Decision Report

Application for Licence

Division 3, Part V *Environmental Protection Act 1986*

Licence Number	L9102/2017/1
Applicant	Chevron Australia Pty Ltd
ACN	086 197 757
File Number	DER2017/001839
Premises	Gorgon LNG Project L007431 Certificate of Title Volume 3158 Folio 477 As defined by the coordinates in Schedule 1 of the Licence
Date of Report	26 July 2018
Status of Report	Final

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1. Definitions of terms and acronyms

In this Decision Report, the terms in Table 1 have the meanings defined.

Table 1: Definitions

Term	Definition
ACN	Australian Company Number
AGRU	acid gas removal unit
aMDEA	activated methyl diethanolamine
AS 1940	Australian Standard AS 1940 – 2004: The storage of flammable and combustible liquids
AS 4323.1	Australian Standard AS 4323.1 – 1995: Stationary source emissions Selection of sampling positions
BOG	Boil off gass
BTEX	Benzene, toluene, ethylbenzene and xylene
Category/ Categories/ Cat.	Categories of Prescribed Premises as set out in Schedule 1 of the EP Regulations
CO_2	Carbon dioxide
CS Act	*Contaminated Sites Act 2003* (WA)
Decision Report	refers to this document.
Delegated Officer	an officer under section 20 of the EP Act.
Department	means the department established under section 35 of the *Public Sector Management Act 1994* and designated as responsible for the administration of Part V, Division 3 of the EP Act.
DWER	Department of Water and Environmental Regulation As of 1 July 2017, the Department of Environment Regulation (DER), the Office of the Environmental Protection Authority (OEPA) and the Department of Water (DoW) amalgamated to form the Department of Water and Environmental Regulation (DWER). DWER was established under section 35 of the *Public Sector Management Act 1994* and is responsible for the administration of the *Environmental Protection Act 1986* along with other legislation.
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986* (WA)
EP Regulations	*Environmental Protection Regulations 1987* (WA)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
Existing Licence	The Licence issued under Part V, Division 3 of the EP Act and in force prior to the commencement of, and during this Review
GTG	Gas turbine generator

Term	Definition
GTP	Gas Treatment Plant
H_2S	Hydrogen sulfide
HCl	Hydrochloric acid
Licence Holder	Chevron Australia Pty Ltd
LNG	liquefied natural gas
m^3	cubic metres
MEG	monoethylene glycol
MRU	mercury removal unit
MS	Ministerial Statement
mtpa	million tonnes per annum
MW	Megawatts
NaOH	Sodium hydroxide
NEPM	National Environmental Protection Measure
NMVOCs	Non-methane VOCs
Noise Regulations	*Environmental Protection (Noise) Regulations 1997* (WA)
NO_2	Nitrogen dioxide
NOx	Oxides of nitrogen
O_3	Ozone
PWD	permanent wastewater disposal
PM	Particulate Matter
PM_{10}	used to describe particulate matter that is smaller than 10 microns (µm) in diameter
Prescribed Premises	has the same meaning given to that term under the EP Act.
Premises	refers to the premises to which this Decision Report applies, as specified at the front of this Decision Report
Primary Activities	as defined in Schedule 2 of the Licence
Risk Event	As described in *Guidance Statement: Risk Assessment*
SOx	Oxides of sulfur
TSEPP	Terrestrial and Subterranean Environment Protection Plan
TSEMP	Terrestrial and Subterranean Environment Monitoring Program

Term	Definition
TWIP	Temporary Wastewater Injection Plant
UDR	*Environmental Protection (Unauthorised Discharges) Regulations 2004* (WA)
µg/m^3	micrograms per cubic metre
µg/L	micrograms per litre
VOCs	Volatile organic compounds
WHO	World Health Organisation
WHRU	waste heat recovery units
WWTP	wastewater treatment plant

2. Purpose and scope of assessment

An application for a licence was submitted by Chevron Australia Pty Ltd (the Applicant) for the Gorgon Liquefied Natural Gas (LNG) Project (Premises). The Premises consists of three LNG processing trains, a domestic gas (DomGas) processing train, and support infrastructure including sewage treatment, power generation, fuel storage and waste management facilities.

The Applicant holds a number of Existing Licenses for the following components of the Premises that are currently operational:

- Gas Treatment Plant (GTP) and utilities consisting of:
    - One LNG processing train (Train 1);
    - LNG and condensate storage facilities;
    - One domestic gas (DomGas) processing train;
    - Gas Turbine Generators (GTG) 1, 2 and 3
    - Janz inlet facilities including slug catchers, Janz and Gorgon Monoethylene Glycol (MEG) regeneration plants, MEG storage tanks and condensate stabiliser;
    - Heating medium heaters;
    - Storage tanks for refrigerant, amine, hydrochloric acid and sodium hydroxide;
    - Boil off gas (BOG) and wet and dry ground flares; and
    - Class 1, 2, 3 and 4 drainage systems;
- Waste concrete storage area;
- Bridging Wastewater Treatment Plant (WWTP);
- Diesel storage facility;
- Liquid waste facility; and
- Waste transfer station.

The following components, which were previously undergoing commissioning, are now entering the operational phase of production:

- LNG Trains 2 and 3;

- GTGs 4 and 5;
- Gorgon inlet facilities;
- Two additional lean-MEG and two rich-MEG storage tanks; and
- Remaining components of the stormwater drainage system (e.g. bunding, hardstands, etc.) associated with Trains 2 and 3.

This application seeks a licence for the entire Premises combining the above new and existing facilities onto a single licence. Existing Licenses will be revoked once the overarching licence is granted.

The Applicant has also applied to carry out minor upgrades on the refrigerant compressor turbines (six in total) within the LNG Trains resulting in a 4% increase in power production.

This Decision Report documents the Delegated Officer's risk assessment of emissions and discharges and determination of the application consistent with the Department of Water and Environmental Regulation's (DWER's) *Guidance Statement: Risks Assessment* and *Guidance Statement: Decision Making* respectively.

2.1 Application details

The Applicant has applied for a licence. Table 2 lists the documents submitted during the assessment process.

Table 2: Documents and information submitted during the assessment process

Document/information description	Date received
Gorgon Project Emissions Verification Report: LNG Trains 1, 2 and 3 and Associated Facilities (W5178/2012/1)	14 August 2017
Application form: Works Approval / Licence / Renewal Amendment / Registration	24 October 2017
Gorgon Project – Application for a Licence to Operate LNG Trains 1 to 3 and their Associated Facilities (Ref: ABU170900173), 20 October 2017	24 October 2017
Chevron's response to DWER's request for further information (Ref: ABU171200551)	15 December 2017

3. Background

The Premises are operated by the Applicant on behalf of a joint venture comprising of the following companies:

- Chevron Australia Pty Ltd;
- Chevron (TAPL) Pty Ltd;
- Shell Development (Australia) Pty Ltd;
- Mobil Australia Resources Company Pty Limited;
- Osaka Gas Gorgon Pty Ltd;
- Tokyo Gas Gorgon Pty Ltd; and
- Chubu Electric Power Gorgon Pty Ltd.

Construction of the Premises commenced in 2009. Due to the size and complexity of the project,

multiple works approvals and licenses have been granted to facilitate staged construction, commissioning and operation of the Premises and supporting infrastructure.

The bridging WWTP, waste transfer station and diesel storage facility were established during the early phase of construction to provide support services for the construction and operation of the Premises. Each facility was considered an independent prescribed premises and was constructed and operated under individual works approvals and licenses (refer to section 5.4.2 for full approvals history).

To accommodate different construction timeframes associated with the Premises, two works approvals were granted for the GTP as summarised in the table below (refer to section 5.4.2 for full approvals history). Separating the approvals allowed for the commencement of early works associated with the stormwater drainage system and LNG and condensate tanks while final design, procurement and approval processes were completed for the LNG trains.

Table 3. Summary of scope of works for works approval issued for the GTP

Works Approval	Scope of works
W4818/2010/1	Granted for the construction of: • LNG and condensate storage facilities; • Liquid Waste Facility; and • Class 1, 2, 3 and 4 stormwater drainage systems.
W5178/2012/1	Granted for the construction of: • LNG Trains 1 to 3 including inlet facilities, condensate stabiliser, acid gas removal units (AGRU) and refrigerant compressors; • DomGas Train; and • Utilities including GTGs 1-5, heating medium heaters; storage of dangerous goods (e.g. refrigerant).

Commissioning plans were developed under Works Approvals W4818/2010/1 and W5178/2012/1 for each stage of the GTP requiring commissioning. Commencement of commissioning occurred following the submission of construction compliance documentation and was undertaken in accordance with the relevant commissioning plan.

The liquid waste facility, which receives liquid waste streams from the GTP for disposal via deep injection wells (permanent disposal wells), was first to be commissioned and operated. Operation of the liquid waste facility was required to facilitate commissioning of the LNG trains which generated liquid wastes requiring disposal via deep well injection. Licence L8894/2015/1 was granted in October 2015 for the operation of the liquid waste facility to coincide with the commencement of commissioning of LNG Train 1. LNG Train 1 consists of:

- LNG Train 1 including Janz inlet facilities, condensate stabiliser, AGRU Train 1 and refrigerant compressors;
- LNG and condensate storage facilities;
- DomGas train;
- Utilities including GTGs 1 to 3 and heating medium heaters;
- Dangerous goods (e.g. refrigerant) storage;
- BOG, wet and dry flares; and
- Class 1, 2, 3 and 4 stormwater drainage systems (associated with the above infrastructure).

During commissioning of LNG Train 1, the Applicant was required to undertake emissions verification testing to verify emissions assessed in the works approval. The Applicant submitted an Emissions Verification Report following commissioning of LNG Train 1 on 19 April 2016. Licence L8952/2016/1 was granted for the operation of LNG Train 1 in July 2016.

LNG Trains 2 and 3, Gorgon inlet facilities and GTGs 4 and 5 were the final components to undergo commissioning. A final Emissions Verification Report capturing emissions from all three LNG trains was submitted on 14 August 2017 (further information provided in section 6.4).

This Application relates to the operation of LNG Trains 2 and 3 (including Gorgon inlet facilities, GTG 4 and GTG 5) as well as consolidating the Existing Licenses for all the above infrastructure onto a single licence. Table 4 lists the prescribed premises categories that have been applied for.

Table 4: Prescribed premises categories

Classification of Premises	Description	Premises production or design capacity or throughput
Category 10	Oil or gas production from well: premises, whether on land or offshore, on which crude oil, natural gas or condensate is extracted from below the surface of the land or the seabed, as the case requires, and is treated or separated to produce stabilised crude oil, purified natural gas or liquefied hydrocarbon gases.	LNG: 18 million tonnes per annual period[1] DomGas: 300 TJ/day Condensate: 1 million tonnes per annual period
Category 34	Oil or gas refining: premises on which crude oil, condensate or gas is refined or processed.	
Category 52	Electrical power generation: premises (other than premises within category 53 or an emergency or standby power generating plant) on which electrical power is generated using a fuel.	584.5 MW
Category 54	Sewage facility: premises — (a) on which sewage is treated (excluding septic tanks); or (b) from which treated sewage is discharged onto land or waters.	1,385 m^3/day
Category 62	Solid waste depot: premises on which waste is stored, or sorted, pending final disposal or re-use.	240,000 tonnes of stockpiled concrete waste per annual period 52,050 tonnes of other solid waste per annual period
Category 73	Bulk storage of chemicals, etc.: premises on which acids, alkalis or chemicals that – (a) contain at least one carbon to carbon bond; and (b) are liquid at STP (standard temperature and pressure), are stored.	1,090 m^3

Note 1: The plant has a nameplate design throughput of 15.6mtpa although is capable of achieving a higher production rate than this. The estimated maximum annual production throughput is 18mtpa and is based on maximum daily rates experienced and assumes plant operation of 342 day per year.

To facilitate construction and operational timeframes, Chevron previously held multiple licenses for the various components of the Gorgon Project. Each Prescribed Premises was considered a stand-alone premises for the purposes of meeting the category descriptions under Schedule

1 of the *Environmental Protection Regulations 1987*. The Liquid Waste Facility was previously licensed under Category 61 – Liquid Waste Facility as it met the category description of '*premises on which liquid waste produced on other premises….is stored, reprocessed, treated or irrigated*' as it received waste from the other licensed premises. As the facilities have been combined onto a single Premises (this Licence), Category 61 no longer applies as liquid waste is no longer received from other premises.

Compressor turbine upgrade:

The Applicant has also applied to undertake minor upgrades on the Frame 7 Gas Turbines (GTs) that drive the refrigerant compressors (six in total). The Applicant has indicated that the upgrade involves '*modifications to the turbine hardware and logic control, which will result in a change to the firing temperature*' and an increase in power production of 4%. Upgrades will be undertaken in a staged manner as follows:

- Train 1 GTs (two in total) – April 2019;
- Train 2 GTs (two in total) – April 2020; and
- Train 3 GTs (two in total) – April 2021.

4. Overview of Premises

4.1 Operational aspects

The Premises are located on Barrow Island; an A-Class Nature Reserve (Crown Reserve 11648) situated 85 km north-west of Onslow. Natural gas is extracted from the Gorgon and Jansz-Io gas fields (situated 65 and 130 km off the west coast of the island) and transported to the GTP on Barrow Island for processing. The GTP produces LNG via three LNG processing trains with a maximum annual throughput of 18 mtpa (15.6 mtpa nameplate design throughput). Lesser amounts of condensate and DomGas are also produced. A summary of the LNG process is shown in Figure 1 and described below.

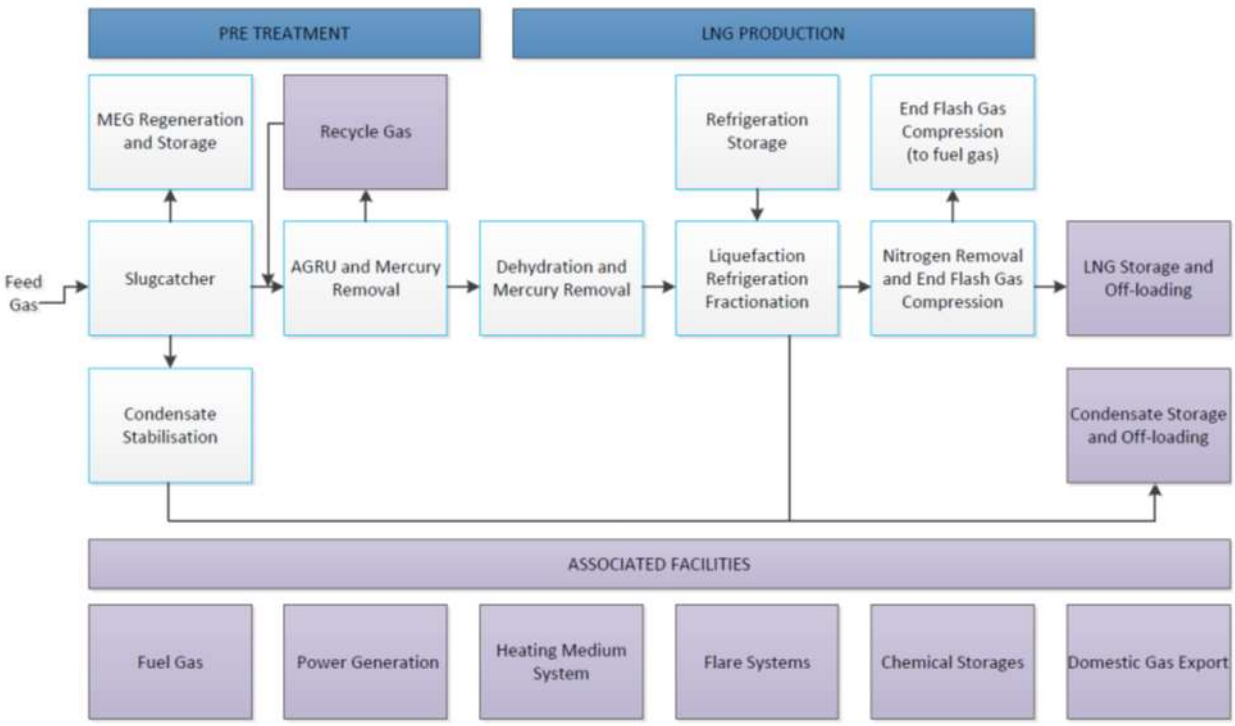

Figure 1: LNG process

Inlet Processing, MEG Regeneration, and Condensate Stabilisation

Jansz-Io and Gorgon feed gas arrives at the inlet processing facility slug catchers, which segregates incoming fluids into three phases (gas, condensate and aqueous) and provides steady flow rates to the downstream units.

The majority of the gas phase is sent to an AGRU for continuation through to the LNG trains; and a portion is sent to the DomGas plant for processing. The MEG / Joule-Thomson process is used to ensure that DomGas meets pipeline moisture and hydrocarbon dew point specifications prior to being exported via a dedicated pipeline to the Dampier to Bunbury Natural Gas Pipeline on the mainland.

The condensate phase is sent to a condensate stabilisation unit where light hydrocarbons are stripped out to produce condensate. This is combined with condensate from the fractionation unit and then stored in the condensate tanks for shipment.

The aqueous phase is sent to a MEG regeneration unit, which regenerates the rich-MEG by removing water and salts. Recovered lean-MEG is returned to the production wellheads by dedicated MEG utility pipelines. The MEG is reused to inhibit hydrate formation in pipelines.

Acid gas removal and carbon dioxide (CO_2) compression and injection

The gas phase stream from the slug catcher and the condensate stabilisation unit is routed to the three AGRUs for CO_2 and hydrogen sulfide (H_2S) (collectively termed acid gas) removal using proprietary aMDEA technology. Acid gas is removed from the feed gas to prevent it from freezing at low temperatures in the cryogenic section of the GTP.

