Gorgon Project

Carbon Dioxide Injection System Pipeline and Wells Operations Environment Management Plan: Summary

Document ID:	ABU161100705	**Revision ID:**	0.5
Revision Date:	25 February 2017	**Next Revision Due:**	TBC
Information Sensitivity:	Public		

Contents

Tables

Figures

1.0 Introduction

1.1 Overview

Chevron Australia Pty Ltd (Chevron Australia) is the operator for the Gorgon Gas Development (also known as the Gorgon Project) on behalf of the Gorgon Joint Venture (GJV). Offshore production wells and pipeline infrastructure associated with the Jansz–Io and Gorgon gas fields gathers and transports gas to the Gorgon Gas Treatment Plant (GGTP) on Barrow Island, where it is processed.

Carbon dioxide (CO_2), which occurs naturally in the feed gas, is separated during the production process and injected in a supercritical state into deep rock formations below Barrow Island. The operation of CO_2 infrastructure has been evaluated as having low environmental impact or risks.

1.2 Location

The CO_2 Pipeline and Wells are located on Barrow Island within the PL93 Licence Area (Figure 1-1). The CO_2 Pipeline runs north from the GGTP on the eastern side of Barrow Island for approximately 7.3 km along the pipeline right-of-way (ROW), connecting to CO_2 Injection Drill Centres (DC-A, DC-B, and DC-C). Pressure Management Drill Centres (DC-D and DC-E) are located more than 4 km west of the CO_2 Pipeline and the Injection Drill Centres.

Detailed information regarding the location and layout of the infrastructure associated with this Plan is included in Section 2.1.

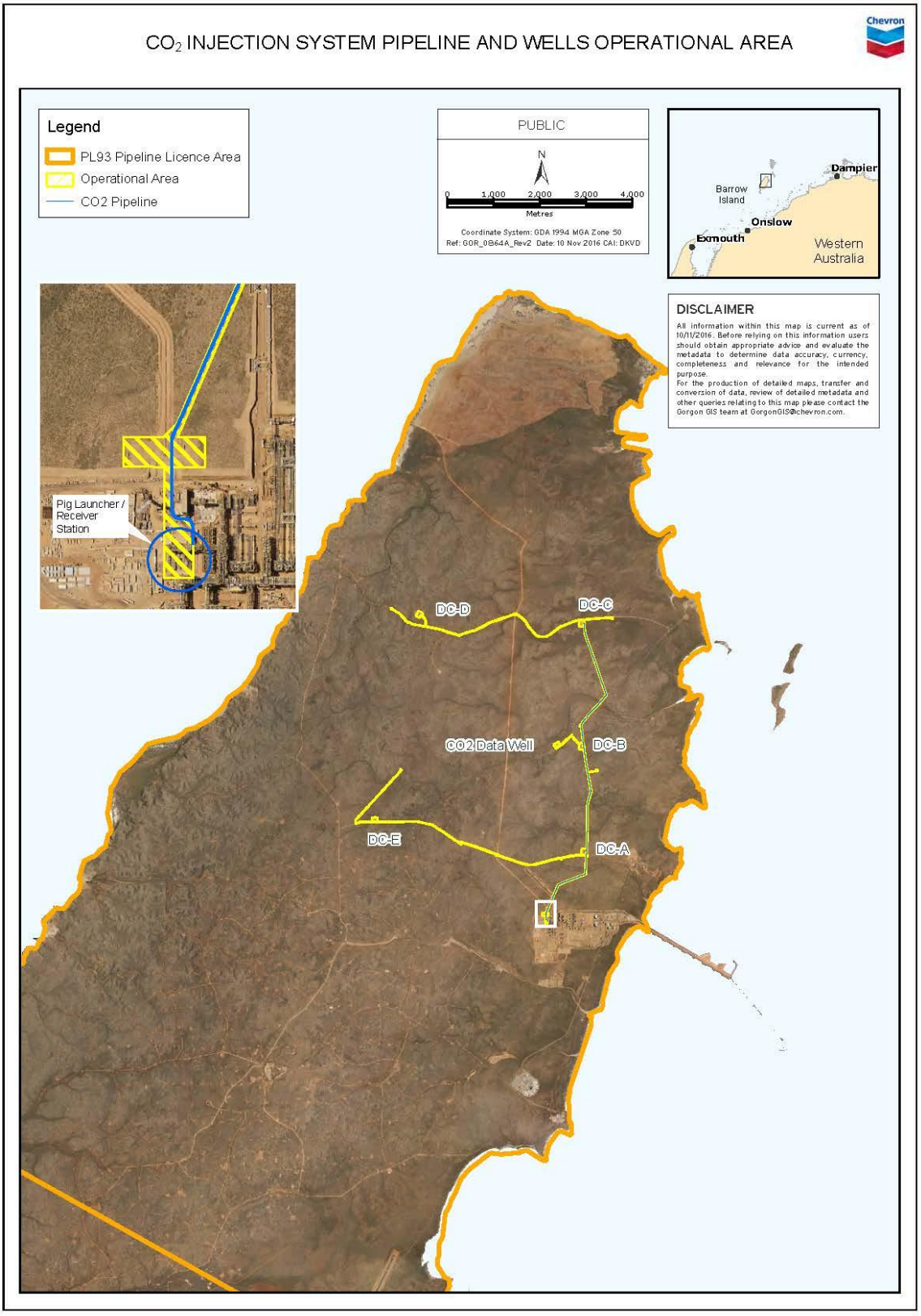

Figure 1-1: CO_2 Pipeline and Wells Operational Area

1.3 Scope

The PL93 Licence Area (Figure 1-1) encompasses much of Barrow Island, identified at the licence application stage to allow for the potential development and expansion of the CO_2 Injection System. The scope of the Environment Management Plan (EMP) is limited to the activity as summarised in Section 2.0.

1.4 Licence Holder and Operator Details

Chevron Australia Pty Ltd is nominated as the operator on behalf of the GJV title holders (Table 1-1) for Pipeline Licence PL93, granted under the *Petroleum Pipelines Act 1969* (WA).

Table 1-1: Titleholder Details

Titles	Details	Titleholders	Operator	Address
PL93	CO_2 Injection System Pipeline Licence Onshore	• Chevron (TAPL) Pty Ltd • Shell Australia Pty Ltd • Mobil Australia Resources Company Pty Ltd • Tokyo Gas Gorgon Pty Ltd • Osaka Gas Gorgon Pty Ltd • JERA Gorgon Pty Ltd	Chevron Australia Pty Ltd	QV1, 250 St Georges Terrace, Perth, WA, 6000

In accordance with the Petroleum Pipelines (Environment) Regulations 2012, contact details for the operator, Chevron Australia Pty Ltd, are listed in Table 1-2.

