stabilisation that will provide protection to impact.	1 Physical, 2 Procedural	1 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					Procedural: Regular pipeline integrity checks. The pipeline location will be included on all admiralty charts will be marked with signs for its entire route.		
0.00 to 8.00	R1	Marine jetty	Jetty operations	Impact with ships may lead to pipeline damage	Physical: The pipeline route will be outside normal ship movement area. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
Non-Location Specific							
All	R1			Design Defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked.	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					Pressure testing during commissioning.		
All	R1			Material defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Steel mill verification of pipe material in accordance with material specification. Pressure testing during commissioning.	1 Physical, 2 Procedural	2 Physical, 3 Procedural
All	R1			Defects introduced during construction.	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
All	R1			External Corrosion	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
All	R1			Overpressure	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. Procedural: Pipeline design pressure is greater than well shut-in pressure. Regular pressure testing. Regular pipeline integrity checks	1 Physical, 2 Procedural	1 Physical, 3 Procedural
All	R1			Seismic activity	Physical Pipeline to be designed and constructed in accordance with Australian Standard 2885.	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Loc. (approx. km)	Loc. Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					The pipeline lies in a low seismic activity risk area. Procedural: Emergency shutdown systems to close off supply of gas in event of rupture. Regular pipeline integrity checks		

APPENDIX C

THREAT ANALYSIS OF PROPOSED CONDENSATE EXPORT PIPELINE

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Table AP C.1 : Threat Analysis of Proposed Condensate Export Pipeline

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
-1.45 to 0.00	R1	Plant area	Pipeline runs from plant condensate tank to the existing loud out pump that is used for current operations.	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
0.00 to 9.80	R1	Marine operations	Vessels (ships/boats) crossing submarine pipeline	A sinking vessel could impact the pipeline, an anchor being dragged or a dropped object (i.e. an anchor) could damage the pipeline	Physical: The pipeline will be provided with stabilisation that will provide protection to impact. Procedural: Regular pipeline integrity checks. The pipeline location will be included on all admiralty charts will be marked with signs for its entire route.	1 Physical, 2 Procedural	1 Physical, 2 Procedural
Non-Location Specific							
All	R1			Design Defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning.	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
All	R1			Material defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Steel mill verification of pipe material in accordance with material specification. Pressure testing during commissioning.	1 Physical, 2 Procedural	2 Physical, 3 Procedural
All	R1			Defects introduced during construction.	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning	1 Physical, 2 Procedural	2 Physical, 2 Procedural
All	R1			External Corrosion	Physical:	1 Physical,	1 Physical,

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	2 Procedural	3 Procedural
All	R1			Overpressure	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. Procedural: Pipeline design pressure is greater than well shut-in pressure. Regular pressure testing. Regular pipeline integrity checks	1 Physical, 2 Procedural	1 Physical, 3 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
All	R1			Seismic activity	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. The pipeline lies in a low seismic activity risk area. Procedural: Emergency shutdown systems to close off supply of gas in event of rupture. Regular pipeline integrity checks	1 Physical, 2 Procedural	2 Physical, 2 Procedural

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APPENDIX D

THREAT ANALYSIS OF PROPOSED DOM GAS PIPELINE

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Table AP D.1 Threat Analysis of Proposed Dom Gas Pipeline