The AGRU is made up of three systems:

- A mercury removal unit (MRU) to remove mercury from the gas stream;
- Absorber system, which is designed to remove CO_2 and H_2S from the gas by absorption into an aMDEA solvent; and
- Regenerator system, which is designed to regenerate the aMDEA solvent for reuse by separating it from the acid gas components following absorption.

For additional liquid recovery, there is a series of inter-stage compressors, knockout drums, and coolers which recover liquids and re-route them back to the AGRU train. This enables additional resource recovery and efficiency.

Dehydration and mercury removal

The dehydration unit removes process water from the treated gas via a molecular sieve after it has been through the AGRUs. Another MRU removes the remaining mercury prior to the gas entering the LNG train to prevent corrosion of the heat exchanger tubes in the main cryogenic heat exchangers.

Liquefaction, Fractionation and Refrigerant Make-Up

Heavy hydrocarbons, which can freeze out in the main cryogenic heat exchangers, are removed prior to liquefaction. The dry treated gas is pre-cooled and fed to a scrub column, which removes the heavy hydrocarbons and aromatic compounds. This also recovers lighter components such as methane, ethane, propane and butane, which are returned to the process and used in refrigerant make-up.

Liquefaction is the main component of the LNG train. Using large gas turbines and a series of cryogenic heat exchangers, liquefaction chills the natural gas to a temperature at which LNG can be produced (-160 °C). The LNG train has refrigeration compressors driven by Frame 7 GTs supplemented with power from electric helper motors. The refrigeration used to liquefy the natural gas into LNG is a mixture of nitrogen, methane, ethane, and propane, known as mixed refrigerant.

Nitrogen Removal and End Flash Gas Compression

The LNG is further cooled in a nitrogen column reboiler and flashed off in the top of the nitrogen rejection column. The LNG product is then pumped to LNG tanks and the flash gas sent to the end flash gas compressor where it is compressed to the pressure required by the high-pressure fuel gas system.

LNG tanks

Two fully contained double-walled LNG tanks, each with a working capacity of 180,000 m^3, provide storage of LNG during continuous production while enabling intermittent exports by LNG carriers. The BOG generated from the LNG tanks is collected, compressed and returned to the high-pressure fuel gas system inside the LNG trains.

Condensate tanks

Four 38,000 m^3 condensate tanks are located within two separate bunded areas in the eastern section of the GTP. The tanks receive condensate from the condensate stabilisation units and the fractionation units in the LNG trains.

Periodic loading of condensate tankers occurs via a load-out line that runs along the materials offloading facility (MOF) and LNG jetty and terminates at two condensate loading arms at the loading platform.

LNG loading

The head of the LNG jetty, located approximately 4 km offshore from the GTP at Town Point, provides two LNG carrier berths. Each of these berths is equipped with four loading arms (two liquid, one hybrid (liquid and vapour), and one vapour return). The BOG generated during the loading of LNG carriers is diverted back down the jetty and MOF via a vapour return arm and the vapour return line to be compressed and recycled as feed gas to the AGRUs. A BOG flare is provided to allow safe disposal of BOG in the event of compressor failure or warm LNG carrier de-inerting.

Pressure relief / liquids disposal, flare, and vent systems

The flaring system is separated into three systems:

- One wet flare - wet, heavy hydrocarbons that contain water or vapour;
- One dry flare - light, dry, potentially cold hydrocarbons to prevent hydrate formation, freezing or condensation; and
- Two BOG flares.

Both the wet and dry systems consist of collection header systems for vapour and liquids, a knockout drum, and a staged ground flare. No liquid burners are installed. The wet and dry ground flares have been constructed as linear relief enclosed ground flares using a series of staging valves which open progressively, depending on the volume of gas being flared. Each stage feeds a number of runners, each runner having a number of flare tips.

The ground flares maximise the availability of pilots and their igniters to ensure combustion of the flared gas. Pilots and igniters are duplicated, and two pilots are provided for each runner. The ground flares are enclosed within a fence.

The BOG system consists of two low-pressure flares (one operational, one spare) located in the vicinity of the LNG tanks.

The design of the plant is such that no flaring should occur during standard operations other than flare pilots and purged gas.

Fuel gas and recycle gas systems

This system provides fuel gas throughout the GTP and returns low-pressure gas (unsuitable for

use as fuel gas) to the process for treatment. The system comprises of:

- High pressure fuel gas in each train to supply fuel to the refrigerant gas turbines;
- High pressure fuel gas system in the utility section to supply the GTGs;
- High pressure fuel gas let-down to separate low-pressure fuel gas and supply fuel gas to the heating medium heaters and pilot/purge gas for the flare systems; and
- Recycle gas system to compress low-pressure flash gas from the AGRUs that is unsuitable for use as fuel gas, back into the process for further treatment.

Heating medium system

Waste heat is recovered from the Frame 7 GT exhausts in waste heat recovery units (WHRU) and sent to heat consumers around the GTP, including the inlet gas heating, AGRU re-boilers, and MEG regeneration package. The system is a closed hot demineralised water recirculating system.

In the event that the Frame 7 GTs are offline or when duty heat from the WHRUs is not sufficient to meet demand, heating medium heaters provide the backup system and the required process heat.

Liquid waste facility

Various liquid waste streams generated from the GTP are directed to the liquid waste facility where they are combined in disposal water tanks prior to disposal via deep well injection. Two deep injection wells (permanent wastewater disposal (PWD) wells) have been nominated for the injection of wastewater located approximately 630 m south of the GTP. Disposal through the deep injection wells is into the isolated Flacourt Formation (part of the Barrow Group), located 1,000 m plus below ground. Secondary disposal wells (temporary wastewater injection plant (TWIP)), located 6 km west of the GTP can also be used to dispose of wastewater.

The major source of wastewater is produced water from the Gorgon and Jansz gas fields. Other wastes include process water streams originating from within the GTP (e.g. wash down water) and contaminated stormwater from the stormwater drainage network.

Treated sewage from the bridging WWTP is also directed to the PDW and TWIP, although this waste is discharged directly down-well, bypassing the liquid waste facility.

4.2 Infrastructure

The Premises infrastructure, as it relates to Category 10, 34, 52, 54, 62 and 73 activities, is detailed in Table 5 and with reference to the Site Plan (attached in the Licence).

Table 5 lists infrastructure associated with each prescribed premises category.

Table 5: Gorgon LNG Project infrastructure

	Infrastructure	**Site Plan Reference[1]**
	Prescribed Activity Categories 10 and 34	
Gas from the Gorgon and Janz-Lo gas fields is transported to Barrow Island to produce LNG and DomGas via 3 LNG trains and 1 DomGas train. Condensate is also produced. LNG and condensate is exported via ship while DomGas is piped to the mainland for distribution to the Dampier to Bunbury Natural Gas Pipeline.		
1	3 x LNG trains	1A, 1B, 1C
2	3 x AGRUs	2A, 2B, 2C

	Infrastructure	Site Plan Reference[1]
3	Janz and Gorgon inlet processing units consisting of separate slug catchers and condensate stabiliser units	3A, 3B
4	Janz and Gorgon MEG regeneration plants	4A, 4B
5	4 x 2,403 m^3 lean-MEG storage tanks	5
6	4 x 4,719 m^3 rich-MEG storage tanks	6
7	2 x 180,000 m^3 LNG storage tanks	7A, 7B
8	4 x 38,000 m^3 condensate storage tanks	8A, 8B, 8C, 8D
9	Wet and dry ground flares	9
10	2 x elevated BOG flares	10A, 10B
11	Heating medium heaters	11
12	DomGas Plant	12
13	602 m^3 ethane refrigerant storage tanks	13
14	2,443 m^3 propane refrigerant storage tank	14
15	2,792m^3 aMDEA storage tank	15
16	319m^3 hydrochloric acid injection tank	16
17	319m^3 sodium hydroxide storage tank	17
	Prescribed Activity Category 52	
Electrical power is provided by five Frame 9 GTGs, which provide 584.5 MW (maximum plant capacity) of power for the GTP as well as the administration area, construction village, and other ancillary demands.		
18	5 x Frame 9 GTGs	18A, 18B, 18C,18D, 18E
	Prescribed Activity Category 54	
The bridging WWTP treats sewage wastewater from the GTP, accommodation village, and other support facilities and has a design capacity of 1,385 m^3/day. The primary disposal method for treated water is via deep well injection however it can be reused for dust suppression.		
19	3 x membrane bioreactor treatment trains	19
20	2 x equalisation tanks	20
21	Aerobic digester tank with two sludge centrifuges	21
22	2 x treated effluent tanks	22
	Prescribed Activity Category 62	

	Infrastructure	Site Plan Reference[1]
The waste transfer station is the primary reception point for solid waste and liquid waste generated on the Premises and other facilities associated with other Chevron operations on Barrow Island. Waste is sorted and consolidated prior to removal from the island to the mainland. A separate site is located at the GTP for the storage of waste concrete.		
23	General sorting and unloading area	23
24	Waste sorting and bailing area	24
25	Putrescible waste sorting and compacting area including two rotary food waste dryers	25
26	Vehicle wash-down area	26
27	Oily water treatment system	27
28	Container and skip bin storage area	28
29	Dangerous goods storage area	29
30	Bunded waste storage area	30
31	Waste concrete storage area at the GTP	31
	Prescribed Activity Category 73	
Diesel fuel supplies fuel for vehicles		
32	7 x 110 m^3 diesel fuel tanks	32
33	2 x 160 m^3 diesel fuel tanks	32
	Directly related activities	
Contaminated wastewater from various waste streams, including process wastewater and contaminated stormwater, is directed to the Liquid Waste Facility for disposal via deep well injection		
34	Liquid waste facility including disposal water tanks	33
35	Permanent disposal wells	34
36	Temporary wastewater injection plant	35
	Other activities	
37	Stormwater drainage system including stormwater holding pond, oily water sump and discharge point	36

Note 1: Refer to Figure 2

4.3 Exclusions to the Premises

The primary method of disposing of CO_2 waste gas from the AGRUs will be via carbon sequestration whereby CO_2 is injected underground into the Dupuy Formation. This application does not include the CO_2 compression and injection system as the infrastructure has not yet been successfully commissioned.

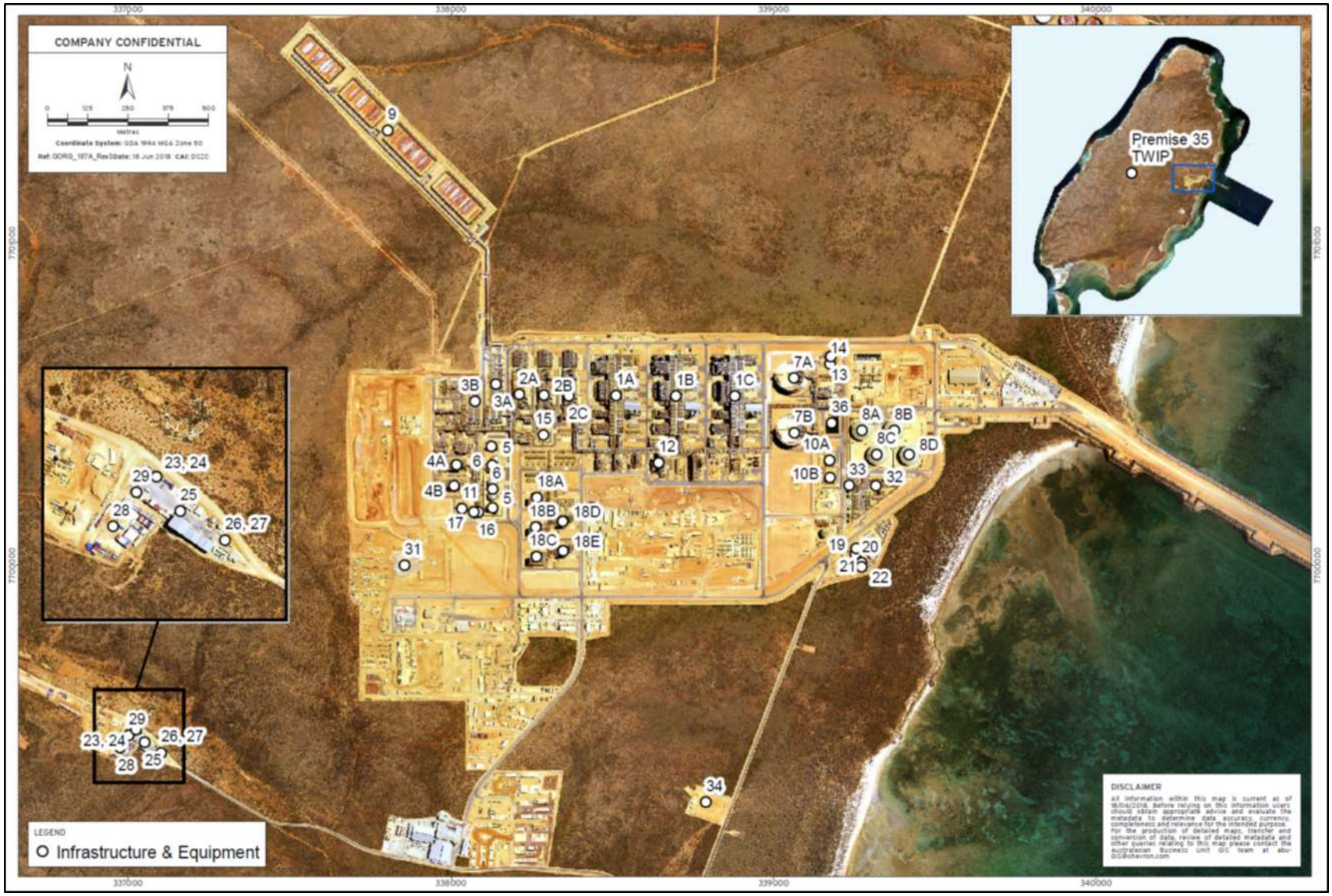

Figure 2: Site Plan

5. Legislative context

Table 6 summarises approvals relevant to the assessment.

Table 6: Relevant approvals and tenure

Legislation	Number	Subsidiary	Approval
Environment Protection and Biodiversity Conservation Act 1999 (Cth)	EPBC 2008/4178	Chevron Australia Pty Ltd	Conditional approval was issued for the initial two train Gorgon LNG Project on 2 October 2007 (EPBC 2013/1294). Approval for the expanded Gorgon LNG Project was issued on 26 August 2009 (EPBC 20084178). See section 5.3.3.
Barrow Island Act 2003 *Land Administration Act 1997*	L007431 Volume 3158; Folio 477		The *Barrow Island Act 2003* (BW Act) and the Gorgon Gas Processing and Infrastructure Project Agreement (Schedule 1 to the BW Act) allows for the implementation of the Gorgon Gas Development and makes provision for land within the Barrow Island Nature Reserve to be used for gas processing purposes under the *Land Administration Act 1997*.
Dangerous Goods Safety Act 2004	Dangerous Goods Licence DGS021356		The licence covers the storage of hydrocarbons and all utilities associated with the primary activities.
Part IV of the EP Act (WA)	Ministerial Statement Number 800 (MS 800) EPA Reports 1221 and 1323		Refer to section 5.1 below

5.1 Part IV of the EP Act

5.1.1 Background

The initial Gorgon Gas Development (two LNG trains) was subject to assessment under Part IV of the EP Act. Approval was granted on 6 September 2007 subject to conditions outlined in Ministerial Statement 748 (MS 748).

In September 2008, the Applicant sought both State and Commonwealth approval through a Public Environment Review (PER) assessment process for the revised and expanded Gorgon Gas Development, as outlined below:

- Addition of a 5 mtpa LNG train, increasing the number of LNG trains from two to three;
- Expansion of the CO_2 injection system, increasing the number of injection wells and surface drill locations; and
- Extension of the causeway and the MOF into deeper water.

The revised and expanded Gorgon Gas Development was approved on 10 August 2009 (MS 800). MS 800 superseded MS 748 for the initial proposal, providing approval for both the initial Gorgon Gas Development and the revised and expanded Gorgon Gas Development.

The Applicant applied for a section change to MS 800 to relocate the ground flares in March 2011. This was determined to not be a significant change and no assessment was necessary.

Since the revised and expanded Gorgon Gas Development was approved, further minor changes have also been made and/or approved and updates to MS 800 made as necessary.

5.1.2 Ministerial Statement 800

MS 800 contains conditions that need to be considered in the assessment of emissions and discharge from the Premises and the imposition of regulatory controls. These are summarised in the following table:

Table 7: Consideration of MS 800 conditions relevant to this application

Condition	Overview	Delegate Officer considerations
7	A Terrestrial and Subterranean Environmental Protection Plan (TSEPP) outlines management measures, including design commitments, to control potential impacts to the terrestrial and subterranean environment. The objectives of the plan are '*to reduce the adverse impacts from the construction and operation of the terrestrial facilities as far as practicable and to ensure that construction and operation of the terrestrial facilities does not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint, including below the surface of the land*.'	The Delegated Officer has determined that where infrastructure controls are required for environmental impacts associated with discharges to ground (e.g. stormwater) these will not be duplicated in the licence.
8	Condition 8 requires the submission of a Terrestrial and Subterranean Environmental Monitoring Program (TSEMP). The objective of the TSEMP is to '*establish a statistically valid ecological monitoring program to detect any Material or Serious Environmental Harm to the ecological elements outside the Terrestrial Disturbance Footprint'*. The TSEMP specifies procedures for monitoring vegetation, fauna (mammals and land birds), surface water landforms and groundwater, including monitoring locations, triggers and reporting.	Environmental monitoring programs described in the TSEMP have been considered in the determination of risk associated with potential emissions and discharges; however, conditions relating to environmental monitoring (e.g. groundwater monitoring) will not be included on the licence to avoid duplication.
16	A Long-term Marine Turtle Management Plan was developed in accordance with condition 16 and specifies commitments to minimise lighting and noise as far as practicable through design and operation to prevent impact on marine turtles. Procedures for monitoring lighting and impacts on turtle populations are also included.	The primary instrument for regulating the impacts on marine turtles from light and noise emissions is MS 800 and the Long-term Marine Turtle Management Plan.