Table 1-2: Operator Contact Details

Company Name	Chevron Australia Pty Ltd
Nominated Liaison Person	Wayne Tsuji/Graeme Harman (public contact)
Position	PGPA Operations Manager/PGPA Operations Manager
Business Address	GPO Box S1580, Perth WA 6845
Telephone Number	08 9413 6764/08 9216 4000 (public contact number)
Fax Number	08 9413 6067
Email Address	ask@chevron.com

1.5 Stakeholder Engagement

Regular consultation with relevant stakeholders has been undertaken by Chevron Australia throughout the development of the environmental impact assessment management documentation for the Gorgon Gas Development and Jansz Feed Gas Project.

Stakeholder consultation has included engagement with the community, government departments, industry operators and contractors to Chevron Australia via planning workshops, risk assessments, meetings, teleconferences, and the formal environmental approval processes.

1.5.1 Stakeholder Identification

In accordance with Regulation 17 of the Petroleum Pipelines (Environment) Regulations 2012, Chevron Australia completed a scoping exercise to determine which authorities, persons, and organisations were considered to be relevant.

No permanent population resides on Barrow Island. Barrow Island has been actively used for petroleum exploration and production purposes since 1957 and access to Barrow Island is restricted to personnel associated with oilfield operations, Western Australian Department of Parks and Wildlife (Parks and Wildlife) staff, and Gorgon Gas Development and Jansz Feed Gas Pipeline staff. Therefore, the relevant stakeholders associated with the operation of the CO_2 Injection System Pipeline and Wells were identified as:

- Department of Parks and Wildlife (State)
- Office of the Environmental Protection Agency (State)
- Department of State Development (State)
- Department of the Environment and Energy (Commonwealth).

1.5.2 Stakeholder Log

Table 1-3 summarises the consultation undertaken specific to this Plan.

Table 1-3: Consultation Summary

Stakeholder	Date	Summary of Consultation	Objections / Claims Raised	Chevron Australia Response
Department of Parks and Wildlife	27 October 2016	Provision of project-specific information	Requested a copy of the EMP	Provided a copy of the EMP
	22 November 2016	Provision of Rev 0.3 of EMP.	No further questions or concerns in relation to the EMP.	N/a
Office of the Environmental Protection Agency	26 October 2016	Provision of project-specific information	None identified	N/a
Department of the Environment and Energy	26 October 2016	Provision of project-specific information	None identified	N/a
Department of State Development	10 November 2016	Provision of project-specific information	None identified	N/a

1.5.3 Ongoing Consultation

Chevron Australia will continue to provide updates regarding Gorgon Operations at regular meetings with these stakeholders.

2.0 Description of the Activity

The activities associated with the operation of the CO_2 Pipeline and Wells include:

- Commissioning and Start-up (Section 2.2)
- Operations (Section 2.3)
- Inspections, Maintenance, and Repair (IMR) (Section 2.4).

Section 2.1 summarises the CO_2 Injection System and includes general details on the location and layout of the infrastructure associated with the CO_2 Pipeline and Wells.

2.1 Carbon Dioxide Injection System Overview

The CO_2 Injection System is designed to dispose, by underground injection, the volume of reservoir carbon dioxide that is removed during routine gas processing operations at the GGTP that would otherwise be vented to the atmosphere.

The separation of reservoir CO_2 from feed gas occurs at the GGTP. The reservoir CO_2 is then transported via an underground pipeline to a series of three drill centres (DC-A, DC-B, and DC-C), each comprising several injection wells, located approximately 1.2 km, 3.6 km, and 6.3 km north of the GGTP. At these drill centres, reservoir CO_2 is injected into the Dupuy Formation, which is situated more than 2000 m beneath Barrow Island and which is overlain by several sealing formations including the lowermost Barrow Group.

Two reservoir surveillance wells, located at DC-A and DC-C, monitor the movement of reservoir CO_2 within the Dupuy Formation. Another surveillance well (CO_2 data well) near DC-B monitors the pressure in the overlying Barrow Group and passive microseismic measurements. Pressure within the Dupuy Formation is managed via four pressure management wells located at DC-D and DC-E more than 4 km west of the pipeline and injection wells. To partially offset increasing reservoir pressure from CO_2 injection, formation water is extracted via the four pressure management wells, which is then injected into the overlying Barrow Group. The pipeline and wells are protected from corrosion via an impressed current cathodic protection system and protected from internal corrosion by dew point management of Co2 entering the pipeline system. The system also comprises support infrastructure (e.g. utility power supply; communication infrastructure).

2.1.1 Timing

Initial commissioning and start-up activities are scheduled to be undertaken between Q1 and Q2 2017. Following start-up, operations are expected to continue for the nominal operational design life (minimum 50 years).

2.1.2 CO_2 Pipeline

A 300 mm nominal diameter carbon steel pipeline runs approximately 7.3 km from the pig launcher in the GGTP to a pig receiver at the northernmost Injection Drill Centre (DC-C). The pipeline transports reservoir CO_2 from the GGTP to the three Injection Drill Centres. Three offtake 'barred-tees' deliver the reservoir CO_2 to the Injection Drill Centres; at each CO_2 Injection Drill Centre, a short riser from the offtake barred tee is above surface and connected to two manually operated isolation valves. These valves allow for the drill centre manifold and well heads to be isolated from the pipeline.

2.1.3 CO_2 Injection Drill Centres

Three CO_2 Injection Drill Centres (DC-A, DC-B and DC-C) receive reservoir CO_2 from the pipeline offtakes. Each drill centre comprises a central manifold connected by flowlines to 'Christmas tree' structures on multiple injection wells. Wellhead and manifold

facilities are surrounded by protective bollards. The locations of the injection drill centres and wells are shown in Figure 1-1.

2.1.4 Surveillance Wells

Two Reservoir Surveillance Wells (A-RS1 and C-RS2, located within DC-A and DC-C respectively) monitor the CO_2 saturation and movement in the injection interval. The Gorgon CO_2 Data Well has been converted to measure pressure in the overlying Barrow Group and also detect microseismic events. The locations of the drill centres are shown in Figure 1-1.

2.1.5 Pressure Management Drill Centres

The Pressure Management Drill Centres (DC-D and DC-E) are more than 4 km west of the nearest Injection Drill Centre (Figure 1-1) and are linked to the injection system via power and fibre-optic communications cables. Each Pressure Management Drill Centre has two water production wells connected by spools to water injection wells that are each capable of pumping up to 3,180 m^3 of formation water, per day. Water production and injection facilities are surrounded by protective bollards.

2.1.6 Utility Power and Fibre-optic Cables

Utility power and fibre-optic communications cables installed along the pipeline ROW enable the monitoring and control of the CO_2 Pipeline and Wells. Cables are located above ground in a utility corridor between the GGTP and a point where the ROW crosses the GGTP ground flare pipeline. From the flare crossing point, the utility power and fibre-optic cables are installed in a common trench with the CO_2 Pipeline at a minimum depth of approximately 750 mm, and then branch off from the main trench to the CO_2 Injection Drill Centres. Cables extend from DC-A to DC-E, and from DC-C to DC-D in a utility corridor that follows the existing road infrastructure (Figure 1-1). In addition, cabling extends from DC-B to the CO_2 Data Well following the existing road infrastructure. Substations are located at the drill centres, with fenced transformers at DC-D and DC-E.