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
-1.11 to 0.00	R1	Class 1 Nature Reserve	Pipeline runs approximately 1.11 km over gentle undulating plateau, and 1km wide dune foreshore.	External corrosion due to being exposed to wind and other weather conditions	Physical: A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Regular pipeline integrity checks. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly.	1 Physical, 2 Procedural	1 Physical, 3 Procedural
0.00 to 61.32	R1	Marine	Vessels (ships/boats) crossing submarine pipeline	A sinking vessel could impact the pipeline, an anchor being dragged or a dropped object (i.e. an anchor) could damage the pipeline	Physical: The pipeline will be provided with stabilisation that will provide protection to impact. Procedural: Regular pipeline integrity checks.	1 Physical, 2 Procedural	1 Physical, 2 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					The pipeline location will be included on all admiralty charts will be marked with signs for its entire route.		
0.00 to 61.32	R1	Marine	Fishing	Fishing activities (i.e. trawling) could damage the pipeline	Physical: The pipeline will be provided with stabilisation that will provide protection to impact. Procedural: Regular pipeline integrity checks. The pipeline location will be included on all admiralty charts will be marked with signs for its entire route.	1 Physical, 2 Procedural	1 Physical, 2 Procedural
0.00 to 61.32.	R1	Marine	Pipeline crossing	An existing submarine pipeline is to be crossed. Excessive wear/erosion of pipeline wall thickness due to pipe movement	Physical: The pipeline will be provided with stabilisation that will limit pipeline movement This pipeline crossing will be designed and constructed to eliminate contact. Procedural: Regular pipeline integrity checks.	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					The pipeline location will be included on all admiralty charts will be marked with signs for its entire route.		
61.32 70 72.0	R1	Tidal Flats	Pipeline runs across tidal flats are and mangrove area	External corrosion due to being exposed to wind and other weather conditions	Physical: Depth of coverage (1200mm) chosen to cater for all reasonable farming activities. A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Buried marker tape will be installed in areas at risk from excavation. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly. There will be regular liaison with the landowners and occupiers. Regular pipeline integrity	1 Physical, 2 Procedural	2 Physical, 5 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					checks.		
72.0 to 90.96	R1	Cattle grazing area	Pipeline runs over gentle undulating plateau	External corrosion due to being exposed to wind and other weather conditions	Physical: Depth of coverage (1200mm) chosen to cater for all reasonable farming activities. A coating of either Fusion Bonded Epoxy (FBE), High Density Polyethylene (HDPE), or polypropylene (PP) will be provided. Procedural: Buried marker tape will be installed in areas at risk from excavation. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly. There will be regular liaison with the landowners and occupiers. Regular pipeline integrity checks.	1 Physical, 2 Procedural	2 Physical, 5 Procedural
76.2, 77.76 & 77.77	R1	Road Crossings	The pipeline intersects several tracks	Potential damage by grading of track and earth movement by	Physical: Depth of cover (to 1200mm) in road reserves	1 Physical, 2 Procedural	2 Physical, 5 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
				heavy vehicles. Potential damage in the event that a vehicle runs of the road/track	and in road crossings. Concrete slabs over pipeline under drainage ditches. Procedural: Buried marker tape will be installed in areas at risk from excavation. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly. There will be regular liaison with the landowners and occupiers. Regular pipeline integrity checks.		
76.12 & 85.15 to 85.34	R1	Ephemeral Water Crossing	The pipeline crosses ephemeral waterway and passes an ephemeral water lake (it does not cross this lake).	External corrosion due to being exposed to wind and other weather conditions	Physical: Depth of cover (to 1200mm) in road reserves and in road crossings. Concrete slabs over pipeline under drainage ditches. Procedural: Buried marker tape will be installed in areas at risk	1 Physical, 2 Procedural	2 Physical, 5 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					from excavation. The pipeline will be marked with signs for its entire route. The route will be patrolled regularly. There will be regular liaison with the landowners and occupiers. Regular pipeline integrity checks.		
All	R1			Design Defects	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning.	1 Physical, 2 Procedural	2 Physical, 2 Procedural
All	R1			Material defects	Physical: Pipeline to be designed and constructed in	1 Physical, 2 Procedural	2 Physical, 3 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Steel mill verification of pipe material in accordance with material specification. Pressure testing during commissioning.		
All	R1			Defects introduced during construction.	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. X-raying of all welds. Procedural: Pipeline design to be verified and design checked. Pressure testing during commissioning	1 Physical, 2 Procedural	2 Physical, 2 Procedural
All	R1			Internal Corrosion	Physical: Corrosion inhibitors to be added at well heads Procedural:	1 Physical, 2 Procedural	1 Physical, 2 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					A comprehensive corrosion analysis will be carried out at the detailed design stage to ensure that the pipeline is protected against corrosion. Regular pipeline integrity checks.		
All	R1			Overpressure	Physical: Pipeline to be designed and constructed in accordance with Australian Standard 2885. Procedural: Pipeline design pressure is greater than well shut-in pressure. Regular pressure testing. Regular pipeline integrity checks	1 Physical, 2 Procedural	1 Physical, 3 Procedural
All	R1			Seismic activity	Physical Pipeline to be designed and constructed in accordance with Australian Standard 2885. The pipeline lies in a low seismic activity risk area.	1 Physical, 2 Procedural	2 Physical, 2 Procedural

Location (approx. km)	Location Class	Predominant Land Use	Environmental Description	Threat Analysis	Protective Measures	Required No. of Protection Measures	Actual No. of Protection Measures
					Procedural: Emergency shutdown systems to close off supply of gas in event of rupture. Regular pipeline integrity checks		