Condition	Overview	Delegate Officer considerations
26	Condition 26 sets requirements for the injection of CO_2 to an underground reservoir. The condition specifies that all practicable means shall be implemented to inject reservoir carbon dioxide removed during gas processing operations on Barrow Island and that at least 80% of reservoir carbon dioxide that would otherwise be vented to atmosphere is injected (based on a 5 year rolling average).	The project is designed to dispose of 100% of CO_2 via the re-injection system. However, during LNG Train 1 operation, which processes only Jansz–Io feed gas, the acid gas from the AGRU was vented to atmosphere. Following the introduction of Gorgon feed gas when Trains 2 and 3 came online, it was intended that all acid gas would be compressed and directed to the injection system. The construction and commissioning of carbon dioxide compression and injection infrastructure is not complete. Until this equipment is operational (estimated Q4 2018), it is proposed that all acid gas (including CO_2) is vented directly to atmosphere. Potential impacts of acid gas venting have been assessed and regulatory controls applied as necessary. However, approval to vent acid gas resulting in non-compliance with the 80% injection target is regulated under Part IV of the EP Act.
28	Condition 28 specifies that a Best Practice Pollution Control Design Report was required to be submitted as part of the Works Approval application for the Gorgon LNG Project. The purpose of the report is to demonstrate best practice pollution control would be implemented for the Gas Treatment Plant.	Commitments made in in accordance with conditions 28 and 29 of MS 800 will be considered as part of this Decision Report noting that the Air Quality Management Plan includes emission targets for major point sources (GTGs and GTs) and ambient air quality monitoring. Advice in EPA Report 1323 (Appendix 3) recommends that emissions to air (specifically NOx, O_3, SO_2 and PM_{10}) are adequately controlled under Part V of the EP Act.
29	An Air Quality Management Plan was developed under condition 29. The purpose of the Air Quality Management Plan is to ensure that air quality meets appropriate standards for the protection of human health and does not cause environmental harm to flora and fauna on the island. Monitoring programs for ambient air quality and point source emissions, along with committed targets, are specified in the plan.	
30	The Solid and Liquid Waste Management Plan has been developed and implemented under condition 30. The objective of the Plan is to '*to ensure all proposal-related solid and liquid wastes are either removed from Barrow Island or, if not, that all practicable means are used to ensure that waste disposal does not cause Material or Serious Environmental Harm to Barrow Island and its surrounding waters'*. The plan provides high level management strategies for prevent environmental harm associated with the generation and disposal of solid and liquid waste.	Commitments made in the plan will be considered as part of this Decision Report noting that the plan makes reference to licenses as a regulatory instrument for injection of liquid waste via deep well disposal and discharge of liquid waste to the terrestrial environment.

Key Findings: The Delegated Officer notes that there is potential for regulatory duplication between Part IV and Part V of the EP Act. In setting regulatory controls, the Delegated Officer will consider commitments made in the above documents and avoid duplication in licence conditions. Where emissions and discharges have been assessed in this Decision Report, the scope of these plans has been reviewed to identify regulatory duplication. Where it is identified that the relevant management plan does not adequately regulate the environmental risk, it may be regulated under Part V of the EP Act.

5.2 Contaminated sites

Barrow Island Nature Reserve (BINR) is currently registered under the CS Act as *Contaminated – remediation required*. There are a number of areas on the BINR where contamination exists as a result of existing infrastructure, most significantly the terminal tank facility (operated as part of the Barrow Island Oil & Gas Processing Facility) located 1 km north of the Premises.

5.3 Other relevant approvals

5.3.1 Planning approvals

The BW Act provides for a long term lease (60 years to 2069) for the GTP and ancillary components.

Key Findings: The Delegated Officer has determined that the Applicant holds relevant tenure over the Premises until 2069 and that, in consideration of the risk assessment, the Licence duration can be set for 20 years in accordance with *Guidance Statement: Licence Duration*.

5.3.2 Department of Mines, Industry Regulation and Safety

The Premises includes infrastructure for the storage and processing of chemicals. The premises is considered a Major Hazard Facility and is subject to the requirements of the *Dangerous Good Safety (Major Hazard Facilities) Regulations 2007*.

Dangerous goods licenses for the storage of dangerous goods have been obtained (DGS021356) under the *Dangerous Goods Safety Act 2004.*

5.3.3 *Environment Protection and Biodiversity Conservation Act 1999* (Cth)

The initial Gorgon Gas Development was approved by the Commonwealth Minister for the Environment and Water Resources on 3 October 2007 (Reference 2003/1294). On 26 August 2009, the Commonwealth Minister for the Environment, Heritage and the Arts issued approval for the revised and expanded Gorgon Gas Development (Reference: 2008/4178) and varied the conditions for the initial Gorgon Gas Development (Reference: 2003/1294).

Conditions imposed under the EPBC Act complement those imposed under Part IV of the EP Act relating to:

- Protection of the terrestrial and subterranean environment;
- Quarantine management;
- Fire management;
- Management of groundwater abstraction;
- Impacts associated with dredging, horizontal directional drilling and offshore pipeline installation;

- Impacts on turtles; and
- Solid and liquid waste management.

Conditions associated with CO_2 injection relate specifically to monitoring potential impacts to the Blind Gudgeon (*Milyeringa verita*); a small subterranean fish.

5.4 Part V of the EP Act

5.4.1 Applicable regulations, standards and guidelines

The overarching legislative framework of this assessment is the EP Act and EP Regulations. The guidance statements which inform this assessment are:

- *Guidance Statement: Regulatory Principles (July 2015)*
- *Guidance Statement: Setting Conditions (October 2015)*
- *Guidance Statement: Licence Duration (August 2016)*
- *Guidance Statement: Publication of Annual Audit Compliance Reports (May 2016)*
- *Guidance Statement: Environmental Siting (November 2016)*
- *Guidance Statement: Decision Making (February 2017)*
- *Guidance Statement: Risk Assessments (February 2017)*

5.4.2 Works approval and licence history

Table 8 summarises the works approval and licence history for the premises.

Table 8: Works approval and licence history

Instrument	Issued	Nature and extent of works approval, licence or amendment
GTP		
W5178/2012/1	23/08/2012	New works approval for the construction of the Gorgon Gas Project LNG (Trains 1 to 3), DomGas processing trains and support infrastructure such as GTGs and flares.
	06/02/2015	Works approval amendment for the installation of additional mercury removal units, liquid mercury draw-off stations and slug catcher solids removal systems for managing higher than anticipated quantities of mercury in the feed gas.
	14/07/2016	Works approval amendment to extend the duration of the works approval to allow commissioning to be completed and to remove regulatory duplication of environmental risk associated with lighting.
W4818/2010/1	05/05/2014	New works approval for the construction of the LNG and condensate storage tanks, liquid waste facility and stormwater drainage system.
	10/04/2014	Works approval amendment to extend the duration of the works approval to allow completion of construction and commissioning.
	22/06/2016	Works approval amendment to extend the duration of the works approval to allow construction and commissioning to be completed and remove regulatory duplication of environmental risk associated with lighting.
L8952/2016/1	14/07/2016	New licence for the operation of the Gorgon Gas Project (Train 1) and support infrastructure including DomGas processing and LNG and condensate storage.

Instrument	Issued	Nature and extent of works approval, licence or amendment
	16/02/2017	Licence amendment to include Category 62 (solid waste depot) for the storage of waste concrete at the GTP site.
L8894/2015/1	15/10/2015	New licence for the operation of the liquid waste facility.
Waste transfer station		
W4827/2010/1	12/05/2011	New works approval for the construction of the Barrow Island waste transfer station (Stages 1 and 2).
	7/03/2013	Works approval amendment to include additional infrastructure to improve permanent waste management and allow staged construction. Proposed upgrades were the result of poor management practices identified during an inspection in 2012.
	16/04/2014	Works approval amendment to extend the duration of the works approval to allow completion of construction.
L8751/2013/1	16/04/2014	New licence for the operation of the Barrow Island waste transfer station (Stage 1).
	18/12/2014	Licence amendment to include the operation of Stage 2 of the Barrow Island waste transfer station.
	08/10/2015	Licence amendment to extend the boundary of the premises of the Barrow Island waste transfer station.
Bridging WWTP		
W4635/2010/1	22/07/2010	New works approval for the construction of the Gorgon Project bridging WWTP
W5152/2012/1	10/05/2012	New works approval for the construction of the Gorgon Project bridging WWTP expansion
L8479/2010/1	18/08/2011	New Licence for the operation of the Gorgon Project bridging WWTP
	06/12/2012	Licence amendment for the operation of the Gorgon Project bridging WWTP expansion
	21/08/2014	Licence renewal for the Gorgon Project bridging WWTP.
	04/03/2016	Licence amendment to include the disposal of treated wastewater from the Gorgon Project bridging WWTP via the permanent disposal wells.
Diesel fuel storage		
W5037/2011/1	09/02/2012	New works approval for the construction of the Gorgon Project temporary power station.
L8794/2013/1	07/05/2015	New licence for the operation of the Gorgon Project temporary power station.
	11/12/2015	Licence amendment to amend conditions relating to stack testing of the Gorgon Project temporary power station.
	13/10/2016	Licence amendment to amend conditions relating to ambient air quality monitoring associated with the Gorgon Project temporary power station.

5.4.3 Compliance inspections and compliance history

A site inspection in 2012 raised concern regarding poor management practices at the waste transfer station, which was operating as a temporary waste management facility to support temporary construction services (e.g. temporary accommodation). A lack of progress towards permanent waste infrastructure to support the commencement of construction of permanent facilities (i.e. the GTP) was also noted. In response, the Applicant applied to amend the works approval for the implementation of infrastructure improvements. The amendment was granted on 7 March 2013 and the upgraded facility is fully operational.

All other previous compliance inspections relating to the above licenses did not identify any significant compliance issues. During the most recent inspections undertaken in 2016, it was determined that all relevant licence conditions were complied with.

A Letter of Warning was issued to the Applicant in 2009 for the unauthorised clearing of 501 m^2 (0.05ha) of vegetation during the completion of geotechnical investigations. The incident was reported to the DWER by the Applicant.

There have been no other statutory notices issued or prosecutions in relation to the Premises. A small number of self-reported incidents have been recorded for the Premises and are detailed through Appendix 1.

6. Modelling and monitoring data

6.1 Air quality modelling

The Applicant carried out the following air quality modelling studies to assess the potential effects on air quality from emissions to air:

- 2008 - Modelling to estimate emissions of oxides of nitrogen (NOx), sulfur dioxide (SO_2), particulates (PM_{10}), and ozone (O_3) during routine and non-routine operation of the GTP for both startup and operation phases. Non-routine (or upset conditions) included cold startup, emergency shutdown, and CO_2 venting. In addition, modelling was carried out to estimate emissions of H_2S during acid gas venting, and estimate nitrogen and sulphur deposition over the adjacent terrestrial and marine environments (TAPM-GRS model used).
- 2010 - Modelling and sensitivity testing to further improve the accuracy of predicted ground level concentrations of NOx and O_3 by refining assumptions made in the 2008 modelling study (TAPM-CTM model used).
- 2010 - Modelling to estimate ground-level concentrations of H_2S and organic compounds (BTEX) during acid gas venting for six selected release scenarios under a complete set of probable weather conditions (Canary model used).
- 2014 - Modelling to estimate ground-level concentrations of mercury and deposition on Barrow Island and in the adjacent ocean (CALPUFF model used).

Modelling studies were reviewed by DWER's air quality experts as part of the assessment of the Air Quality Management Plan, which was developed under condition 29 of MS 800. It was determined that appropriate model selection, input data, and assumptions were used to ensure reliable conclusions on the predicted concentrations of pollutants.

The modelling assessed ambient air quality against various air quality criteria to assess impacts on human health, occupational health exposure effects, non-occupational health exposure effects (impacts on human health from exposure outside of working environments), and effects on the terrestrial environment of the BINR. Due to the remote location of the BINR (85 km from the mainland), with the exception of accommodation camps, there are no significant residential receptors in the vicinity of the Premises. In their assessment (EPA Report 1323), the EPA noted

the lack of data available on the effects of air pollutants on fauna and flora. In the absence of standards, the EPA considered that limits for humans were the only available surrogate standards for mammals and that the deposition limits described in the World Health Organisation Air Quality Guidelines for Europe (WHO, 2005) were an appropriate surrogate for assessing the impact of air pollutants on vegetation.

The results of the modelling compared to relevant air quality criteria are presented in the following tables (Table 9 to Table 16).

Table 9: Summary of maximum predicted pollutant concentrations against assessment criteria (2008 model results)

Pollutant	TAPM-GRS grid	Maximum on grid (µg/m^3)	Averaging period	Assessment criteria		Percentage of assessment criteria
				ppm	µg/m^3	
Background conditions						
NO_2	1 km	30.9	1 hour	0.12	246	12.5
		0.49	Annual	0.03	62	0.8
SO_2	1 km	1.08	1 hour	0.20	571	0.2
		0.19	24 hour	0.08	229	0.1
		0.02	Annual	0.02	57	0.1
O_3	10 km	130.9	1 hour	0.10	214	61.2
		108.8	4 hour	0.08	171	63.6
Routine operating conditions						
NO_2	1 km	42.6	1 hour	0.12	246	17.3
		0.7	Annual	0.03	62	1.2
SO_2	1 km	14.6	1 hour	0.20	571	2.6
		2.6	24 hour	0.08	229	1.2
		0.2	Annual	0.02	57	0.3
PM_{10}	1 km	0.9	24 hour	--	50	1.8
O_3	10 km	131.9	1 hour	0.10	214	61.6
		109.6	4 hour	0.08	171	64.1
Cold startup						
NO_2	1 km	341	1 hour	0.12	246	139
SO_2	1 km	14.8	1 hour	0.20	571	2.6
PM_{10}	1 km	1	24 hour	--	50	2
O_3	10 km	132.2	1 hour	0.10	214	61.8
Emergency shutdown						
NO_2	1 km	37.5	1 hour	0.12	246	15.3

Pollutant	TAPM-GRS grid	Maximum on grid (µg/m^3)	Averaging period	Assessment criteria		Percentage of assessment criteria
				ppm	µg/m^3	
SO_2	1 km	9.1	1 hour	0.20	571	1.6
PM_{10}	1 km	0.7	24 hour	--	50	1.3
O_3	10 km	133.2	1 hour	0.10	214	62.2
Acid gas venting						
NO_2	1 km	42.6	1 hour	0.12	246	17.3
SO_2	1 km	14.9	1 hour	0.20	571	2.6
PM_{10}	1 km	2.3	24 hour	--	50	4.7
O_3	10 km	272	1 hour	0.10	214	127

Table 10: Summary of maximum predicted pollutant concentrations at sensitive receptor locations (Chevron Camp and Butler Park) as percentage of assessment criteria (2008 model results)

Pollutant	Averaging period	Percentage of assessment criteria (%)				
		Background	Routine operations	Cold startup	Emergency shutdown	Acid gas venting
Chevron Camp						
NO_2	1 hour	6.1	8.1	33.3	6.5	7.7
SO_2	1 hour	0.1	0.9	0.7	0.5	0.9
PM_{10}	24 hour	n/a	0.6	0.6	0.6	1.6
O_3	1 hour	n/a	n/a	n/a	n/a	93.5
Butler Park						
NO_2	1 hour	7.3	8.5	33.3	8.5	8.5
SO_2	1 hour	0.1	1.1	1.1	0.5	1.1
PM_{10}	24 hour	n/a	0.6	0.7	0.6	1.6
O_3	1 hour	n/a	n/a	n/a	n/a	93.5

Table 11: summary of maximum predicted pollutant concentrations against national occupational health exposure standards (under all modelled operating conditions) (2008 model results)

Pollutant	Maximum on grid (µg/m^3)	Averaging period	TWA (µg/m^3)	Percentage of assessment criteria
Routine operating conditions				
NO_2	14.1	8 hour	5600	0.25
SO_2	6.3	8 hour	5200	0.12
Non-routine operations – cold startup				
NO_2	86.6	8 hour	5600	1.5
SO_2	5.7	8 hour	5200	0.11
Non-routine operations – emergency shutdown				
NO_2	12.2	8 hour	5600	0.22
SO_2	4.4	8 hour	5200	0.08
Non-routine operations – acid gas venting				
NO_2	15.7	8 hour	5600	0.28
SO_2	6.3	8 hour	5200	0.12
H_2S	1774	8 hour	14 000	12.7

Table 12: Summary of maximum predicted O_3 and NO_2 concentrations against assessment criteria (2010 TAPM model results)

		Maximum predicted O_3 concentrations			Assessment Criteria (µg/m^3)
		Base case	Base case plus one AGRU	Base case plus three AGRUs	
One-hour Averaging Period	Maximum on Grid (µg/m^3)	140	147	167	214
	Percentage of Criteria (%)	65%	69%	78%	214
Four-hour Averaging Period	Maximum on Grid (µg/m^3)	119	119	125	171
	Percentage of Criteria (%)	70%	70%	70%	171

Averaging Period	Maximum Predicted NO_2 Concentration (µg/m^3) Base Case	Assessment Criteria (µg/m^3)
One-hour Averaging Period	20	246

Table 13: maximum predicted pollutant concentrations during acid gas venting at sensitive receptors (Chevron Camp and Butler Park) compared to assessment criteria (2010 canary model results)

Pollutant	Averaging period	Maximum ground-level concentrations (ppb)		Assessment criteria (ppb)
		Butler Park	Chevron Camp	
Benzene	1 hour	1	<1	9
Toluene	1 hour	2	1	90
Ethylbenzene	1 hour	<1	<1	1 800
Xylene	1 hour	<1	<1	40
H_2S	Peak Concentration	<1	<1	1.0 – 3.5[1]

Note 1: The impact assessment criterion for H_2S varies with population size (e.g. 2 people – 3.5 ppb; 10 people – 3.0 ppb; ~30 people – 2.5 ppb; ~125 people – 2 ppb; ~500 people – 1.5 ppb; >2000 people – 1.0 ppb).