2.1.7 Cathodic Protection

The CO_2 Pipeline and Wells are protected from external corrosion by an impressed current cathodic protection system, comprising up to 12 sacrificial anode ground beds with power provided from the GGTP via the utility power cables (Figure 1-1). Above-ground cathodic protection test posts are installed along the ROW and at the drill centres to allow for inspection (Section 2.4.1).

2.2 Commissioning and Start-up

Commissioning and start-up of the CO_2 Pipeline and Injection Wells involves introducing reservoir CO_2 to the system by opening the isolation valve within the GGTP. If required, commissioning and start-up activities may be supported on site by a small team of field personnel who undertake observations at the drill centres or IMR activities. Information regarding IMR activities and associated vehicle operations is provided in Section 2.5.

2.3 Operations

The principal activity during operations is the steady-state flow of super-critical CO_2 through the pipelines. This flow is monitored and controlled from the Central Control Room (CCR) on Barrow Island.

The CO_2 is disposed of via subsurface injection into the Dupuy Formation. The CO_2 injection system is designed to inject 100% of the reservoir CO_2 recovered from the GTP gas stream processing. The peak design rate for CO_2 injection is 276 MMscf/d; the peak design annualised rate of CO_2 injection is 254 MMscf/d (Note: Actual flow rates

may be lower than these design rates depending on Gorgon Field production performance, facility up-time and the CO_2 injection reservoir performance).

Pressure in the formation is monitored in the injection wells during operations, with pressure management achieved by extracting the brackish water from the Dupuy Formation via the water production wells and reinjecting it via the water injection wells into the overlaying Barrow Group saline aquifer (Flacourt and Malouet Formations), which is geologically isolated from the surface environment.

To support the maintenance of the pressure management wells and interconnecting spools, scale inhibitor is added continuously in low concentrations to the water prior to reinjection. Other treatments that may be added to the water from time-to-time include small quantities of oxygen scavenger and biocide to prevent bacterial degradation of the injection formation.

2.4 Inspections, Maintenance, and Repair

IMR of the CO_2 Injection System is undertaken to ensure integrity of the system is maintained at or above acceptable standards. IMR activities may occur at any time during commissioning, start-up, or operations.

2.4.1 Inspections

Inspections are performed to check the integrity of the CO_2 Pipeline and Wells, and proactively identify maintenance or repair activities that may be required. Inspections may be routine, or may be triggered by specific events (such as cyclones or seismic events) that could affect the infrastructure. Potential inspection techniques include:

- visual inspections
- cathodic protection measurements
- pigging (in-line inspections)
- non-destructive testing.

2.4.2 Maintenance and Repairs

Maintenance and repair activities may need to occur during the operational life of the Gorgon Project to:

- prevent deterioration and/or failure of infrastructure
- maintain reliability and performance of infrastructure.

Repairs to the facilities are not planned activities; therefore, it is difficult to confirm the exact characteristics of a repair in advance (e.g. location, extent, duration).

However, maintenance and repair activities are expected to be rare and infrequent, though the exact frequency of maintenance activities depends on the results of inspections. Such activities may comprise:

- maintenance of the ROW and licence areas
- maintenance of facilities and equipment
- maintenance of cathodic protection systems
- pigging (in-line maintenance/cleaning)
- repairs.

2.5 Vehicles and Equipment

Onshore IMR activities are expected to be undertaken within the Operational Area. Activities are expected to take place during daylight hours; however, some

maintenance (e.g. at the pig receiver station) or urgent repair activities in the Operational Area may also need to occur at night. ROW inspections are expected to be undertaken approximately monthly and involve a small number of personnel and a single light vehicle driving along the ROW for a day.

Vehicles and equipment used for maintenance and repairs are expected to include:

- combination of light vehicles and trailer for personnel transport and support;
- flatbed trucks for transporting excavators, cranes, and other equipment; vacuum trucks; tipper trucks for backfill and/or spoil removal; and a range of hand tools.
- Portable lighting may be used, but only in the highly unlikely event that maintenance and repair activities must be undertaken at night.
- Temporary diesel generators.

3.0 Description of the Environment

The potential extent of the environmental aspects and impacts arising from planned activities during the commissioning, start-up, operation, and IMR of the CO_2 Pipeline and Wells is expected to be limited to the Operational Area (see Section 3.2.4).

However, the potential extent of the environmental aspects and impacts arising from unplanned events or from infrequent and non-routine activities may have a localised effect on the land environment immediately adjacent to the Operational Area, as described and risk assessed in Section 0.

The description of the environment is structured as follows:

- Barrow Island conservation status (Section 3.1)
- the physical environment of Barrow Island (Section 3.2)
- the environment associated with the Operational Area where planned activities occur (Section 3.2.4)
- the environment associated with land adjacent to the Operational Area that may be affected if an unplanned event occurs (Section 0).

3.1 Barrow Island Conservation Status

Barrow Island is reserved under the *Conservation and Land Management Act 1984* (WA) as a Class A Nature Reserve for the purpose of conservation of flora and fauna.

3.2 Physical Environment of Barrow Island

3.2.1 Climate

Barrow Island is characterised by an arid subtropical climate with daytime temperatures ranging from 20 to 34 °C in summer, and from 17 to 26 °C in winter (Ref. 1). Average annual rainfall at Barrow Island is 318 mm with most rain (85%) occurring between January and July (Ref. 1). Rainfall is generally associated with tropical cyclones, which may occur between November and April. Between 1960 and 2003, an average 3.84 cyclones passed within 400 nm of Barrow Island each year (Ref. 2).

3.2.2 Geology, Landform and Soils

The surface geology of Barrow Island generally comprises calcarenite and limestone overlain by alluvium, colluvium, and aeolian sand. Tertiary limestone ridges occur throughout the central upland plateaus of Barrow Island. The terrain ranges from steeper slopes in the west, to flatter, more gentle undulations as the ridges continue east (Ref. 1). Soil types are highly variable, ranging from 'silty clays' and 'clayey loam' textures in western parts of Barrow Island to coarser 'clayey sands', 'sandy loams' and 'sandy clays' dominating towards the east (Ref. 3).

3.2.3 Hydrogeology

The surface hydrology on Barrow Island is characterised by run-off and short-term standing water after rainfall events, high rates of evaporation, and high infiltration capacities of the surface sands and limestone (Ref. 1). The Operational Area traverses several highly seasonal drainage lines, which generally align in a west-east orientation, but does not cross any permanent watercourses (Ref. 1). All watercourses are ephemeral and typically only flow for short periods following high-intensity rainfall, such as that associated with severe storms or cyclones (Ref. 1).