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APPENDIX E

ISO RISK CONTOURS

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Figure AP E.1

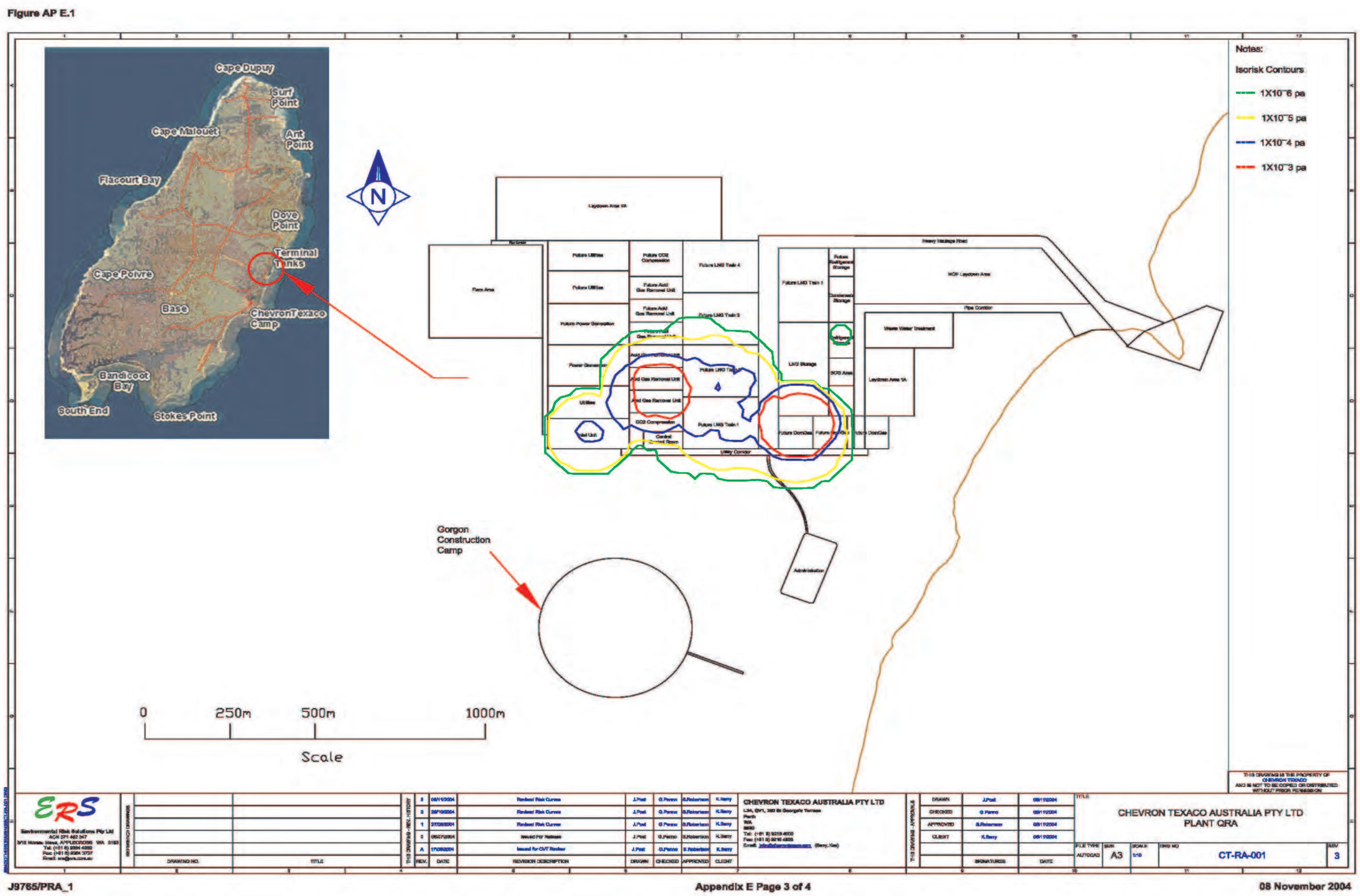
Figure AP E.1
Cape Dupuy
Surf Point
Cape Malouet
Ant Point
Flacourt Bay
Dove Point
Terminal Tanks
Cape Poivre
Base
ChevronTexaco Camp
Bandicoot Bay
South End
Stokes Point
N
Notes:
Isorisk Contours
1X10^-6 pa
1X10^-5 pa
1X10^-4 pa
1X10^-3 pa
Gorgon Construction Camp
0
250m
500m
1000m
Scale
CHEVRON TEXACO AUSTRALIA PTY LTD
PLANT QRA
CT-RA-001
A3
3
J9765/PRA_1
Appendix E Page 3 of 4
08 November 2004

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