Table 14: Summary of maximum predicted pollutant concentrations during acid gas venting compared to assessment criteria (2010 Canary model results)

Pollutant	Maximum Ground-level Concentrations (ppb)						Assessment criteria – TWA[1] (ppb)
	GTP	Permanent Operations Facility	MOF	Terminal Tanks Site	Jetty	WA Oil Base	
Benzene	89	8	5	4	<1	<1	1000
Toluene	120	15	9.5	8	1	<1	100 000
Ethylbenzene	6	<1	<1	<1	<1	<1	100 000
Xylene	50	3	2	1	<1	<1	80 000
H_2S	28	6	4	3	<1	<1	5000

Note 1. The TWA concentration is measured over a normal eight-hour work day and a 40-hour work week, and is the concentration of an atmospheric contaminant to which nearly all workers may repeatedly be exposed, day after day, without adverse effect.

Table 15: Estimated annual atmospheric pollutant concentrations for benzene, toluene, and xylene (acid gas venting) (2010 Canary model results)

Pollutant	Annual average ground-level concentrations (ppb)		Assessment criteria (ppb)
	Worst-case (outside the GTP)	Residential Locations[1]	
Benzene	1.2	0.2	3
Toluene	2.3	0.3	100
Xylene	0.45	0.2	200

Note: The residential locations considered as part of the modelling study included the Chevron Camp and Butler Park.

Table 16: summary of maximum predicted mercury concentrations at sensitive receptor locations (under all modelled operating conditions) (2014 model results)

Sensitive receptor	Assessment criteria ng/m³	Averaging period	Maximum ground-level concentrations[1,2,6,7] (ng/m³) (Percentage of Criteria [%])			
			Routine operations[3]	Routine operations[3] (including background levels) [4]	Non-routine operations with 20% CO_2 venting[5]	Non-routine operations with 20% CO_2 venting[5] (including background Levels) [4]
Residential Criteria						
Chevron Camp	1800	1-hour[5]	0.68 (0.038%)	2.68 (0.15%)	21 (1.2%)	23 (1.3%)
	200	Annual	0.0055 (0.0055%)	1.256 (0.63%)	0.04 (0.02%)	1.29 (0.65%)
Butler Park	1800	1-hour[5]	0.9 (0.0021%)	2.9 (0.16%)	34 (1.9%)	36 (2.0%)
	200	Annual	0.009 (0.05%)	1.259 (0.63%)	0.08 (0.04%)	1.33 (0.67%)
Occupational criteria						
GTP	25 000	8-hour	2.2 (0.0088%)	4.2 (0.017%)	100 (0.4%)	102 (0.408%)
Permanent Operations Facility			1.7 (0.0068%)	3.7 (0.015%)	35 (0.14%)	37 (0.148%)
MOF			0.5 (0.002%)	2.5 (0.01%)	15 (0.06%)	17 (0.068%)
Terminal Tanks Site			0.65 (0.0026%)	2.65 (0.011%)	38 (0.15%)	40 (0.16%)
Jetty Head			0.23 (0.0009%)	2.23 (0.0089%)	10 (0.04%)	12 (0.048%)
WA Oil Base			0.18 (0.0007%)	2.18 (0.0087%)	20 (0.08%)	22 (0.088%)

Note 1: Concentrations and assessment criteria are presented in ng/m³ to aid in presentation of results, as the predicted ground-level concentrations are very low.

Note 2: Concentrations are the total of elemental Hg, divalent Hg, and particulate Hg. More than 99% of the Hg emissions are associated with elemental Hg.

Note 3: Routine operations do not include any CO2 venting.

Note 4: Background Hg levels are determined based on global emissions and comprise primarily elemental Hg. For the region near Barrow Island, anthropogenic sources should be minimal, with the largest local sources being emissions from soils, vegetation, and fires. Estimates of background levels across Australia were presented in a modelling study that included all known sources including industrial emissions and natural sources. Annual predictions from this study

indicate that for a location near Onslow a typical value is 1.25 ng/m^3; with a shorter-term peak concentration of 2 ng/m^3 being considered reasonable.

Note 5: Non-routine operations include 20% CO2 venting (as a conservative estimate). To provide worst-case estimates of the 1-hour and 8-hour Hg concentrations, predictions were obtained from the model run assuming CO2 venting occurs for every hour over a 3-year period. This ensured CO2 venting would occur at the time of worst-case dispersion. The annual average concentration is based on 80% of the non-CO2 venting model run and 20% of the result from the model run with CO2 venting.

Note 6: The 1-hour criteria are the 99.9th percentile.

Note 7: Non-routine shutdown and black-start conditions were also modelled; however, maximum ground-level concentrations at any grid point increased by a maximum of 0.10% from the modelled routine operations case. Therefore, the results have not been included.

Note 8: Annual Hg deposition rates were also modelled, with a maximum rate of 55 µg/m^2/year occurring within the GTP footprint (associated with non-routine operations with 20% CO2 venting), without taking into account the re-emission of the highly volatile elemental Hg.

6.2 Environmental Risk Assessment Studies

In addition to the air quality modelling studies outlined above, the proposal was also subject to the following risk assessments:

- Screening-level health risk assessment (HRA) to evaluate potential human health risks specifically associated with acid gas venting;
- Screening-level terrestrial and marine ecological risk assessments (ERA) to assess potential environmental impacts to terrestrial and marine flora and fauna; and
- Screening-level HRA and ERA to evaluate potential human health risks and environmental impacts specifically associated with mercury emissions.

The ERAs were based on effects (where known) of respective atmospheric pollutants and air toxics on the likely exposure pathways to identified sensitive ecological receptor species. The assessments considered the environmental setting (e.g. physical and climatic conditions), and the effects of air pollutants at certain dose concentrations in comparison to modelled concentrations to determine the potential risk to fauna and flora.

The ERA determined that routine emissions from the GTP are '*unlikely to result in anything more than short-term reversible impacts on terrestrial and marine flora and fauna'* and that the likelihood of this occurring was low. Risks associated with mercury deposition were also considered negligible.

Risks associated with acid gas venting were further investigated to determine potential effects of H_2S and BTEX emissions. The ERA considered that acid gas venting from all three AGRUs would occur infrequently (i.e. once in five years over a maximum period of five days due to pigging of the CO_2 injection pipeline). In this situation, it was estimated that there is potential for ground level concentrations of benzene to cause short-term reversible impacts to susceptible fauna within 50 m of the northern fence line of the Premises. Provided suitable atmospheric conditions (i.e. wind and weather stability) were experienced, the ERA predicted that the probability of this occurring was 0.07%. It is noted that the predicted 50 m impact zone is within the approved terrestrial disturbance footprint.

6.3 Ambient air quality monitoring

Ambient air quality monitoring is undertaken in accordance with the Air Quality Management Plan. Monitoring commenced in 2012 with the aim of capturing baseline data and continued through commissioning, startup, and operation of the GTP. Details of the ambient monitoring program are provided in Table 17 and the location of ambient monitors shown in Figure 3. The communications tower monitoring station was relocated in August 2016 from the terminal tanks. It is understood that the monitoring locations are indicative and may be subject to further changes to support meeting the objectives of the Air Quality Management Plan approved under MS 800.

Table 17 Ambient Air Quality Monitoring Program

Monitoring location	Monitoring equipment[1]	Parameters	Frequency
Butler Park[2] Monitoring Station	Chemiluminescence Analyser (1)	NO NOx NO_2	Continuous[3]
	Tapered Element Oscillating Microbalance (TEOM) (1)	PM_{10}	Continuous[3]
	UV Fluorescence Analyser (2)	SO_2 H_2S	Continuous[3]
	Passive Diffuse Samplers[4] (1)	NMVOC	Continuous (but sample collected fortnightly)
	Gas Filter Correlation/Infra-red (GFC/IR) Analyser (1)	CO	Continuous[3]
	UV Absorption Analyser (1)	O_3	Continuous[3]
	Automated Weather Station (1)	Wind speed and direction Ambient temperature Relative humidity	Continuous[3]
Communications Tower Monitoring Station [5]	Chemiluminescence Analyser (1)	NO NOx NO_2	Continuous[3]
	TEOM (1)	PM_{10}	Continuous[3]
	UV Fluorescence Analyser (2)	SO_2 H_2S	Continuous[3]
	Passive Diffuse Samplers[4] (1)	NMVOC	Continuous (but sample collected fortnightly)
	GFC/IR Analyser (1)	CO	Continuous[3]
	UV Absorption Analyser (1)	O_3	Continuous[3]
	Automated Weather Station (1)	Wind speed and direction Ambient temperature Relative humidity	Continuous[3]
Reference Site - South of the GTP (e.g. at a suitable location near the Barrow Island Airport)	Passive Diffuse Sampler (1)	NMVOC	Continuous (but sample collected fortnightly)
Barge (WAPET) Landing	Passive Diffuse Sampler (1)	NMVOC	Continuous (but sample collected fortnightly)

Monitoring location	Monitoring equipment[1]	Parameters	Frequency
P36 Well Site	Automated Weather Station	Wind speed and direction Rainfall Ambient and differential temperature Solar radiation Barometric pressure Relative humidity	Continuous[3]
	Passive Diffuse Sampler (1)	NMVOC	Continuous (but sample collected fortnightly)
Relocatable Monitoring Stations[6]	Electrochemical Cell (1) Infra-red (1) Photo Ionisation Detector[7] (1)	H_2S CO_2 NMVOC	Continuous[3]

Note 1: For each type of monitoring equipment, the numbers in brackets represent the total number of monitoring equipment located at the monitoring site.

Note 2: A monitoring station was located at Butler Park as this is considered the closest permanent sensitive receptor to the GTP.

Note 3: Monitoring data from continuous monitoring equipment is downloaded daily using remote modem access to a data storage server located in Perth.

Note 4: This monitoring is for screening exercise purposes only to determine whether additional more rigorous monitoring is required. Depending on the NMVOC monitoring results at the two monitoring stations, there is potential for escalation of NMVOC monitoring from the Passive Diffuse Samplers to either:

- Fourier Transform Infra-red (FTIR) Spectrophotometry, or
- Gas Chromatograph with either a Photo Ionisation Detector or Flame Ionisation Detector (GC/FID, GC/PID), or other open path analyser.

Note 5: A monitoring station will be located at the Communications Tower based on technical considerations including air quality modelling, wind direction and proximity to other emissions sources.

Note 6: This monitoring is meant as a screening exercise only, so as to determine whether additional more rigorous monitoring is required. The four proposed relocatable monitoring stations are expected to be located in low-lying areas so as to assess any potential impacts to receptors (e.g. fauna) during acid gas venting events. Therefore, the locations of relocatable monitoring stations are subject to change.

Note 7: Depending on the NMVOC monitoring results at the four relocatable monitoring stations, there is potential for escalation of NMVOC monitoring from the Photo Ionisation Detector to either:

- Passive Diffuse Samplers, or
- TO-14A Passivated Canisters.

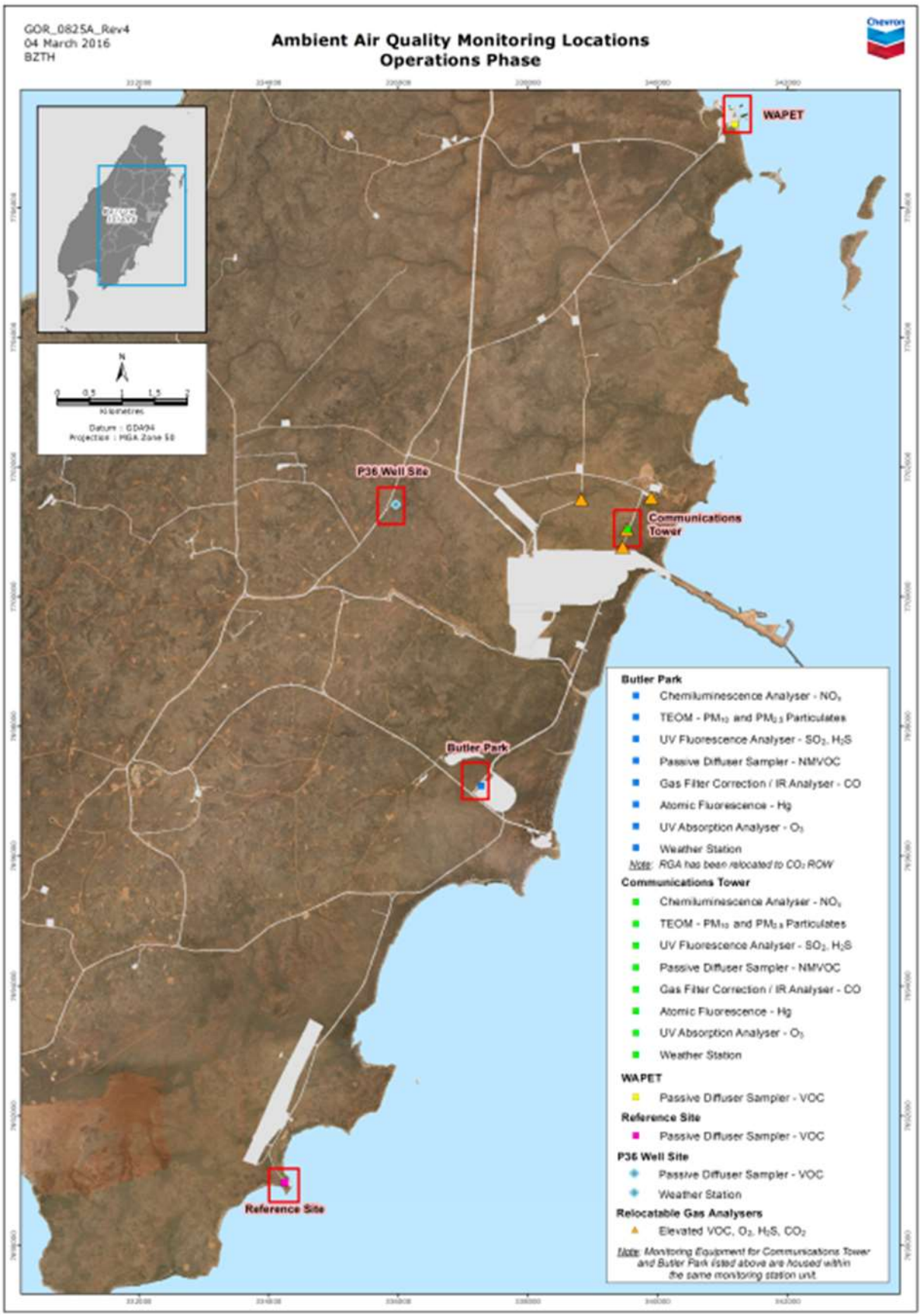

Figure 3: Location of ambient air quality monitoring sites

6.4 Emissions Verification Monitoring

Condition 5 of Works Approval W5178/2012/1 required the submission of an Emissions Verification Report (EVR) following commissioning of the GTP. A partial EVR was submitted in April 2016 capturing emissions from LNG Train 1 and facilities approved under Licence L8952/2016/1.

A final EVR was submitted on 14 August 2017 following commissioning of LNG Trains 2 and 3, and GTGs 4 and 5. The purpose of this report was to verify emissions from the whole Premises. Verification testing included monitoring of both point source emissions and ambient air quality.

6.4.1 Point source emissions monitoring

Point source monitoring included stack testing of key emissions sources as a means of providing indicative emissions concentrations.

The GTGs and GTs were not operating at normal loads during the commissioning period. The maximum load that the GTGs were operating at was 35 MW (approximately 30% of capacity) with loads observed as low as 12 MW (10% capacity). At low loads, turbines do not operate as efficiently and may result in higher emissions as shown in Table 18. Additionally, when operating at low loads, emission controls (i.e. dry low NOx burners) are not able to operate as they only operate above a 60 to 70% load.

A reduction in emission concentrations is expected as the plant reaches steady state/higher loads and the dry low NOx burners are able to operate effectively. Dry low NOx burners were commissioned on GTG1, GTG3, GTG4 and GTG5 in June 2017; monitoring results show that when the burners were operational, emissions from the GTGs met relevant targets and design criteria (Table 18).