There is one shallow unconfined potentially fresh water aquifer on Barrow Island. This fresh water aquifer forms a lens of relatively fresh groundwater at depths typically between 9 m and 53 m, and floats upon denser, saline groundwater located

predominantly within the Tertiary Limestone (Ref. 2). Although beneficial uses of this fresh water aquifer are limited, it is an important environment for the stygofauna identified on Barrow Island.

Salinity of the water in this lens varies considerably across Barrow Island. Recharge to the aquifer is from rainfall and occurs most rapidly in areas of highly permeable soils overlying porous karst limestone. Lower salinities occur in areas of more rapid groundwater recharge. Higher salinities occur where recharge is slower, generally in areas where clays and silts are overlying the more porous and permeable limestone.

Salinity of the lens is also higher in coastal areas where seawater influx occurs close to the surface of the water-table.

Several saline ground water systems occur on Barrow Island:

- Tertiary Limestone extending from the mean sea level down to approximately 300 m below mean sea level
- Windalia Sand Member of the Muderong Shale, generally at depths between 650 m and 700 m below mean sea level
- the Barrow Group comprising the Flacourt and Malouet Formations and the Flag Sandstone, generally at depths between 1000 m and 2000 m below mean sea level
- the Dupuy Formation, generally at depths between 2000 m and 2300 m below mean sea level
- the Biggada Formation generally at depths greater than 3000 m below mean sea level.

The Dupuy Formation and Barrow Group systems are described in more detail below.

3.2.3.1 Barrow Group Formation

The Barrow Group Formation is an underground saline aquifer situated at depths between 1200 m and 1900 m below the surface; it is divided into three separate formations—the Flacourt Formation, Malouet Formation, and Basal Barrow Group Shale (Figure 3-1). The Flacourt Formation is the proposed receiving interval for the produced Dupuy Formation water in the pressure management system. The Flacourt Formation is a saline aquifer situated at depths approximately 1200 m in true vertical depth. This Formation comprises sandstone-dominated sandstone/shale sets. Of the core data points taken for the Barrow Group Flacourt Formation, high formation quality was exhibited (Ref. 4).

The underlying Malouet Formation also comprises interbedded sands and shales, although the reservoir quality is not as high as the Flacourt. A pressure baffle within the Malouet Formation hydraulically separates the Lower Malouet Formation from the rest of the Barrow Group. This zone is monitored for pressure changes in the Gorgon CO_2 Data Well. At the base of the Barrow Group is the Basal Barrow Group Shale, which is the top seal (cap rock) for the underlying Dupuy Formation, and hence is the seal for the injected reservoir CO_2.

The components of the upper Barrow Group (Flacourt and Upper Malouet Formations) behave as a single, hydraulically connected unit; however, the Barrow Group Formation is hydraulically separated from the shallow unconfined Tertiary Limestone by a thick sequence (more than 1000 m) of low permeability material (Ref. 4). Water quality is highly alkaline and saline (Total Dissolved Solids [TDS] approximately >30 000 mg/L), and contains hydrocarbons. It is generally characterised as containing stable minerals with a very low proportion of soluble metals.

A thick sequence of low permeability material (Muderong Shale and Gearle Siltstone) hydraulically separates the Barrow Group from the surface groundwater aquifer. The shallow unconfined aquifer forms a lens of fresher groundwater floating upon the denser, more saline sea water. Seasonal fluctuations in rainfall and tidal influence affect

this boundary between the fresh and saline water making it a transition zone, rather than a clear boundary (Ref. 5).

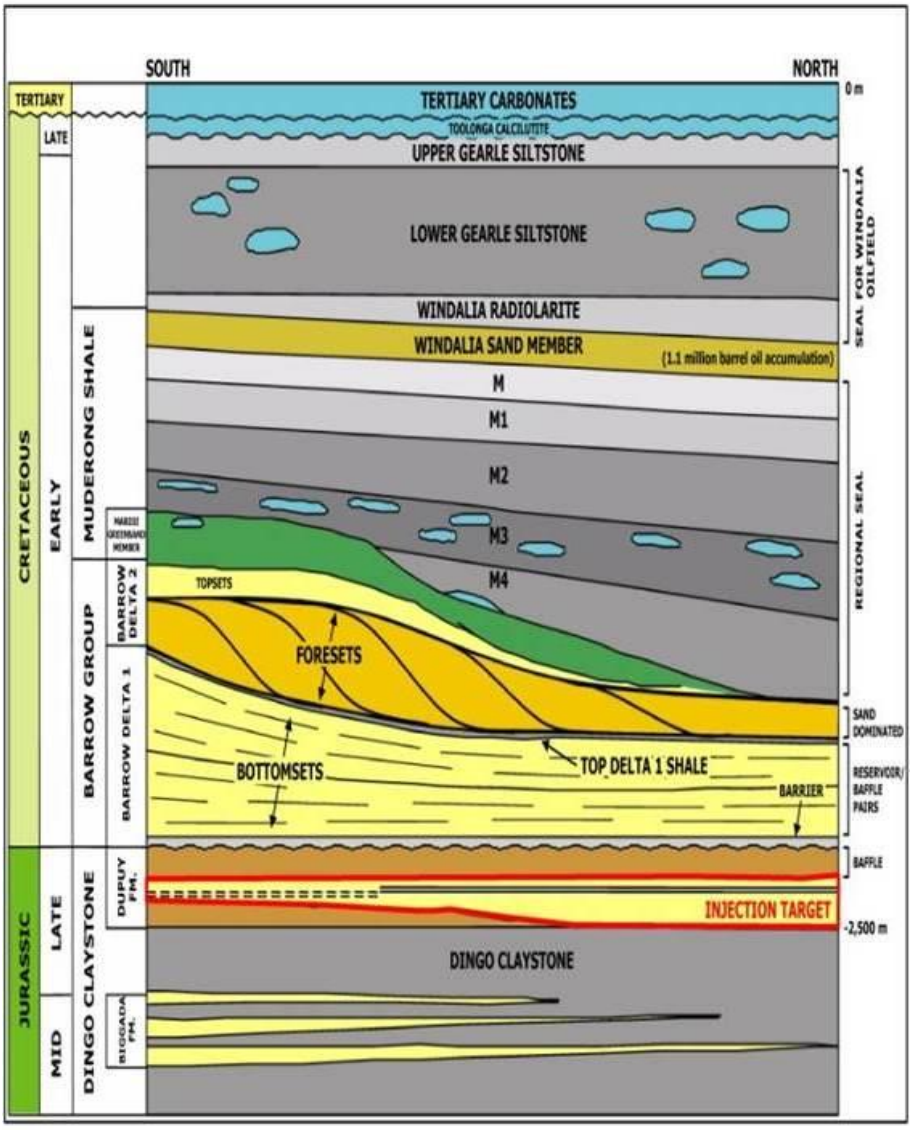

Figure 3-1: Hydrogeological Formations on Barrow Island

3.2.3.2 Dupuy Formation

Water produced from the Dupuy Formation is brackish (approximately 5000–6000 mg/L sodium chloride; 7000–8000 ppm TDS), and may occur at temperatures up to approximately 100 °C upon release (Ref. 6). Trace levels of naturally occurring dissolved hydrocarbons and metals have been identified in the formation water.

3.2.4 Surface water

All drainage lines on Barrow Island are ephemeral and typically only flow for short periods of time following high intensity rainfall such as that associated with storms or cyclones. Operational experience suggests these drainage lines are likely to be inundated between 3-7 days, depending on rainfall.

3.3 Operational Area

The Operational Area comprises land that was cleared and disturbed during construction and installation activities. Consequently, the particular values and sensitivities associated with the Operational Area are limited.

3.3.1 Terrestrial Flora and Vegetation

No particular flora and vegetation values or sensitivities are located within the Operational Area. All flora and vegetation within the Operational Area were cleared during construction. Weed species, including Buffel Grass, have been recorded in various locations on Barrow Island and Chevron Australia has established Weed Hygiene Zones (WHZs) for management purposes, including areas that transect the Operational Area.

3.3.2 Ecological Communities

No Threatened Ecological Community, as listed in the Parks and Wildlife's Threatened Ecological Database (Ref. 7), has been recorded or is known to occur on Barrow Island.

Barrow Island is recognised as being of high conservation significance for subterranean fauna communities, with 19 troglofauna and 63 stygofauna species recorded to date. Ten subterranean fauna species recorded on Barrow Island are listed as specially protected fauna under the *Biodiversity Conservation Act 2016* (WA) and two species, the Blind Gudgeon fish *Milyeringa justitia* (*M. veritas*) and Blind Cave Eel *Ophisternon candidum*, are listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act). Barrow Island subterranean fauna communities are listed by Parks and Wildlife as a Priority 1 Ecological Community ('not adequately defined').

Preliminary geological reviews suggest that strata on Barrow Island (e.g. interbedded sand/limestone) are relatively continuous (Ref. 8), and it is expected that if subterranean fauna occur beneath the Operational Area, it would be of no greater significance to that present elsewhere on Barrow Island. Subterranean fauna is known to exist up to approximately 50 m below ground level. Shallow surface formations and the watertable identified as subterranean fauna habitat are geologically isolated from the deeper formations.

3.3.3 Significant Fauna Habitats

The Operational Area was cleared during construction and does not provide any habitats of particular value or sensitivity.

3.3.4 Terrestrial Fauna

In the absence of fauna habitats of particular value or sensitivity, the Operational Area does not specifically support terrestrial fauna values, although mobile and transient fauna may be encountered in the Operational Area, including mammal, bird, and reptile species.

Four resident mammal species that may be encountered in the Operational Area are listed as specially protected fauna under the *Biodiversity Conservation Act 2016* (WA) or listed as Vulnerable under the EPBC Act. They are Barrow Island Euro *Macropus robustus isabellinus*, Spectacled Hare-wallaby *Lagorchestes conspicillatus conspicillatus*, Barrow Island Golden Bandicoot *Isoodon auratus barrowensis*, and Boodie *Bettongia lesueur*. All these species are widespread across Barrow Island.

Barrow Island supports numerous species of migratory shorebirds as well as resident shorebirds. Many of these species are protected under International treaties (e.g. JAMBA, CAMBA, ROKAMBA). Barrow Island is both a staging site and an important non-breeding site for migratory shorebirds. The highest abundance of shorebirds on Barrow

Island, with over two-thirds of records for most species, is associated with the south-eastern and southern coasts of the Island.

All avifauna with the potential to be encountered in the Operational Area occur widely across Barrow Island. The most common terrestrial avifauna species that have the potential to be encountered are the Spinifex-bird *Eremiornis carteri*, White-winged Fairy-wren (Barrow Island) *Malurus leucopterus edouardi*, Singing Honeyeater *Lichenostomus virescens*, White-breasted Wood Swallow *Artamus leucorhynchus*, and the Welcome Swallow *Hirundo neoxena* (Ref. 1). The White-winged Fairy-wren (Barrow Island) is the only terrestrial bird species on Barrow Island to be listed as Vulnerable under the *Biodiversity Conservation Act 2016* (WA) and the EPBC Act (Ref. 1), but the species is abundant in most habitats on Barrow Island (Ref. 1; Ref. 9) Other listed terrestrial avifauna species with the potential to be encountered in the Operational Area include four vagrant or migratory species protected under international agreements (Oriental Cuckoo *Cuculus saturatus*, Fork-tailed Swift *Apus pacificus*, White-throated Needletail *Hirandapus caudacutus*, and Yellow Wagtail *Motacilla flava*) and the Australian Bustard *Ardeotis australis*, which is listed by Parks and Wildlife as a Priority 4 species ('rare, near-threatened and other species in need of monitoring') (Ref. 1).

Reptile species also have the potential to be encountered in the Operational Area, although all species are abundant and widespread on Barrow Island, and none are listed as threatened under the *Biodiversity Conservation Act 2016* (WA) or the EPBC Act (Ref. 1).

3.3.5 Cultural Heritage

Cultural heritage surveys have not identified any cultural heritage sites or materials within the Operational Area.

3.3.6 Petroleum Activities and Infrastructure

Barrow Island has been actively used for petroleum exploration and production activities since 1957 and access is restricted to personnel associated with the oilfield operations, the Gorgon Gas Development, and Parks and Wildlife staff. Infrastructure associated with the Gorgon Gas Development Project, and the Barrow Island oil field road network traverse the Operational Area and adjacent land.

The Barrow Island oil field extracts crude oil, water and gas from the Windalia, Mardie B, M3, Gearle, Jurassic, Malouet and Tunney Formations on Barrow Island. Formation water for pressure management is extracted from Barrow Group Flacourt Formation, processed then injected into the Windalia Formation. Formation water is re-injected into the Windalia reservoir and also disposed of to the Barrow Group Flacourt Formation.

3.4 Land Adjacent to the Operational Area

In the unlikely event of an unplanned incident, there is the potential to expose the environment outside the defined Operational Area. As such, this area is described in the following subsections.

3.4.1 Terrestrial Flora and Vegetation

The flora and vegetation of Barrow Island, including the land adjacent to the Operational Area, is typical of the arid Pilbara region, and also has floral affinities with the Cape Range area on the mainland in the dominance of *Triodia* hummock grasses and sparse, low-lying *Melaleuca* shrubs (Ref. 10; Ref. 11). No Declared Rare Flora, pursuant to the *Wildlife Conservation Act 1950* (WA), or Threatened Flora species or plant communities listed under the EPBC Act have been recorded anywhere on Barrow Island.

Vegetation associations on land adjacent to the Operational Area are described as seasonal drainage line associations, associations located on flats, limestone hillslope associations, and disturbed limestone slope associations. These associations are generally characterised by varying combinations of *Triodia* grasses and shrub species such as *Melaleuca cardiophylla*, *Acacia* spp., *Hakea lorea*, *Gossypium robinsonii*, and *Petalostylis labicheoides* (Ref. 1; Ref. 12). A hybrid population of *Acacia bivenosa* x *sclerosperma* subsp. *sclerosperma* was found in a drainage line approximately 40 m from the pipeline ROW near DC-B; this population has remained stable and in good condition throughout construction (Ref. 13; Ref. 14).