Table 18: Results of stack testing undertaken during commissioning

Sample	Date	Measured concentration (mg/m^3)			
		NO_X[1, 2]	CO[1]	SO_2[1, 3]	NMVOC[4]
Target [5]		70	125	-	40
Design Specification [6]		51.3	18.7	0.01	1.2
GTG1	19-Nov-15	89	51	1.7	- [7]
	20-Nov-15	118	14	- [7]	- [7]
	02-Jun-16	93	62	5.4	<10
	10-Aug-16	116	5	9	<10
	11-Dec-16	108	14	4.3	<10
	30-Mar-17	74	21	2.8	<10
	23-May-17	100	<1	- [7]	0.59
	28-Jun-17	26	1	- [7]	0.5
GTG2	19-Dec-15	67	52	1.1	<20
	14-Jan-16	89	21	4.4	<10
	12-Feb-16	149	38	12.8	<10

Sample	Date	Measured concentration (mg/m^3)			
		NO_x[1, 2]	CO[1]	SO_2[1, 3]	NMVOC[4]
	02-Jun-16	90	49	6.1	<10
	21-Nov-16	80	179	2.4	<10
GTG3	01-Jun-16	21	10	1.7	<10
	09-Aug-16	108	33	15	<10
	12-Dec-16	84	125.2	4.3	<10
	23-May-17	97	<1	- [7]	0.3
	29-Jun-17	26	1	- [7]	0.5
GTG4	23-May-17	71	52	- [7]	1.9
	29-Jun-17	38	2	- [7]	0.5
	01-Jul-17	100	<1	- [7]	- [7]
GTG5	23-May-17	78	1	- [7]	0.65
	29-Jun-17	28	2	- [7]	0.5
Target [5]		350	125	-	40
Design Specification [6]		51.3	18.8	1.2	0.02
GT Frame 7 PR1	11-Feb-16	159	333	9.3	<10
	25-Feb-16	106	125	5.3	<10
	03-Jun-16	81	115	2.7	<10
	12-Aug-16	120	1	4.6	<10
	18-Nov-16	122	3	5.8	<10
	01-Jul-17	100	3	- [7]	0.5
GT Frame 7 MR1	23-Feb-16	111	107	5.3	<10
	11-Aug-16	89	6	3.8	<10
	21-Nov-16	138	3	6.8	<10
	01-Jul-17	120	7	- [7]	0.5
GT Frame 7 PR2	24-May-17	80	20	- [7]	0.2
	30-Jun-17	90	24	- [7]	0.5
GT Frame 7 MR2	24-May-17	79	9	- [7]	0.4
	30-Jun-17	85	18	- [7]	0.5

Sample	Date	Measured concentration (mg/m^3)			
		NO_x[1, 2]	CO[1]	SO_2[1, 3]	NMVOC[4]
GT Frame 7 PR3	24-May-17	29	2	- [7]	2.6
	30-Jun-17	26	1	- [7]	0.5
GT Frame 7 MR3	24-May-17	77	8	- [7]	0.3
	30-Jun-17	78	7	- [7]	0.5
Target [5]		350	125	-	40
Design Specification [6]		80	39	8	0.4
Heating Medium Heater A	12-Feb-16	36	8.3	1.6	<10
Heating Medium Heater B	26-Feb-16	55	6.3	0.4	<10
	27-Feb-16	56	30	4.8	<10

Note 1: Emission targets and measured concentration at 15 % O2 reference level, dry, at 0 ° C and 101.3 kPa.
Note 2: Calculated as NO_2.
Note 3: There is no emission target stated for SO_2.
Note 4: Emission targets and measured concentration at 3 % O_2 reference level, dry, at 0 ° C and 101.3 kPa.
Note 5: Targets are specified in the *Gorgon Gas Development and Jansz Feed Gas Pipeline: Air Quality Management Plan*
Note 6: Derived from the *Gorgon Gas Development and Jansz Feed Gas Pipeline: Best Practice Pollution Control Design Report*
Note 7: Not tested
Note 8: Red values indicate that the measured concentration is above the emission target.

The Frame 7 GTs were tested during the tuning of the dry low NOx burners. During this period the turbines were not considered to be operating in a stable state due to variations in load and fuel gas composition changes; subsequently, stack testing results indicate that emissions to not meet design specifications. Tuning of the dry low NOx burners was completed during June and July 2017. Data sourced from the manufacturer indicates that the GTs will generally meet design criteria once the burners are tuned (Figure 4) although some variability is evident due to operating conditions at the time of testing.

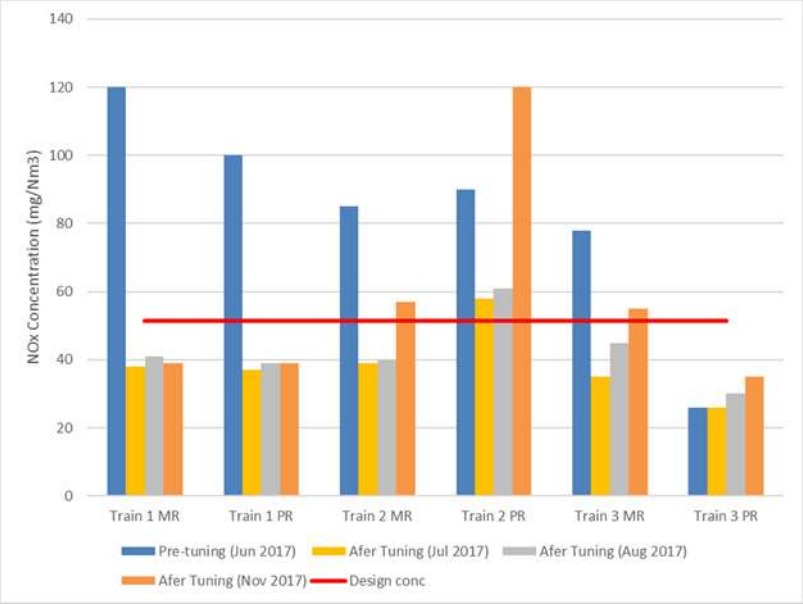

Figure 4: Data comparison of emissions from GTs pre-and post-tuning of Dry Low NOx burners (Chevron, 2017d)

Stratification testing was undertaken on the GTGs and GTs to confirm that the monitoring locations conform to Australian Standard 4323.1-1995 *Stationary source emissions, Method 1: Selection of sampling positions*. The testing indicates that the emissions profiles were uniform and that the monitoring data is reliable and accurate. It is noted that GTG2 was not tested for stratification; however, given that the equipment is the same specification as the other GTGs, this is not considered a significant issue.

6.4.2 Ambient monitoring

The results of ambient air quality monitoring were reviewed by DWER's air quality experts who verified that the data was valid. The data, which consisted of measured results from 2011 up to May 2017 (where available), indicated that the relevant assessment criteria had been met with the exception of PM_{10}, NOx, H_2S and O_3 (Table 19).

Table 19: Summary of exceedances of ambient air quality criteria

Pollutant	Averaging period	Guideline	Terminal tank/ comm. tower	Butler Park
			No. of exceedances	
PM_{10}	1 day	50ug/m^3 [1]	39	263
	1 year	25ug/m^3 [1]	1	0
NO_2	1 hour	0.12ppm [1]	19	0
	1 year	0.03ppm [1]	0	0
O_3	1 hour	0.10ppm [1]	1	1
	4 hours	0.08ppm [1]	3	1
SO_2	1 hour	0.20ppm [1]	0	0
	1 day	0.08ppm [1]	0	0
	1 year	0.02ppm [1]	0	0
H_2S	30 minutes	7ug/m^3 [2]	7	7
CO	8 hours	9ppm [1]	0	0
Hg_E	8 hours	0.003ppm [3]	0	0
Benzene	1 year	0.003ppm [1]	0	0
Toluene	1 day	1ppm [1]	0	0
	1 year	0.1ppm [1]	0	0
Xylene	1 day	0.25ppm [1]	0	0
	1 year	0.2ppm [1]	0	0

Note 1: NEPM
Note 2: Elemental Mercury and Inorganic Mercury Compounds: Human Health Aspects, Concise International Chemical Assessment Document 50 (WHO, 2003). Equates to 4.6ppb.
Note 3: Workplace exposure standards for airborne contaminants (SWA, 2013)

Particulates (PM_{10})

The majority of exceedance of the criteria for particulates (PM_{10}) were attributable to vehicle movements and construction activities. Data indicates that the number of exceedances has declined as the construction was completed and the Premises transitioned into operations (Table 20).

In 2016 the terminal tanks monitoring station was relocated to the communications tower which is located adjacent to an unsealed road. Exceedances at the communication tower are considered to be attributable to local sources such as vehicle movements and not the operation of the GTP. Similarly, exceedances at the Butler Park monitoring location were considered to be a result of vehicle movements on roads and in unsealed car parks. Exceedances were associated with north easterly, south westerly and north westerly winds which align with these areas in and around the Butler Park monitoring station.

Table 20. Number of exceedances of the PM_{10} 24 hour ambient criteria per calendar year

Year	Terminal tanks	Communications tower	Butler Park
2011	65	-	11
2012	104	-	135
2013	97	-	45
2014	38	-	29
2015	9	-	24
2016	1	30	8
2017	-	47	11

Nitrogen dioxide (NO_2)

NO_2 concentrations measured at the communications tower and Butler Park were higher than predicted, although this was not unexpected given that the modelling did not consider operation of the GTGs and GTGs without NOx reduction technology. The maximum NO_2 concentrations recorded at the communications tower and Butler Park were 383 ppb and 25.9 ppb respectively (319% and 22% of the assessment criteria). Recorded 99th percentile values were 13 ppb and 6 ppb at the communications tower and Butler Park (11% and 5% of the assessment criteria).

19 exceedances of the 1-hour assessment criteria were recorded at the terminal tanks and communications tower monitoring stations. The Applicant investigated the exceedances and determined that the monitoring was being influenced by nearby pollution sources and that exceedances were not a direct result of emissions from the GTP. Three of the exceedances were the result of emissions from a pumping station situated near the terminal tanks. The remaining 16 exceedances occurred following the relocation of the monitor to the communications tower and were attributed to a temporary diesel generator which was providing power to the monitoring site. No additional exceedances were recorded following connection of the monitoring station to permanent power on 12 September 2016. The maximum NO_2 concentration recorded after this date was 41.4 ppb (35% of the assessment criteria).

Hydrogen sulfide (H_2S)

Ground level concentrations of H_2S were relatively low while the GTP was processing Janzs feed gas. However, concentrations increased following the introduction of Gorgon feed gas in March 2017 and the commencement of venting from all three AGRUs. Since then, concentrations of H_2S were shown to be higher than predicted by the modelling with ambient monitoring data showing seven exceedances of the assessment criteria (7 µg/m^3) at the

communications tower monitoring location attributable to GTP emission sources.

Seven exceedances were also recorded at Butler Park between March 2015 and February 2016 (prior to the introduction of Gorgon feed gas). These were attributed to onsite sources (i.e. blockages at the WWTP). Since then, no additional exceedances have been recorded at Butler Park.

Ozone (O_3)

One exceedance of the criteria for O_3 was recorded in 2012 (Figure 5). An investigation into this exceedance determined it was from regional sources such as bushfires.

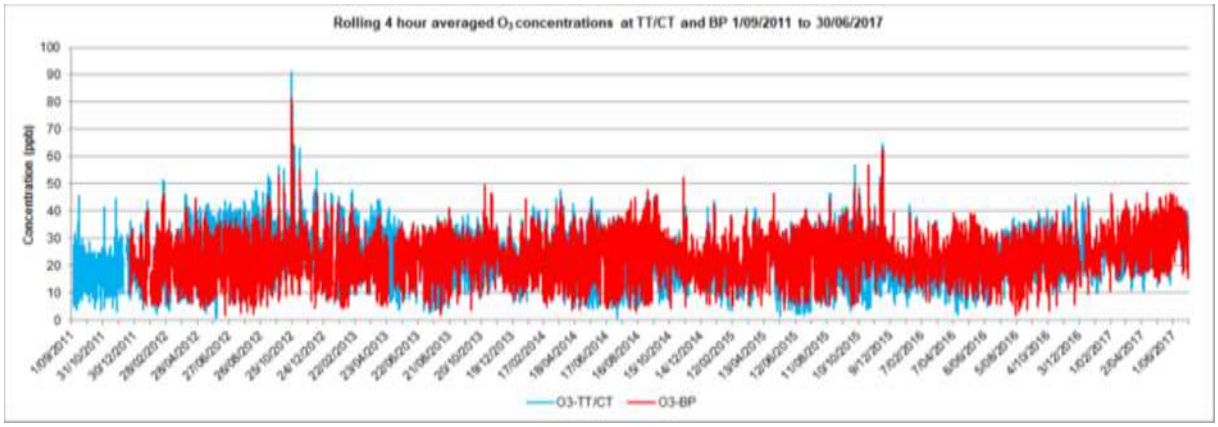

Figure 5: Rolling 4 hour O_3 concentrations between September 2011 and June 2017 (Chevron, 2017a).

7. Consultation

The application for a licence was made available on DWER's website for public comment from 18 December 2017 to 8 January 2018. Four letters were also sent to direct interest stakeholders inviting submissions.

The Delegated Officer extended the consultation period until 15 January 2015 to accommodate time lost during the Christmas holiday period. Comments received are detailed in Appendix 2.

8. Location and siting

8.1 Siting context

The Premises is located on Barrow Island situated 85 km off the Pilbara coast, north-north-east of the town of Onslow and 140 km west of Karratha. Barrow Island is reserved under the Western Australian *Conservation and Land Management Act 1984* (CALM Act) as a Class A nature reserve for the purposes of '*conservation of flora and fauna'*. The BINR is a unique remnant of Australia's natural ecology. The island's status as a Class A nature reserve reflects its importance as a refuge for wildlife species, with some endemic to the BINR and some extinct on the Australian mainland.

Oil production has occurred on the island since 1967. The Applicant also manages operations of the Barrow Island oil and gas facility on behalf of a separate joint venture, which includes Santos Offshore Pty Ltd, Mobil Australia Resources Company Pty Ltd, and Chevron (TAPL) Pty Ltd. The Barrow Island oil and gas facility is spread over a large portion of the island with a 4.5% footprint by land area. This facility is regulated under Licence L4467/1972/14.

8.2 Residential and sensitive Premises

The distances to residential and sensitive receptors are detailed in Table 21.

Table 21: Receptors and distance from activity boundary

Sensitive Land Uses	Distance from Prescribed Activity
Butler Park (Chevron operated worker accommodation camp)	2.5 km south of the GTP
OWA Camp (Chevron operated worker accommodation camp)	2.5 km south of the GTP
Varanus Island oil and gas facility (including workers accommodation camp)	18 km north east of the GTP
Residential premises (Onslow)	~85 km from the GTP

Key finding: In accordance with the *Guidance Statement: Risk Assessments*, the Delegated Officer has determined that this assessment will not consider the risk of potential impacts to people in accommodation camps occupied by the Applicant. Potential impacts to people at these locations are subject to requirements under occupational health and safety regulations and obligations.

The Butler Park and OWA Camps are both operated by the Applicant (on behalf of different joint venture partners); therefore, the Delegated Officer considers that people at both camps are excluded as potential receptors.

8.3 Specified ecosystems

Specified ecosystems are areas of high conservation value and special significance that may be impacted as a result of activities at or emissions and discharges from the Premises. The distances to specified ecosystems are shown in Table 22. Table 22 also identifies the distances to other relevant ecosystem values which do not fit the definition of a specified ecosystem.

Table 22: Environmental values

Specified ecosystems	Distance from the Premises
Managed Lands and Waters	The Gorgon Gas Project is located on the BINR is a Class A Nature Reserve Marine waters surrounding the north, west and south sides of Barrow Island form part of the Barrow Island Marine Management Area (including the Bandicoot Bay Conservation Area ~13 km to the south of the GTP). An exclusion zone exists on the east side of the island adjacent to the GTP for the Barrow Island Port Area. The Barrow Island Marine Park is located on the west side of the island (~10 km from the GTP) and incorporates the Western Barrow Island Sanctuary Area.
Threatened Ecological Communities and Priority Ecological Communities	The BINR is listed as a Priority Ecological Community. Smaller areas identified as Priority Ecological Communities are located at the GTP site as well as to the north, south and west of the Premises.

Biological component	Distance from the Premises
Threatened / priority flora	Three species of priority flora are located on Barrow Island west of the Premises.
Threatened / priority fauna (terrestrial and marine)	Barrow Island is recognised as an important refuge for native terrestrial mammal species that have either declined in numbers or become extinct on the mainland. A considerable number of threatened and priority fauna are known to occur on the island including a number species that are listed under the *Wildlife Conservation Act 1950* (WA) and the Threatened (Vulnerable) Species list of the EPBC Act. Some of these species are known to occur within or adjacent to the Premises. Green and flatback turtles (both listed as vulnerable under the EPBC Act) nest on Barrow Island. Flatback turtle rookies are recorded near the Premises (300 m away).
Threatened / priority fauna (subterranean)	Barrow Island is recognized as being of high conservation significance for subterranean fauna communities at state, national and international levels. The subterranean fauna demonstrates high level of endemicity and species diversity and includes one of only two stygal vertebrate species occurring in Australia (Blind Gudgeon). Twelve of the species are listed under the *Wildlife Conservation Act 1950* and the Blind Gudgeon is listed as vulnerable under the EPBC Act. 13 stygofauna taxa were recorded in monitoring bores at the terminal tanks (approximately 1 km north of the Premises boundary).

8.4 Groundwater and water sources

The distances to groundwater and water sources are shown in Table 23.

Table 23: Groundwater and water sources

Groundwater and water sources	Distance from Premises	Environmental value
Groundwater	There is one shallow unconfined fresh water aquifer on Barrow Island. This fresh water aquifer forms a lens of relatively fresh groundwater floating upon denser, saline ground water at depths between 9 m and 53 m. The aquifer is principally recharged from rainfall. Groundwater discharge is predominantly to the ocean, although given the high evaporation rates; loss of groundwater is expected to occur via evaporation in areas where the water table is shallower than two metres below the ground surface.	Groundwater supplies domestic water for oil and gas operations. The groundwater system is linked to the marine ecosystem (<100 m from the Premises). Groundwater supports subterranean fauna which has high conservation significance.