One Priority 3 ('poorly known') flora species (*Corchorus congener*) listed by Parks and Wildlife has previously been recorded near the Operational Area (Ref. 15; Ref. 16). Priority 3 flora is a non-legislative category aimed to manage plant taxa listed by Parks and Wildlife that are known from only a few collections or sites in WA, that have not been adequately surveyed, but are not considered under imminent threat. *Corchorus congener* is widespread across Barrow Island (Ref. 12) and the land adjacent to the Operational Area is not considered to be of any particular significance to this species.

3.4.2 Ecological Communities

Subterranean fauna communities, supporting species of troglofauna and stygofauna listed under the *Biodiversity Conservation Act 2016* (WA) and EPBC Act (as described in Section 3.3.2) may occur beneath the land adjacent to the Operational Area, but are not expected to be of any greater significance to that present elsewhere on Barrow Island.

On Barrow Island, *Triodia angusta* dominated 'Creekline Vegetation' communities are listed by Parks and Wildlife as a Priority 1 ('poorly known or not adequately defined') Ecological Community. However, the listing of Barrow Island 'Creekline Vegetation' as a Priority Ecological Community (PEC) reflects the level of disturbance as a result of past land use management practices, and the PEC does not include previously disturbed creeklines (Ref. 13). Although some seasonal drainage line vegetation associations adjacent to the Operational Area may comprise similar compositions of plant species to the Creekline Vegetation PEC, the drainage lines are classed as previously disturbed and therefore are not classified as PEC.

3.4.3 Significant Fauna Habitats

Habitats on Barrow Island considered important for their high biodiversity or for supporting protected or rare and endangered fauna include termite mounds and Boodie warrens. Termite mounds occur widely across Barrow Island including on land adjacent to the Operational Area (Ref. 1). Boodie warrens are widely and evenly distributed in low density across Barrow Island. Surveys indicate that the two closest Boodie warrens are approximately 100 m from the Operational Area (Ref. 1).

Vegetation adjacent to the Operational Area may also provide nesting habitat for the White-winged Fairy-wren (Barrow Island), but the species nests in a wide variety of habitats across Barrow Island (Ref. 1; Ref. 9).

Barrow Island drainage lines are considered to be Priority Ecological Communities, however this listing does not extend to drainage lines that have been previously disturbed. Vegetation also slows water flow, which decreases erosion, sediment loss, turbidity at outflows into the ocean, and increases water recharge.

3.4.4 Terrestrial Fauna

Mobile and transient mammals, birds and reptiles, as described in Section 3.3.4, are expected to be present on the land adjacent to the Operational Area, although the land is not expected to be of specific significance to fauna.

3.4.5 Cultural Heritage

Three isolated aboriginal heritage artefacts, comprising stone flakes and fragments, are located within 100 m of the Operational Area (Ref. 17; Ref. 18; Ref. 19; Ref. 20).

3.4.6 Petroleum Activities and Infrastructure

As described in Section 3.3.6, infrastructure associated with the Gorgon Gas Development Project, and the Barrow Island oil field road network traverse land adjacent to the Operational Area.

4.0 Environmental Risk Assessment Methodology

An Environmental Risk Assessment Workshop was undertaken to evaluate impacts and risks arising from the petroleum activities described in Section 2.0. The risk assessment also considered emergency conditions and spill response activities.

The risk assessment was undertaken in accordance with the Chevron Australia Health, Environment, and Safety (HES) Risk Management Process (Ref. 21) and the processes outlined in ISO 31000:2009 Risk Management – Principles and Guidelines and Handbook 203:2012 Managing Environment-related Risk (Ref. 22).

The environmental impact and risk evaluation process comprised these components:

- identification and description of the petroleum activity
- identification of particular environmental values
- identification of relevant aspects
- identification of relevant environmental hazards
- exposure evaluation
- evaluation of impacts and risk
- consequence
- control measures and as low as reasonably practicable (ALARP) evaluation
- likelihood
- quantification of the level of risk
- risk acceptance criteria
- environmental performance objectives, standards, and measurement criteria.

Table 4-1 summarises the environmental impacts, risks, and control measures in place to manage the activity.

Table 4-1: Summary of the Potential Impacts Risks and Control Measures

Source of Environmental Impact or Risk (Hazards)	Potential Environmental Impacts and Risks (Consequences)	Control Measures
Operation of CO_2 Pipelines or Wells has the potential to result in a leak of reservoir CO_2	A release of CO_2 has the potential to result in above-ground impacts such as: • localised asphyxiation hazard to terrestrial fauna if CO_2 settles temporarily in low-lying areas A release of CO_2 has the potential to result in below-ground impacts such as: • localised plant stress impacts from increases in soil CO_2 concentrations • change the physical properties of subsurface formations resulting in impacts to subterranean communities	• Hydrotesting / pressure testing, conducted in accordance with industry standards, is carried out on the CO_2 Pipeline and Wells (completed in the construction phase) • Inspection, monitoring, and maintenance of the CO_2 pipeline ROW and drill centres, aligned with Appendix 1 of the CO_2 Pipeline Inspection, Maintenance and Monitoring Plan (Ref. 23), including but not limited to: ○ scheduled monthly visual inspection of the pipeline ROW and drill centres ○ intelligent pigging (assessment of wall thickness) within two years of start-up ○ Cathodic Protection (CP) Potential Monitoring Survey approximately every 2 years ○ Direct Current Voltage Gradient (DCVG) every 10 years. • A Leak Detection System is in place during operations to detect if the system is leaking • Permit to Work (PTW) system includes a risk assessment that identifies risks associated with onshore excavation activities and includes an approved excavation certificate • Shutdown and venting of the CO_2 Pipeline and Wells is undertaken in accordance with CO_2 Pipeline Isolation Plan (Ref. 24) • Implement the CO_2 Disposal Management Plan (Ref. 25)

Source of Environmental Impact or Risk (Hazards)	Potential Environmental Impacts and Risks (Consequences)	Control Measures
Operation of pressure management wells has the potential to result in a leak of Dupuy Formation water	A release of higher-temperature brackish Dupuy Formation water has the potential to result in localised impacts to seasonal drainage line vegetation, and to underlying stygofauna	• Hydrotesting, conducted in accordance with industry standards, is carried out on the water spool lines (completed in the construction phase) • A monthly visual inspection will be undertaken of the Pressure Management drill centres • Pressure management wells will be equipped with functional flow and pressure meters to provide real-time flow and pressure data to the CCR • Pressure management wells will be fitted with trip shutdown valves and maintained in accordance with the CMMS • The pressure management system will be isolated following a detection of a leak in accordance with the CO2 Isolation Plan (Ref. 24) • Spills will be contained in accordance with Section 3.1 the Gorgon Operations - Procedure for use of Spill Kits Located in Gorgon Operations Areas (Ref. 28) to prevent the spill reaching the natural environment which includes measures such as: ○ Blocking drainage channels and other exit points from the hardstand; ○ Installing earthen (or other) bunds around the perimeter of the hardstand; or ○ Mobilising vacuum trucks to to clean up excess water from the hardstand. • Spills will be cleaned up in accordance with Section 3.1 the Gorgon Operations - Procedure for use of Spill Kits Located in Gorgon Operations Areas (Ref. 28) and will require: ○ Clear definition of the clean-up task; and ○ Execution of site clean-up response.
Excavation within WHZs for inspection and maintenance activities has the potential to spread weeds	Spreading weeds has the potential to change vegetation and ecological community structure, composition, and diversity	• PTW system includes a risk assessment that identifies weed hygiene risks and associated controls for managing vegetation disturbance and excavation activities in WHZs • Quarantine response will be implemented following the detection of a new weed species or proliferation of an existing weed species within the Operational Area, as per the QMS (Ref. 38)

Source of Environmental Impact or Risk (Hazards)	Potential Environmental Impacts and Risks (Consequences)	Control Measures

Transport of chemicals to Pressure Management Drill Centres	A chemical spill has the potential for localised soil contamination and associated impacts to flora and vegetation adjacent to the Operational Area	• Chemical containers (e.g. IBC's) will be stored within the Chemical Injection Skids at the pressure management drill centres
		• Chemical containers (e.g. IBC's) will be secured during transport to the pressure management drill centres
		• A work instruction / Standard Operating Procedure is implemented for lifting bulk fluids from transport vehicles
		• Chemicals selected and assessed in accordance with the Chemical Selection and Use ABU Environmental Performance Standard (Ref. 68)
		• Spills will be contained in accordance with Section 3.1 the Gorgon Operations - Procedure for use of Spill Kits Located in Gorgon Operations Areas (Ref. 28) to prevent the spill reaching the natural environment which will include measures such as:
		  ○ Contain the spread of the spill by using the materials in the spill kit to stop the spread of the spill and control its flow path;
		  ○ Surround the spill with spill booms or socks; or
		  ○ Blocking drainage channels and other exit points from the hardstand.
		Spills will be cleaned up in accordance with Section 3.1 the Gorgon Operations - Procedure for use of Spill Kits Located in Gorgon Operations Areas (Ref. 28) and will require:
		  ○ Clear definition of the clean-up task; and
		  ○ Execution of site clean-up response
		• Vehicles involved in transporting bulk chemical containers / maintenance inspections will contain a spill kit

Excavation for inspection and maintenance activities has the potential to create a trap for terrestrial fauna	Excavations left open overnight have the potential to trap terrestrial fauna, potentially resulting in injury or mortality	• Egress controls and physical barriers will be implemented, where required, in excavations left open overnight • PTW system includes a risk assessment that identifies risks associated with onshore excavation activities
The movement of vehicles within the Operational Area for IMR activities has the potential to create a hazard (vehicle strike) to terrestrial fauna	Fauna death from fauna strike	• In-vehicle Monitoring System to manage vehicle speeds within the ROW • Driver requirements before driving on Barrow Island are met • Trained fauna handler • Any harm or mortality to EPBC Act listed species is reported to the Department of the Environment and Energy

5.0 Management Approach

The implementation strategy in the EMP identifies the systems, practices, and procedures used to ensure the environmental impacts and risks of the activities are continuously reduced to ALARP and the environmental performance outcomes and standards are met. These are predominantly driven through Chevron Australia's Operational Excellence Management System (OEMS).

5.1 Operational Excellence Management System

The implementation strategy of the EMP was developed in line with Chevron Australia's OEMS. Chevron's Operational Excellence Management System is aligned to ISO 14001:2004; Table 5-1lists the key components.

Table 5-1: OEMS Elements Relevant to the Activity

OEMS Element	Element Description	Key Processes Relevant to the Activity
Safe Operations (OE-03)	Operate and maintain facilities to prevent injuries, illness, and incidents	• (OE-03.01.01) ABU HES Risk Management (Ref. 21) • (OE-03.09.01) Marine Safety Reliability and Efficiency – ABU Standardised OE Process (Ref. 31) • (OE-03.06.02) Managing Safe Work – ABU Standardised OE Process (Ref. 32)
Management of Change (OE-04)	Manage both permanent and temporary changes to prevent incidents	• (OE-04.00.01) Management of Change for Facilities and Operations – ABU Standardised OE Process (Ref. 33)
Incident Investigation (OE-09)	Investigate and identify root causes of incidents to reduce or eliminate systemic causes to prevent future incidents	• (OE-09.00.01) Incident Investigation and Reporting – ABU Standardised OE Process (Ref. 34)
Community and Stakeholder Engagement (OE-10)	Reach out to the community and engage in open dialogue to build trust	• (OE-10.00.01) Community and Stakeholder Engagement – ABU Standardised OE Process (Ref. 35)
Compliance Assurance (OE-12)	Verify conformance with OE requirements in applicable company policy and government laws and regulations	• (OE-12.01.19) Compliance Assurance Audit Program ABU Standardised OE Procedure (Ref. 36) • (OE-12.01.18) Compliance Assurance Management of Instances of Potential Noncompliance (Ref. 37)

5.2 Environment Plan Review

Regulation 18 of the Petroleum Pipelines (Environment) Regulations and Condition 7.5 of the Pipeline Licence (PL93) require that Chevron Australia submit a proposed revision of the accepted EMP to the Minister:

- before commencing a new activity
- before any significant modification or change, or a new stage of an existing activity
- before, or as soon as practicable after, any significant new environmental impact or risk occurs, or any significant increase in an existing environmental impact or risk which occurred or is to occur.

Additionally, Regulation 20 of Petroleum Pipelines (Environment) Regulations and Condition 7.6 of PL93 require that Chevron Australia submit a proposed revision of the EMP five years from the date when the EMP is accepted by the Minister.

6.0 Acronyms and Abbreviations

Table 6-1 defines the acronyms and abbreviations used in this document.