Groundwater and water sources	Distance from Premises	Environmental value
Barrow Group Formation	The Barrow Group Formation is an underground saline aquifer situated at depths between 1,200 m and 1,900 m below the surface and is divided into three separate formations; the Flacourt and Malouet which are present beneath the BINR, and Flag Sandstone. The components of the Barrow Group Formation 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 1,000 m) of low permeability material. Water quality is highly alkaline and saline (total dissolved solids conc. approximately >30,000 mg/L), and is considered to be saturated with hydrocarbons. It is generally characterised as containing stable minerals with a very low proportion of soluble metals. A thick sequence of low permeability material (lower Gearle siltstone) hydraulically separates the Barrow Group Formation from the surface groundwater aquifer.	No beneficial use.

8.5 Meteorology

8.5.1 Wind direction and strength

The Applicant maintains three meteorological monitoring stations on Barrow Island (Figure 6). Data measured at the P36 Well monitoring station between 2010 and 2014 indicates that the prevailing winds are from the south-west. During winter months (May – July), Barrow Island is subject to easterly winds.

It is important to note that these wind roses show historical wind speed and wind direction data for the P36 Well station and should not be used to predict future data.

8.5.1 Regional climatic aspects

Barrow Island is characterised by an arid, sub-tropical environment with hot summers and moderate winters. Tropical cyclone activity occurs from November to April and can generate significant rainfall.

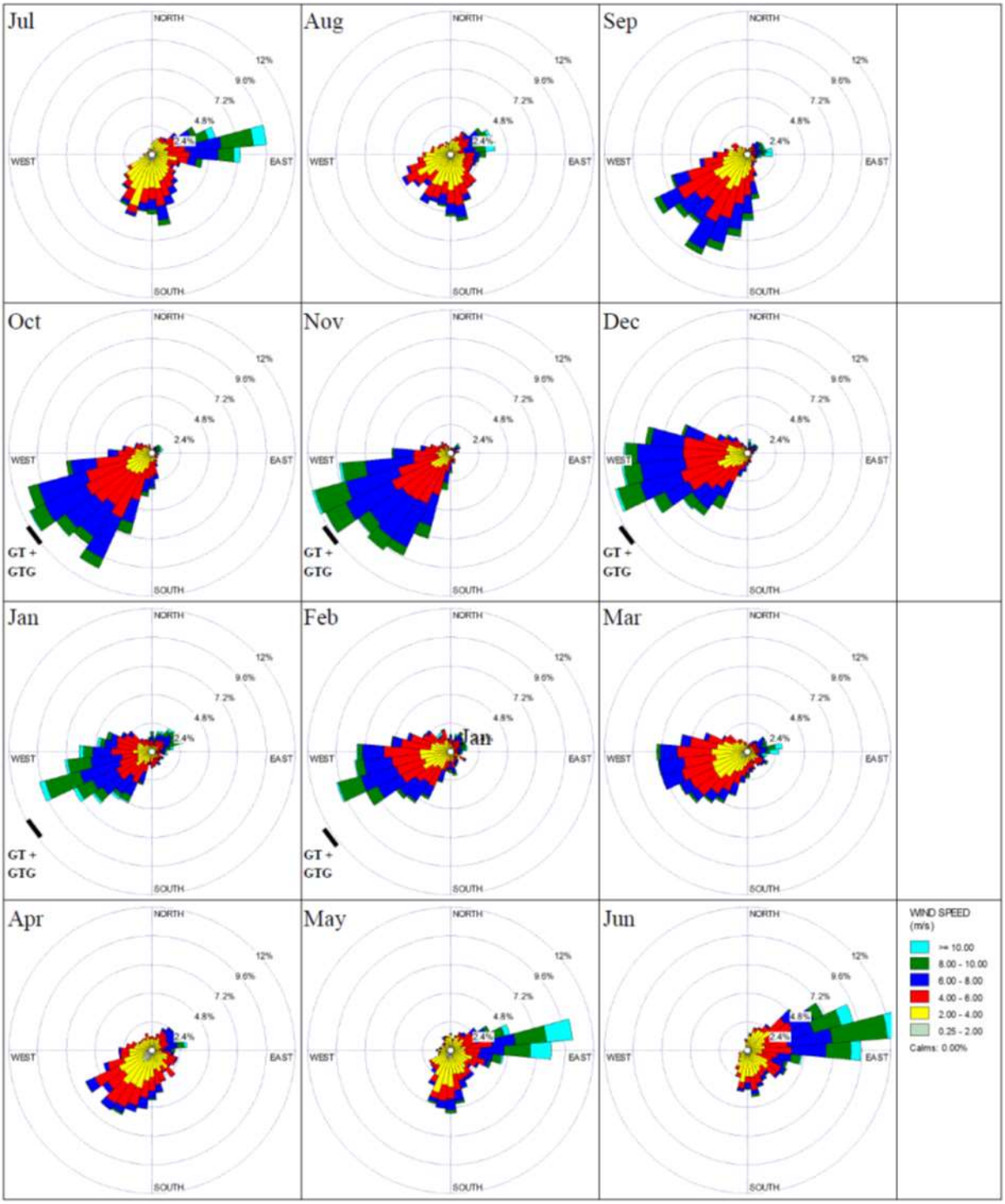

Figure 6 Wind roses by month for P36 Well meteorological monitoring site for 2010 to 2014 (Chevron, 2017a)

9. Risk assessment

9.1 Determination of emission, pathway and receptor

In undertaking its risk assessment, DWER will identify all potential emissions pathways and potential receptors to establish whether there is a Risk Event which requires detailed risk assessment.

To establish a Risk Event there must be an emission, a receptor which may be exposed to that emission through an identified actual or likely pathway, and a potential adverse effect to the receptor from exposure to that emission. Where there is no actual or likely pathway and/or no receptor, the emission will be screened out and will not be considered as a Risk Event. In addition, where an emission has an actual or likely pathway and a receptor which may be adversely impacted, but that emission is regulated through other mechanisms such as Part IV of the EP Act, that emission will not be risk assessed further and will be screened out through Table 24 and Table 25.

The identification of the sources, pathways and receptors to determine Risk Events are set out in Table 24 and Table 25 below.

Table 24: Identification of emissions, pathway and receptors during operation

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		**Potential emissions**	**Potential receptors**	**Potential pathway**	**Potential adverse impacts**		
Category 10 and 34 **LNG and DomGas processing trains and storage facilities**	LNG, DomGas and condensate processing and storage	Air emissions - point source Combustion gases and mercury (Hg): GTs, heating medium heaters and ground flares Hg, H_2S and BTEX: AGRU venting O_3 (secondary pollutant)	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	In accordance with the *Guidance Statement: Risk Assessments*, worker accommodation camps are not considered a potential receptor. The Delegated Officer has determined that there is sufficient separation distance to other sensitive receptor for there to be no source-pathway-receptor link.
			Flora and fauna within the Class A Nature Reserve		Survival and health impacts to flora and fauna	Yes	See section 9.4 (combustion gases), 9.5 (mercury), 0 (H_2S and BTEX) and 9.7 (O_3)

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
		Air emission (fugitive – gaseous compounds escaping from valves, flanges, pump seals, connectors and storage of environmentally hazardous materials)	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	As above.
			Flora and fauna within the Class A Nature Reserve		Survival and health impacts to flora and fauna	Yes	See section 9.8
		Noise	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	In accordance with the *Guidance Statement: Risk Assessments*, worker accommodation camps are not considered a potential receptor. BINR is considered one premises for the purpose of the *Environmental Protection (Noise) Regulations 1997*; therefore, the specified limits in the regulations do not apply to the accommodation camps. The Delegated Officer has determined that there is sufficient separation distance to other sensitive receptor for there to be no source-pathway-receptor link.
			Turtle nesting beaches located 300m away		Disruption to turtle nesting behaviour.		The Delegated Officer has determined that potential noise impacts on marine turtles are regulated under MS 800 (condition 16) through the Long Term Marine Turtle Management Plan.
		Light					The Delegated Officer has determined that impacts on marine turtles from light are regulated under MS 800 (condition 16) via the Long Term Marine Turtle Management Plan.

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		**Potential emissions**	**Potential receptors**	**Potential pathway**	**Potential adverse impacts**		
		Breach of containment (storage of condensate and other chemicals including MEG, aMDEA, refrigerant (propane and ethane), HCL and NaOH)	Flora and fauna within the Class A Nature Reserve Marine environment (<50m)	Direct discharge	Soil and groundwater contamination inhibiting vegetation growth and survival and health impacts to terrestrial and subterranean fauna. Contamination of the marine environment should spills migrate.	Yes	See section 9.9
Category 52 ***Power Generation***	Gas turbines generators	Air emissions - point sources Combustion gases and Hg O_3 (secondary pollutant)	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	As above, receptor not considered and separation distance
			Flora and fauna within the Class A Nature Reserve		Survival and health impacts to flora and fauna	Yes	See sections 9.4 (combustion gases), 9.5 (mercury), and 9.7 (O_3)
		Noise	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	As above, receptor not considered and separation distance.
		Light	Turtle nesting beaches located 300 m away		Disruption to turtle nesting behaviour.	No	As above, regulated under MS 800.

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		**Potential emissions**	**Potential receptors**	**Potential pathway**	**Potential adverse impacts**		
Category 62 Waste storage	Handling and stockpiling of concrete waste	Dust	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	As above, receptor not considered and separation distance
			Vegetation adjacent to waste processing areas		Potential suppression of photosynthetic and respiratory functions	Yes	See section 9.10.
	Receipt, handling and storage of solid and liquid wastes at the Waste Transfer Station	Asbestos dust	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow		N/A	No	As above, receptor not considered and separation distance
		Noise					
		Odour	Fauna within the Class A Nature Reserve		Alteration of normal behaviours and breeding of native fauna impacting population dynamics and ecosystem function	Yes	See section 9.11
		Breach of containment of storage tanks	Flora and fauna within the Class A Nature Reserve	Direct discharge	Soil and groundwater contamination inhibiting vegetation growth and survival and health impacts to terrestrial and subterranean fauna	Yes	See section 9.9

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
		Litter	Fauna within the Class A Nature Reserve	Air / wind dispersion	Fauna injury/fatality due to ingestion or entrapment. Alteration of normal behaviours and breeding of native fauna impacting population dynamics and ecosystem function	Yes	See section 9.11
Category 54 ***Wastewater Treatment Plant***	Treatment of sewage	Odour	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	As above, receptor not considered and separation distance
		Light	Turtle nesting beaches located 300 m away	Air dispersion	Disruption to turtle nesting behaviour.	No	As above, regulated under MS 800.
	Sewage pipes and holding tanks	Rupture of pipes or overtopping of holding tanks	Vegetation adjacent to discharge area Groundwater and adjacent marine environment	Direct discharge	Soil contamination inhibiting vegetation growth and survival Groundwater contamination Nutrient enrichment of marine environment	Yes	See section 9.9

	Use of treated wastewater for dust suppression	Discharge to ground	Vegetation adjacent to discharge area Groundwater and adjacent marine environment	Direct discharge	Soil contamination inhibiting vegetation growth and survival Groundwater contamination Nutrient enrichment of marine environment	No	Currently all wastewater from the WWTP is disposed of via deep well injection. The Applicant has indicated that there may be scope in the future to reuse wastewater for dust suppression on roads and other construction areas. The Applicant holds relevant approvals from Department of Health for the re-use of wastewater which focus on impacts on human health. The re-use of treated effluent outside of the Premises boundary is not within the scope of this Licence and is subject to the UDRs and the general provisions of the EP Act regarding causing pollution. The Solid and Liquid Waste Management Plan states: "*The requirements for discharge to the terrestrial environment are defined in the operating licence obtained under Part V of the EP Act, where applicable. Where disposal of liquid waste is not managed under Part V of the EP Act, discharges to the terrestrial environment will be assessed in accordance with this Plan. An environmental assessment will be conducted to minimise potential environmental risks to ALARP and to ensure no pollution or Material or Serious Environmental Harm is caused. This assessment considers factors such as:* • *characteristics of the waste* • *characteristics of the receiving environment* • *potential to cause pollution (as defined by section 72 of the EP Act)* • *potential impacts to fauna, flora, and fauna habitats* • *potential run-off and sedimentation impacts, such as erosion*." The Delegated Officer considers that the Solid and Liquid Waste Management Plan can adequately regulate non-standard

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
							discharges of treated wastewater where it is used for dust suppression. Discharge of treated water for dust suppression is also subject to the UDRs and the general provisions of the EP Act regarding causing pollution.
	Disposal of liquid wastes (injection well failure)	Discharge to groundwater	Groundwater dependent ecosystems; subterranean fauna	Direct discharge (deep well injection via the Permanent Disposal Wells and Temporary Wastewater Injection Plant)	Groundwater contamination causing health impacts to subterranean fauna	Yes	See section 9.13
Category 73 ***Bulk storage of chemicals***	Bulk storage of fuel	Breach of containment	Flora and fauna within the Class A Nature Reserve Marine environment (<50m)	Direct discharge	Soil and groundwater contamination inhibiting vegetation growth and survival and health impacts to terrestrial and subterranean fauna	Yes	See section 9.9
		Odour	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	As above, receptor not considered and separation distance
		Light	Turtle nesting beaches located 300m away		Disruption to turtle nesting behaviour.	No	As above, regulated under MS 800.
Stormwater drainage infrastructure	Capture, treatment and disposal of potentially	Discharge of stormwater to ground	Terrestrial ecosystems Groundwater dependent	Direct discharge Indirect discharge via	Disruption of normal ecosystem function	Yes	See section 9.12

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		**Potential emissions**	**Potential receptors**	**Potential pathway**	**Potential adverse impacts**		
	contaminated stormwater at the GTP, bridging WWTP and diesel storage facility		ecosystems	infiltration	Reduction in groundwater quality impacting on groundwater dependent flora and fauna		
					Soil contamination inhibiting vegetation growth and survival		
Liquid Waste Facility	Disposal of liquid wastes via deep well injection via the Permanent Disposal Wells and Temporary Wastewater Injection Plant	Discharge to groundwater aquifer via seepage of liquid wastes from receiving formations	Groundwater dependent ecosystems, subterranean fauna	Indirect	Groundwater contamination causing health impacts to subterranean fauna	Yes	See section 9.13
		Discharge to groundwater following well failure	Groundwater dependent ecosystems, subterranean fauna and terrestrial and marine flora and fauna	Direct discharge	Contamination of surrounding land, drainage paths, marine waters and groundwater causing health impacts to terrestrial, marine and subterranean fauna and flora		

Table 25 Identification of emissions, pathway and receptors during upset conditions

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		**Potential emissions**	**Potential receptors**	**Potential pathway**	**Potential adverse impacts**		
Category 10 and 34 LNG and DomGas processing trains and storage facilities	Flaring	Air emissions – point source Combustion gases and Hg	Applicant operated accommodation camps (Butler Park and OWA Camp) Varanus Island Onslow	Air / wind dispersion	N/A	No	As above, receptor not considered and separation distance
			Flora and fauna within the Class A Nature Reserve		Survival and health impacts to flora and fauna	Yes	See sections 9.4 (combustion gases) and 9.7 (O_3)
		Dark smoke	Nearest human receptors are the Licensee operated accommodation camps (Butler Park and OWA Camp).		Impact on visual amenity	No	As above, receptor not considered and separation distance Note: air quality impacts associated with flaring and dark smoke are assessed under section 9.4.

9.2 Consequence and likelihood of risk events

A risk rating will be determined for risk events in accordance with the risk rating matrix set out in Table 14 below.

Table 26: Risk rating matrix

Likelihood	Consequence				
	Slight	Minor	Moderate	Major	Severe
Almost certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	Extreme
Unlikely	Low	Medium	Medium	Medium	High
Rare	Low	Low	Medium	Medium	High

DWER will undertake an assessment of the consequence and likelihood of the Risk Event in accordance with Table 15 below.

Table 27: Risk criteria table

Likelihood		Consequence		
The following criteria has been used to determine the likelihood of the Risk Event occurring.		The following criteria has been used to determine the consequences of a Risk Event occurring:		
			Environment	Public health* and amenity (such as air and water quality, noise, and odour)
Almost Certain	The risk event is expected to occur in most circumstances	Severe	• **onsite impacts**: catastrophic • **offsite impacts local scale**: high level or above • **offsite impacts wider scale**: mid-level or above • Mid to long-term or permanent impact to an area of high conservation value or special significance^ • Specific Consequence Criteria (for environment) are significantly exceeded	• Loss of life • **Adverse health effects:** high level or ongoing medical treatment • Specific Consequence Criteria (for public health) are significantly exceeded • **Local scale impacts:** permanent loss of amenity
Likely	The risk event will probably occur in most circumstances	Major	• **onsite impacts**: high level • **offsite impacts local scale**: mid-level • **offsite impacts wider scale**: low level • Short-term impact to an area of high conservation value or special significance^ • Specific Consequence Criteria (for environment) are exceeded	• **Adverse health effects:** mid-level or frequent medical treatment • Specific Consequence Criteria (for public health) are exceeded • **Local scale impacts**: high level impact to amenity
Possible	The risk event could occur at some time	Moderate	• **onsite impacts**: mid-level • **offsite impacts local scale**: low level • **offsite impacts wider scale**: minimal • Specific Consequence Criteria (for environment) are at risk of not being met	• **Adverse health effects:** low level or occasional medical treatment • Specific Consequence Criteria (for public health) are at risk of not being met • **Local scale impacts:** mid-level impact to amenity
Unlikely	The risk event will probably not occur in most circumstances	Minor	• **onsite impacts**: low level • **offsite impacts local scale**: minimal • **offsite impacts wider scale**: not detectable • Specific Consequence Criteria (for environment) likely to be met	• Specific Consequence Criteria (for public health) are likely to be met • **Local scale impacts:** low level impact to amenity
Rare	The risk event may only occur in exceptional circumstances	Slight	• **onsite impact**: minimal • Specific Consequence Criteria (for environment) met	• **Local scale**: minimal to amenity • Specific Consequence Criteria (for public health) met

^ Determination of areas of high conservation value or special significance should be informed by the *Guidance Statement: Environmental Siting.*

* In applying public health criteria, DWER may have regard to the Department of Health's *Health Risk Assessment (Scoping) Guidelines.*

"onsite**"** means within the Prescribed Premises boundary.