Table 6-1: Acronyms and Abbreviations

Acronym/Abbreviation	Definition
°C	Degrees Celsius
ABU	Australian Business Unit
ALARP	As low as reasonably practicable
CCR	Central Control Room
Chevron Australia	Chevron Australia Pty Ltd
CO_2	Carbon dioxide
DC	Drill Centre
EMP	Environment Management Plan
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
GGTP	Gorgon Gas Treatment Plant
GJV	Gorgon Joint Venture
HES	Health, Environment, and Safety
IMR	Inspection, Maintenance, and Repair
ISO	International Organization for Standardization
km	Kilometre
m	Metre
mg/L	Milligrams per litre
mm	Millimetre
nm	Nautical mile
OE	Operational Excellence
OEMS	Operational Excellence Management System
PEC	Priority Ecological Community
PGPA	Policy, Government and Public Affairs
ppm	Parts per million
PTW	Permit to Work
Q1, Q2,etc.	Three-month quarter of a calendar year
ROW	Right-of-Way
TDS	Total Dissolved Solids
WA	Western Australia
WHZ	Weed Hygiene Zone

7.0 References

Ref. No.	Document	Document No.
1.	Chevron Australia. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Terrestrial and Subterranean Environment Monitoring Program.* Perth, Western Australia.	GOR-COP-01696
2.	Chevron Australia. 2008. *Gorgon Gas Development Revised and Expanded Proposal: Public Environmental Review*. Perth, Western Australia.	
3.	Lewis, MM and Grierson, IT. 1990. *Land Units and Soils of Barrow Island.* Roseworthy Agricultural College, South Australia.	
4.	Gibson-Poole, CM. 2009. *Site Characterisation for Geological Storage of Carbon Dioxide: Examples of Potential Sites from the North West Shelf, Australia*. Doctoral dissertation, School of Petroleum, The University of Adelaide. Adelaide, South Australia.	
5.	Chevron Australia. 2015. *Gorgon Project: Liquid Waste Facility and Permanent Waste Disposal Wells Licence*. Perth, Western Australia.	
6.	Baker Petrolite. 2010. *Review of Scale , Corrosion and Production Chemical Risks: Gorgon Dupuy Depressurization Project*. Baker Hughes. BC-3009.	
7.	Department of Parks and Wildlife. *Threatened Ecological Database*. Available online https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities	
8.	Biota Environmental Sciences. 2007. *Barrow Island Gorgon Gas Development: Summary of 2004–2006 Subterranean Fauna Surveys*. Perth, Western Australia.	
9.	Bamford, AR and Moro, D. 2011. Nest Site Selection of the White-winged Fairy-wren *Malurus leucopterus edouardi* on Barrow Island. *Corella*, 35:3, pp. 84–86.	
10.	Trudgen, ME. 1989. *A Report on the Progress of the Regeneration of Vegetation on Areas Disturbed During Oil Production on Barrow Island*. Report prepared for the West Australian Petroleum Pty Ltd. Perth, Western Australia.	
11.	Mattiske Consulting Pty Ltd. 1997. *1996 Assessment of Revegetation on Seismic Lines, Barrow Island*. Perth, Western Australia.	
12.	Astron Environmental Services. 2010. *Gorgon CO_2 Injection Pipeline Flora & Vegetation Survey – April 2010*. Perth, Western Australia.	
13.	Astron Environmental Services. 2014. *Gorgon Project: Astron Environmental Services Barrow Island Targeted Flora Species Monitoring Program 2014 Annual Report*. Perth, Western Australia.	
14.	Astron Environmental Services. 2012. *Barrow Island Targeted Flora Species Monitoring Program – Erythrina vespertilio and Acacia bivenosa x sclerosperma subsp. sclerosperma field visit*. Perth, Western Australia.	
15.	Department of Parks and Wildlife. 2015. *Priority Ecological Communities for Western Australia: Version 22*. Perth, Western Australia.	
16.	Astron Environmental Services. 2010. *Gorgon CO_2 Injection Pipeline Flora & Vegetation Survey April 2010*. Perth, Western Australia.	
17.	Archae-aus Pty Ltd. 2009. *Preliminary Advice of Indigenous Archaeological Heritage Assessment of Proposed Extensions to the Gorgon Project Area, Barrow Island Pilbara, WA*. Perth, Western Australia.	
18.	Archae-aus Pty Ltd. 2010. *The Second Addendum to the report of an Indigenous Archaeological Heritage Assessment of Proposed Greater Gorgon Development on Barrow Island*. Perth, Western Australia.	

Ref. No.	Document	Document No.
19.	Archae-aus Pty Ltd. 2009. *An addendum to the report of an Indigenous Archaeological Heritage Assessment of the Proposed Greater Gorgon Development on Barrow Island*. Perth, Western Australia.	
20.	Wanati Pty Ltd. 2012. *Aboriginal Archaeological Assessment CO_2 Pressure Management Well Locations Barrow Island, Western Australia*. Unpublished reported prepared for Chevron Australia.	
21.	Chevron Australia. *Health, Environment, and Safety (HES) Risk Management Process*. Perth, Western Australia.	OE-03.01.01
22.	Standards Australia/Standards New Zealand. 2009. *ISO 31000:2009 Risk Management – Principles and Guidelines*. Sydney, Australia/Wellington, New Zealand.	
23.	Chevron Australia. *CO_2 Pipeline Inspection, Maintenance and Monitoring Plan*. Perth, Western Australia.	GOR-COP-0043
24.	Chevron Australia. *CO_2 Pipeline Isolation Plan*. Perth, Western Australia.	GOR-1900-PPL-PLN-CVX-00002
25.	Chevron Australia. *Gorgon Project Carbon Dioxide Disposal Management Plan*. Perth, Western Australia.	G1-NT-REPX0001721
26.	Chevron Australia. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Weed Hygiene Common User Procedure*. Perth, Western Australia.	G1-PP-HES-PRC-0016
27.	Chevron Australia. *Chemical Selection and Use ABU Environmental Performance Standard*. Perth, Western Australia.	OE-07.01.104
28.	Chevron Australia. *Gorgon Operations – Procedure for the Use of Spill Kits Located in Gorgon Operation Areas*. Perth, Western Australia.	GOR-COP- 0097
29.	Chevron Australia. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Fauna Handling Common User Procedure*. Perth, Western Australia.	G1-PP-HES-PRC-0009
30.	Chevron Australia. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Traffic Management Common User Procedure*. Perth, Western Australia.	G1-PP-HES-PRC-0010
31.	Chevron Australia. *Marine Safety Reliability and Efficiency – ABU Standardised OE Process*. Perth, Western Australia.	OE-03.09.01
32.	Chevron Australia. *Managing Safe Work (MSW) – ABU Standardised OE Process*. Perth, Western Australia.	OE-03.06.02
33.	Chevron Australia. *Management of Change for Facilities and Operations – ABU Standardised OE Process*. Perth, Western Australia.	OE-04.00.01
34.	Chevron Australia. *Incident Investigation and Reporting – ABU Standardised OE Process*. Perth, Western Australia.	OE-09.00.01
35.	Chevron Australia. *Community and Stakeholder Engagement – ABU Standardised OE Process*. Perth, Western Australia.	OE-10.00.01
36.	Chevron Australia. *Compliance Assurance Audit Program ABU Standardised OE Procedure*. Perth, Western Australia.	OE-12.01.19
37.	Chevron Australia. *Compliance Assurance Management of Instances of Potential Noncompliance*. Perth, Western Australia.	OE-12.01.18
38.	Chevron Australia. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Terrestrial and Marine Quarantine Management System.* Perth, Western Australia.	GOR-COP-01854