9.3 Acceptability and treatment of Risk Event

DWER will determine the acceptability and treatment of Risk Events in accordance with the Risk treatment table 16 below:

Table 28: Risk treatment table

Rating of Risk Event	Acceptability	Treatment
Extreme	Unacceptable.	Risk Event will not be tolerated. DWER may refuse application.
High	May be acceptable. Subject to multiple regulatory controls.	Risk Event may be tolerated and may be subject to multiple regulatory controls. This may include both outcome-based and management conditions.
Medium	Acceptable, generally subject to regulatory controls.	Risk Event is tolerable and is likely to be subject to some regulatory controls. A preference for outcome-based conditions where practical and appropriate will be applied.
Low	Acceptable, generally not controlled.	Risk Event is acceptable and will generally not be subject to regulatory controls.

9.4 Risk assessment – combustion gases (NOx, SOx, VOCs, CO) and PM

9.4.1 Description of emission

Emissions from the Premises includes combustion gases such as NOx, CO, SOx, VOCs and PM from burning of natural gas. Natural gas is used as the fuel source in the GTGs, GTs and heating medium heaters. Combustion of natural gas also occurs during flaring when excess gas is purged/released from the ground and BOG flares for safety and operational purposes.

9.4.2 Identification and general characterisation of emission

Design specifications for the above equipment are summarised in Table 29 and Table 30.

Table 29: Base emission rates and design emission targets for Frame 9 GTG, Frame 7 GTs and heating medium heaters

Pollutant	Base emission rates at actual exhaust gas conditions[1, 2, 3] (g/s)	Base emission concentrations at standard reference conditions[4] (mg/m^3)
Frame 9 GTGs		
NOx	14.9	51.3
CO	5.5	18.7
NMVOC	0.4	1.2
SOx	0.004	0.01
Frame 7 GTs		
NOx	11.6	51.3 (59.5[5])

Pollutant	Base emission rates at actual exhaust gas conditions[1, 2, 3] (g/s)	Base emission concentrations at standard reference conditions[4] (mg/m^3)
CO	4	18.8
NMVOC	0.3	1.2
SOx	0.004	0.02
Heating Medium Heaters[6, 7, 8]		
NOx	1.7	80
CO	0.8	39
NMVOC	0.2	8
SOx	0.001	0.4

Note 1. Base emission rates for GTGs reported in g/s are emission rates at actual exhaust gas conditions i.e. 1 atmosphere and 550 °C temperature; 8.15% water content, and 13.47% oxygen level.
Note 2. Base emission rates for GTs reported in g/s are emission rates at actual exhaust gas conditions, i.e. 1 atmosphere and 548.3 °C temperature; 8.04 % water content, and 13.59 % oxygen level.
Note 3. Base emission rates for Heating Medium Heaters reported in g/s are emission rates at actual exhaust gas conditions, i.e. 1 atmosphere and 442 °C temperature; 18.04% water content, and 2.4% oxygen level.
Note 4. Base emission concentrations reported in mg/m^3 are calculated at standard reference conditions (e.g. dry conditions, 1 atmosphere, 0 °C, 15% oxygen reference level for GTGs and GTs and dry conditions, 1 atmosphere, 0 °C, 7% oxygen reference level for Heating Medium Heaters).
Note 5. Concentration in brackets is design concentration following modifications to GTs
Note 6. NO_x base emission concentrations is based on 50 ppmv NO_x (manufacturer's data, dry conditions, 3% oxygen level).
Note 7. CO base emission concentrations is based on 40 ppmv CO (manufacturer's data, dry conditions, 3% oxygen level).
Note 8. NMVOC base emission concentrations are calculated using the United states Environmental Protection Agency (USEPA) AP42 factors for boiler/furnace with a heat output greater than 1—MMBtu/h at 15% excess air.

Table 30: Base emission rates for flares

Pollutant	Base emission rate – Routine flaring (g/s)	Base emission rate – Non-routine (process upset) flaring (g/s)
Dry Flare System[1, 2]		
NOx	0.2	246
CO	1	1338
NMVOC	0.2	611
SOx	0.00004	0.009
Wet Flare System[3, 4]		
NOx	0.1	170
CO	0.6	926
NMVOC	0.04	223
SOx	0.00004	10
Enrichment Gas (dry and wet flares)[5]		
NOx	0.9	N/A

Pollutant	Base emission rate – Routine flaring (g/s)	Base emission rate – Non-routine (process upset) flaring (g/s)
CO	5.1	N/A
NMVOC	1.2	N/A
Sox	0.001	N/A
BOG Flare[6, 7]		
NOx	0.01	47
CO	0.1	253
NMVOC	0.003	116
SOx	0.000005	0.0016

Note 1. Base emission rates for CO and NO_x were calculated based on emission factors for industrial flares in USEPA AP42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources, and calculated for a combined pilot and purge gas flow rate of 263 kg/h and compressor seal gas flow rate of 260.9 kg/h. Sulfur emissions are based on the maximum expected content of sulfur in the fuel gas (52tabili. 150 ppbv). The flare is specified as smokeless; hence, PM10 emissions are negligible and not included above.

Note 2. The process upset flaring rate is assumed to represent 20% of the design dry flare relief case of 831.3 kg/s, equivalent to 598 320 kg/h. The dry flare relief case is based on a propane refrigerant compressor blocked outlet (one LNG train) plus LNG train startup flaring from scrub column overhead at 30% flow.

Note 3. Base emission rates for CO and NO_x were calculated based on emission factors for industrial flares in USEPA AP42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources, and calculated for a combined pilot and purge gas flow rate of 273 kg/h and compressor seal gas flow rate of 28.6 kg/h. Sulfur emissions are based on the maximum expected content of sulfur in the fuel gas (52tabili. 150 ppbv). The flare is specified as smokeless; hence, PM10 emissions are negligible and not included above.

Note 4. The process upset flaring rate is assumed to represent 20% of the design dry flare relief case of 574.5 kg/s, equivalent to 413 640 kg/h. The wet flare relief case is based on a blocked discharge at the Gorgon inlet facilities scenario.

Note 5. Base emission rates for CO and NOx were calculated based on emission factors for industrial flares in USEPA AP42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources for an enrichment gas flow rate of 2285 kg/h.

Note 6. Base emission rates for CO and NOx were calculated based on emission factors for industrial flares in emission factors for industrial flares in USEPA AP42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources, and calculated for a pilot gas flowrate of 36 kg/h. Sulfur emissions are based on the actual content of sulfur in the LNG (<17 mg/Nm3). The flare is specified as smokeless; hence, PM10 emissions are negligible and not included above.

Note 7. The worst-case process upset flaring rate is assumed to represent simultaneous failure/unavailability of both BOG compressors, resulting in an instantaneous hydrocarbon rate to flare of 31.5 kg/s, equivalent to 113 364 kg/h.

Under normal operating conditions the GTGs operate under an N+1 configuration, whereby four GTGs are operational and one is on standby. The heating medium heaters operate infrequently; i.e. they are designed to operate only when the Frame 7 GTs are offline or when duty heat from the WHRUs is not sufficient to meet demand. Flaring is only anticipated during upset conditions or during planned and unplanned shutdowns. No flaring is anticipated during normal operations (apart from maintenance of a pilot flame).

As discussed in section 6.4.1, GTGs and GTs are not currently operating at loads sufficient to enable emissions controls (i.e. dry low NOx burners); as such, emission concentrations are higher than predicted. The low loads are a result of commissioning issues associated with the CO_2 compression and injection system. It is anticipated that once the CO_2 compression and injection system is operational, power demand will increase and load requirements for activating the dry low NOx burners will be met. Point source emissions monitoring carried out (Table 18 and Figure 4) indicates that with the dry low NOx burners operating, emissions will generally meet design specifications. There is some variability in the results for the GTs where design criteria were not met following the tuning of the dry low NOx burners and further testing may be required to confirm continued performance.

The primary point source of particulate emissions is from incomplete combustion during flaring generating dark smoke (soot). Particulate emissions from the GTGs and GTGs are not considered significant and are generally below 5 mg/Nm^3 for gas turbines. VOC emissions from the gas turbines are also low due to their high combustion efficiency.

Burning of liquid hydrocarbons or incomplete combustion during flaring can also contribute to dark smoke and result in increased emissions of VOCs. During a typical operating year, non-routine flaring is estimated to occur for 135 hours (average) for the wet and dry flares combined. Non-routine flaring associated with the BOG flare include planned flaring associated with warm LNG carrier de-inerting and unplanned flaring associated with BOG compressor/BOG recycle compressor failure. The plant design assumes 12 warm LNG carriers per year with flaring occurring for a period of approximately 24 hours. Design estimates state that unplanned BOG flaring could occur for up to 115 hours per year.

The quantity of gas flared during commissioning was higher than predicted due to delays in commissioning and additional startups required for each train (Table 31). Delays to the BOG recycle compressor, BOG compressor and end flash gas compressor also resulted in higher flaring as BOG was not able to be recirculated to the LNG trains.

Table 31: Estimated and actual quantities of gas flared during commissioning

Point source	Estimated total Quantity (tonnes)	Measured quantity of gas flared (tonnes)	Percent difference (tonnes)
Wet ground flares	422,200	802,792	190%
Dry ground flares	493,000	712,950	145%
BOG flares	36,600	298,849	816%

9.4.3 Description of potential adverse impact from the emission

Gases (NOx, SOx, CO, VOCs) and PM are common pollutants produced by industrial processes and motor vehicles as a result of fuel combustion. The ratio and rate of pollutants produced are dependent on fuel type and combustion efficiency. For humans; both short-term exposure and long-term exposure to increased levels of NOx and SO_2 may cause respiratory irritation and problems, particularly for those with asthma. Exposure to CO at high concentrations for short periods may affect the amount of oxygen in the bloodstream, leading to fatigue and dizziness.

As discussed in section 0 and risk tables above, for the purposes of this assessment, no human receptors were identified on Barrow Island. Key receptors include the flora and fauna found on the island; however, no data is available on the effects of these pollutants on the flora and fauna of Barrow Island (EPA, 2009).

Acid deposition occurs when SO_2 and NOx react with water, oxygen and other oxidants in the atmosphere to form acidic compounds which precipitate in rain or in dry form as gas or particles. Deposition of SO_2 and NOx can contribute to acidification of surface waters and potentially damage vegetation.

9.4.4 Criteria for assessment

In the absence of criteria specific to fauna, the NEPM assessment criteria for humans are considered appropriate surrogates for assessing impacts to fauna (Table 32).

Table 32: NEPM assessment criteria

Pollutant	Averaging period	Maximum concentration (µg/m^3)
NO_2	1-hour	247
	Annual	62
CO	8-hour	11,254
SO_2	1-hour	572
	24-hours	229
	Annual	57
Particulates as PM_{10}	24-hours	50
	Annual	25

Assessment criteria for NOx and SOx impacting on vegetation have been derived from the WHO Air Quality Guidelines for Europe (WHO, 2000) which recommend critical levels and critical loads for NOx and SOx deposition (Table 33).

Table 33 WHO Air Quality Guidelines for Europe (WHO 2005) deposition limits

Pollutant	Units	NOx	SO_2
Critical level	µg/m^3 [1]	30	10 – 30
Critical load	kg/ha/year	15 – 20[2]	8 – 16

Note 1: Expressed as an annual mean
Note 2: Based on lowland dry heathland

Point source emission targets are specified in the Air Quality Management Plan (Table 34). These targets are based on the New South Wales *Protection of the Environment Operations (Clean Air) Amendment (Industrial and Commercial Activities and Plant) Regulations 2010*.

Table 34: Point source emission targets as described in the Air Quality Management Plan

Emission source	Pollutant	Emission target (mg/m^3) [1]
Frame 9 GTGs	NOx [2]	70
	CO [3]	125
	NMVOC [4]	40
Frame 7 GTs	NOx [2]	350
	CO [3]	125
	NMVOC [4]	40

Note 1. Emission targets apply at the point of discharge to the environment.
Note 2. Calculated as NO2 at a 15% oxygen reference level, dry, at 0 °C and 101.3 kPa.
Note 3. Calculated at 15% oxygen reference level, dry, at 0 °C and 101.3 kPa.
Note 4. Calculated at 3% oxygen reference level, dry, at 0 °C and 101.3 kPa.

9.4.5 Applicant controls

The facility has been designed to incorporate contemporary emission controls, which are detailed in the Best Practice Pollution Design Report developed under MS 800. Infrastructure and operational controls are summarised below:

- Dry low NO_x burners are fitted to the GTGs and GTs;
- Frame 7 GTs are fitted with WHRUs which provide the routine process heat requirements during normal operation of the GTP;
- Low NOx burners are installed on the heating medium heaters;
- Low sulfur content in fuel gas used in GTGs, GTs, heating medium heaters, and flares;
- Preventative maintenance has been implemented where appropriate;
- The GTP is designed so that no flaring occurs during standard operations other than flare pilots and purged gas;
- Dark smoke is minimised through the flare tip design, which allows high-pressure gas flow and efficient combustion to occur in a smokeless manner;
- No liquid burners have been installed;
- The ground flares have been designed to maximise the availability of pilots and their igniters and to ensure efficient combustion; and
- To prevent burning of entrained liquids which can damage the flare tips, the wet and dry gas flare knockout drums are appropriately sized to remove liquids from the flare gas and prevent carry over.

Flaring will be minimised by the following non-routine operating procedures:

- In the case of GTP emergencies, systems are designed to shut down the production facilities in a staged manner within the pressure limitations of each system to prevent flaring;
- The fuel gas system is balanced to the needs of the LNG train and GTG, preventing flaring of excess product;
- Compressors are provided with the ability to restart from a pressurised condition following a non-emergency trip, avoiding depressurising to the flare for startup;
- During standard operations, methane-rich gas from the condensate stabiliser is compressed and returned to the feed gas. If the stabiliser overhead compressors are offline the gas is routed to the recycle gas system, rather than being flared;
- The main cryogenic heat exchanger has the capability to route gas via a pipeline to the end flash gas compressor in the event of any tube leaks, rather than being flared;
- BOG produced during the cool-down process associated with de-inerting of warm LNG carriers is diverted to the BOG recycle compressor and recycled through the AGRUs in the LNG train; and
- In the event of a BOG compressor failure, the BOG recycle compressor can act as backup to the main BOG compressor so that BOG vapour can be routed to the recycle compressor, rather than being flared.

Emissions verification testing has been undertaken to verify emissions used for input in the modelling assessment (section 6.4.1). The Applicant carries out stack emission testing on the GTGs and GTs for NO_x, CO and VOCs in accordance with the requirements of Existing Licence L8952/2016/1 and Works Approval W5818/2012/1.

No stack testing is proposed for the heating medium heaters due to the low frequency of operation (i.e. they are only expected to operate when the Frame 7 GTs are offline or when duty heat from the WHRUs is not sufficient to meet demand). Regular maintenance programs are in place to ensure efficient operation of the heating medium heaters to maintain emissions at the design specifications.

The volume of gas vented and flared, and the fuel consumption of the GTGs and heating

medium heaters will continue to be monitored and recorded to check for variations from the assumptions made during this assessment.

Ambient air quality monitoring will continue to be undertaken in accordance with the Air Quality Management Plan developed under MS 800 (condition 29). Other environmental monitoring programs to monitor and identify adverse impacts on fauna and vegetation are carried out in accordance with the TSEMP.

9.4.6 Key findings

The Delegated Officer has reviewed the information regarding emissions of combustion gases and has found:

1. Although dry low NOx burner technology installed on the GTGs and GTs are not currently operational due to low power loads, emissions verification monitoring indicates that the design emission standards will be achieved once power load demand increases.
2. Ambient air quality monitoring indicates that the relevant air quality assessment criteria will be met without the dry low NOx burners operating and with increased flaring during commissioning.
3. Proposed modifications to the GTs is not expected to significantly change the likelihood of ground level concentrations meeting the relevant air quality assessment criteria.
4. Following the planned modifications, emissions from the GTs will require validation to confirm the manufacturer's design specifications have been met.
5. Premises power demand dictates the number of GTGs that are operational at any one time; therefore, the Applicant cannot guarantee that all five GTGs will be operational at the time of scheduled stack testing.
6. Ongoing ambient monitoring required under MS 800 will continue to verify ambient air quality is meeting relevant air quality criteria under all operating scenarios.

9.4.7 Consequence

Emissions modelling demonstrated that all relevant ambient air quality assessment criteria would be met during routine operations (section 6.1). The maximum modelled NO_2 ground level concentration on BINR during upset conditions (cold startup) was estimated to be 139% of the assessment criteria (Table 32). However, this maximum concentration was predicated to occur immediately north-east of the GTP.

Ambient air quality monitoring showed that the assessment criteria was met for combustion gases even with the GTGs and GTs operating without the dry low NOx burners and with the increased flaring experienced during commissioning. Although exceedances of the assessment criteria were recorded at the communication tower monitoring location, these were attributed to local sources (i.e. a temporary diesel generator interfering with data capture) (refer to section 6.4.2). The maximum ground level concentrations recorded at the communications tower monitoring station following the removal of the interfering emission source was 41.4 ppb (35% of the assessment criteria).

Proposed upgrades to the GTs are expected to result in a 16% increase in the concentration of NOx emitted to atmosphere, correlating to a similar increase in ambient concentrations. Based on the above, maximum ground level concentrations at the communication tower and Butler Park monitoring sites following the planned upgrades are estimated to be less than 50ppb (42% of the assessment criteria).

The Delegated Officer has determined that air quality assessment criteria are likely to be met and that there will be minimal off-site impact. Therefore, the Delegated Officer considers the consequence of combustion emissions to be **Minor**.

9.4.8 Likelihood of Risk Event

The Delegated Officer has determined that emissions of combustion gases impacting on flora and fauna on Barrow Island will probably not occur under most circumstances. Therefore, the Delegated Officer considers the likelihood to be **Unlikely**.

9.4.9 Overall rating of combustion emissions

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of combustion emissions is **Moderate**.

9.5 Risk assessment – mercury

9.5.1 Description of mercury emissions

Emissions of mercury are released to air from the GTGs, GTs, heating medium heaters, flares and AGRU vents potentially causing adverse impacts to flora and fauna on Barrow Island.

9.5.2 Identification and general characterisation of emission

Feed gas from the Janzs-Lo and Gorgon gas fields contains naturally occurring mercury, which is emitted to atmosphere during the LNG process via the AGRU vents, heating medium heaters, flares, GTs and GTGs. Applicant controls described below (section 9.5.5) mean that these sources only contribute a small portion of mercury emitted. The rich-MEG tank vents are considered the main source of mercury emissions during normal operations, contributing approximately 99.3% of mercury released to atmosphere from the Premises. During non-standard operations (continuous venting from all the AGRUs), the MEG flash gas compressor vent is the main source of mercury (approximately 98.8%).

Mercury emitted from the AGRU vents and rich-MEG tanks is considered to be predominantly in elemental form (>99%). Modelling assumed that the ratio of elemental, divalent and particulate mercury from the turbines and flares is 50:30:20 and 80:10:10 respectively.

9.5.3 Description of potential adverse impact from the emission

Mercury is a toxic element that has potential to cause health effects to humans and animals. It occurs naturally in the environment in three main forms; elemental, inorganic and organic. Elemental mercury readily vaporises and can cause adverse health effects if inhaled, such as neurological and behavioural disorders (WHO, 2003). When emitted to atmosphere, elemental mercury can be oxidised into other forms of mercury and deposited onto land and into aquatic systems. Chemical and biological processes can transform mercury into other inorganic and organic species that persist in the environment and bio-accumulate up the food chain. Airborne residence times of elemental mercury can range from half a year to two years (Denis *et a*l., 2006).

9.5.4 Criteria for assessment

The Department of Environment and Conservation (NSW) *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*, 2005 provides impact assessment criteria for mercury. The assessment criteria of 1.8 µg/m^3 (1-hour average) of inorganic mercury applies at and beyond the Premises boundary.

The WHO *Concise International Chemical Assessment Document 50 Elemental mercury and inorganic mercury compounds: Human health aspects*, 2003 recommends an impact assessment criteria for elemental mercury of 0.2 µg/m^3 (annual average). This is the tolerable concentration for long-term inhalation exposure to elemental mercury vapour.

The national occupational exposure standard (SWA, 2013) for elemental mercury is 25 µg/m^3 (time weighted average measured over a normal 8 hour work day and 40 hour work week).

9.5.5 Applicant controls

The Premises has been designed to incorporate contemporary emission controls which are detailed in the Best Practice Pollution Design Report developed under MS 800. Emission controls are summarised below:

- Mercury Removal Units (MRUs) are installed upstream of each AGRU to prevent mercury being released via acid gas venting;
- MRUs are also installed on each LNG train prior to the main cryogenic heat exchangers;
- MRUs are installed upstream of the high-pressure fuel gas system to reduce mercury content in fuel gas powering utilities including the GTGs and heating medium heaters;
- Preventative maintenance program has been implemented where appropriate;
- Routine performance monitoring of the MRUs is undertaken to ensure the manufacturer's specifications are being achieved, including monitoring of the mercury concentration upstream of the MRUs, monitoring the pressure drop across the absorbent bed, and monitoring of MRU effluent concentrations.

The MRUs are capable of removing mercury down to 0.01 µg/m^3, which is the specification required for the aluminium equipment in the LNG train.

In addition to pollution control equipment, environmental monitoring programs (e.g. monitoring groundwater, terrestrial flora and fauna, and marine water quality) have been implemented to detect any adverse environmental impacts in accordance with management plans developed under MS 800.

9.5.6 Consequence

Mercury emissions are expected to be minimal with ground level mercury concentrations during non-routine operations (acid gas venting) estimated to be less than 5% of the assessment criteria (Table 16). Although emissions modelling did not explicitly consider the scenario of 100% venting from three AGRU trains, the Delegated Officer considers that mercury levels will remain low and ambient air quality assessment criteria will be met. Results of testing undertaken during commissioning indicates that MRUs are meeting design specifications (Chevron, 2017a). Emissions are expected to be further reduced once the CO_2 injection system becomes operational resulting is less venting to atmosphere.

Based on this information mercury emissions are expected to have minimal on-site impact and therefore the Delegated Officer considers the consequence of mercury emissions to be **Slight**.

9.5.7 Likelihood of Risk Event

The Delegated Officer has determined that the likelihood of mercury emissions causing low level environmental impact on Barrow Island will be **Rare**.

9.5.8 Overall rating of mercury emissions

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of mercury emissions is **Low**.

9.6 Risk assessment – acid gas venting (BTEX and H_2S)

9.6.1 Description of emissions from acid gas venting

The acid gas containing CO_2 and minor residual amounts of VOCs and H_2S is vented to atmosphere via the AGRU vents. Each AGRU has its own acid gas vent (three in total). Secondary releases of acid gas are also emitted through other vents (see Table 35).

9.6.2 Identification and general characterisation of emission

Due to delays in the operation of the CO_2 compression and injection system, all acid gas from the three LNG trains is vented from the AGRUs. Continuous acid gas venting is expected to be temporary until the CO_2 compression and injection system becomes available (expected Q4 2018).

Once the CO_2 compression and injection system is operational it is planned that all acid gas will be compressed and injected into the subsurface geological formation beneath the BINR. After this point, acid gas venting will only occur in the event of a failure of the CO_2 compression and injection system, process trip, or during other process upset conditions. It is anticipated that approximately half of these events will occur from 15 minutes to one hour, with most remaining events lasting between four hours and one week (cumulative total 73 days per year).

Condition 26.2 of MS 800 specifies that all practical measures must be taken to inject acid gas with a target of 80% of acid gas injected (calculated over a 5 year rolling average). Chevron's long-term performance target is to inject 95% of acid gas into the Dupuy Formation per year.

Estimated emission rates are provided in Table 35. These rates represent the maximum pollutant emissions during upset conditions (i.e. CO_2 compression and injection system failure). Measured emissions rates are the results of compositional analysis undertaken as part of emissions verification.

Table 35: Estimated base emission rates and actual emissions from AGRU vents.

Source [1]	Vent description and location	Pollutant base emission rate (g/s)			Measured emission rate (g/s) [2]	
		NMVOC	BTEX	H_2S	BTEX	H_2S
Vent 1	The main low-pressure acid gas vent stack from the discharge of the Amine Regenerator Reflux Drum Vent in each of the AGRUs (three in total)	8.04	104.9	8.1	52.6	1.1 – 2.7
Vent 6	Low-pressure vent upstream of MEG flash gas compressor (one in total)	2.03	6.05	0.65	Flow rates too low to allow sampling for compositional analysis	

Note 1: Only Vents 1 and 6 will be operational under this Licence as remaining vents relate to CO_2 compression and injection infrastructure.
Note 2: NMVOC emissions were not determined.

9.6.3 Description of potential adverse impact from the emission

BTEX compounds are toxic and can potentially cause a wide range of significant health effects impacting the neurological and respiratory systems. Benzene is also a known carcinogen.

Hydrogen sulfide has a pungent odour at low concentrations; however, there are few detectable toxicological health hazards at concentrations less than 1 ppm (1.5 mg/m^3) even with exposure for long periods. Eye irritation can occur between 10 to 20 ppm. Respiratory difficulties can be experienced above 320 ppm (WHO, 2000).

9.6.4 Criteria for assessment

Assessment criteria for BTEX compounds are provided in the NEPM and are detailed in Table 36.

Table 36: NEPM (Air Toxics) standards for BTEX

Pollutant	Averaging period	Monitoring investigation level		Goal (Maximum allowable exceedance)
		ppm	µg/m^3	
Benzene [2]	1 year	0.003	9.6	-
Toluene [2]	1 day	1.0	3780	-
	1 year	0.1	380	-
Xylene [2]	1 day	0.25	1085	-
	1 year	0.2	870	-

The NSW DEC *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW DEC, 2005) sets residential criteria for H_2S based on population density. Criteria range from 4.83 µg/m^3 for a population of less than two, to 1.38 µg/m^3 for populations greater than 2,000 (1 hour averaging period).

The WHO provides a criteria for H_2S of 7 µg/m^3 (30-minute average) which is based on odour annoyance (WHO, 2000). The recommended guideline for eye irritation is 150 µg/m^3 (24-hour average) (WHO, 2000).

In the absence of residential receptors on the island, the WHO criteria of 150 µg/m^3 (24-hour average) has been adopted as a surrogate to assess health impacts to fauna as it represents actual health impacts rather than nuisance odour.

9.6.5 Applicant controls

The location of vents, size, overall stack height and anticipated flow rates of exit gas all promote the dispersion of the acid gas vented. Ground level concentrations will be reduced as a result of the design features and the operating philosophy.

Venting of acid gas is considered temporary e until the CO_2 compression and injection system is functioning. It is expected that once the CO_2 compression and injection system is operational, all acid gas will be compressed and injected. Some venting may occur during process trips or with process upset conditions however these events will be infrequent and short term.

Environmental monitoring will continue in accordance with the TSEMP to identify potential impacts to fauna and flora.

9.6.6 Key findings

The Delegated Officer has reviewed the information regarding acid gas emissions and has found:

1. Condition 26 of MS 800 specifies an injection target for acid gas of 80% (calculated of a 5 year rolling average) and compliance with this target is managed under Part IV of the EP Act.

9.6.7 Consequence

The predicted ground level concentration of H_2S and BTEX at selected sensitive receptor locations were below the relevant assessment criteria (section 6.1).

A screening level ERA was also undertaken to assess impacts on marine and terrestrial flora and fauna, which concluded that predicted ground level concentrations of H_2S and BTEX under all modelled acid gas venting scenarios showed no potential for material or serious environmental harm (Section 6.2). Worst case conditions, considered to be simultaneous venting of acid gas from three AGRUs, may result in short-term reversible impacts to susceptible flora and fauna; however, the likelihood of this event occurring has been calculated to be 0.07%. The Delegated Officer notes that the ERA does not consider the current operating scenario where simultaneous venting will occur from all three AGRUs for an extended period (at least 1 year).

Modelling of BTEX emissions considered six scenarios, including the unavailability of the CO_2 compression and injection system due to planned maintenance or a process trip resulting in venting from the AGRU. The maximum annual average concentrations of benzene outside the GTP were predicted to be 40% of the assessment criteria while toluene and xylene were predicted to be less than 5% of the criteria. The maximum 1-hourly concentrations of BTEX were predicted to be 11% of the assessment criteria at Butler Park. Although emissions modelling did not explicitly consider the current scenario of 100% venting from three AGRU trains on a long term continuous basis, the Delegated Officer considers that BTEX levels will remain low and that ambient air quality assessment criteria will be met.

Ambient air quality monitoring data indicates that there were seven exceedances of the H_2S criteria (7 µg/m^3) at the communications tower monitoring location attributable to GTP emission sources (section 6.3). However, this criteria is set for odour annoyance to human receptors. The maximum measured concentration of H_2S (24-hour average) was 1.2 ppb (approximately 18 µg/m^3) which is significantly less than the WHO guideline for health impacts.

Despite modelling under-predicting concentrations of H_2S, the Delegated Officer considers that there will be minimal on-site impacts from BTEX and H_2S emissions and therefore has determined the consequence of BTEX and H_2S emissions to be **Slight**.

9.6.8 Likelihood of Risk Event

The Delegated Officer has determined that the likelihood health impacts to fauna occurring will be **Rare**.

9.6.9 Overall rating of acid gas venting

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of BTEX and H_2S emissions is **Low**.

9.7 Risk assessment – ozone

9.7.1 Description of ozone emissions

Ozone is a secondary pollutant produced by the reaction of NOx, VOCs and sunlight. Emissions of NO_X and VOCs from various sources including the GTGs, GTs, flares and acid gas venting all contribute to the creation of ground level ozone. Ozone is also a naturally occurring pollutant.

9.7.2 Description of potential adverse impact from the emission

Ozone can be toxic with potential health effects including eye and throat irritation and exacerbation of existing respiratory problems. Impacts to vegetation from ozone exposure include visible foliage injury, growth retardation, and increased sensitivity to stress (WHO, 2000).

9.7.3 Criteria for assessment

Assessment criteria for ozone are provided in the NEPM and are detailed in Table 37.

Table 37: NEPM standards for ozone

Pollutant	Averaging period	Monitoring investigation level		Goal (Maximum allowable exceedance)
		ppm	µg/m^3	
O_3	1 hour	0.10	214	1 day a year
	4 hours	0.08	171	1 day a year

9.7.4 Applicant controls

The location of vents, size, overall stack height and anticipated flow rates of exit gas all promote the dispersion of the pollutants via their source. A summary of controls for reducing NOx and VOC emissions has been provided in sections 9.4.5 and 9.6.5.

Venting of acid gas is considered a temporary emission until the CO_2 compression and injection system is functioning. It is expected that once the CO_2 compression and injection system is operational, all acid gas will be compressed. Some venting may occur during process trips or with process upset conditions; however, these events will be infrequent and short term.

Ambient air quality monitoring will continue in accordance with the *Air Quality Management Plan* to monitor for assessment criteria exceedances and to identify any potential impacts.

9.7.5 Key findings

The Delegated Officer has reviewed the information regarding ozone and has found:

1. Ozone is not a direct emission but is created by the reaction of NOx and VOC emissions in the atmosphere.
2. Ongoing ambient monitoring will be carried out in accordance with requirements of MS 800.

9.7.1 Consequence

The 2008 modelling studies indicated that ground level concentrations of ozone could reach 93.5% of the assessment criteria at the accommodation facilities (Table 10). It is noted that this was based on a worst case scenario of all three AGRUs venting simultaneously. Further modelling was undertaken in 2010 to improve the accuracy of these predictions. Results showed a significant reduction in ozone concentrations with the maximum ground level concentrations of ozone anywhere on Barrow Island predicted to be 78% (1 hour average) and 70% (4 hour average) of the assessment criteria (Table 12).

Ambient air quality monitoring data indicates that ground level ozone concentrations will meet the assessment criteria. There is some evidence that high ozone events occur due to recirculation of NOx emission plumes from the GTP; however, for these events the peak 1-hour ozone concentration was estimated to be 0.052 ppm (52% of the criteria). Although one exceedance of the 1-hour criteria and three exceedances of the 4-hour criteria were recorded

(section 6.4.2), these all occurred on the same day and were attributed to regional sources (i.e. bushfires) rather than the operation of the GTP.

The Delegated Officer has determined that consequence criteria for ozone are at risk of being met, due to potential exceedances associated with regional sources (i.e. bushfires). Low-level off-site impacts from O_3 may occur and wider scale off-site impacts will are expected to be minimal. The Delegated Officer has determined the consequence of ozone emissions to be **Moderate**.

9.7.2 Likelihood of Risk Event

The Delegated Officer has determined that the likelihood of health impacts to vegetation and fauna occurring will be **Rare**.

9.7.3 Overall rating of ozone

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of ozone emissions is **Medium**. Ozone levels will continue to be monitored in accordance with commitments of the *Air Quality Management Plan*.

9.8 Risk assessment – fugitive gaseous emissions

Gaseous compounds escaping from valves, flanges, pump seals, connectors and storage of environmentally hazardous materials can have adverse impacts on local air quality. However, fugitive releases of gaseous compounds are expected to be minimal.

Applicant controls in place to prevent the release of fugitive emissions include:

- The processing plant and storage facilities are constructed in accordance with relevant safety standards;
- The condensate tanks are fitted with internal floating roofs to minimise VOC emissions;
- The MEG, aMDEA, HCl and NaOH tanks are designed with nitrogen blanketing to prevent emissions;
- A vent fume scrubber is also installed in the HCl tank roof to reduce venting emissions; and
- Preventative maintenance procedures are in place for the GTP and storage facilities including a leak detection and repair program.

9.8.1 Consequence

The Delegated Officer has determined there will be minimal impacts from fugitive gaseous emissions and therefore the consequence is considered to be **Slight**.

9.8.2 Likelihood of Risk Event

The Delegated Officer has determined that the likelihood health impacts to vegetation and fauna occurring will be **Rare**.

9.8.3 Overall rating of fugitive gaseous emissions

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of fugitive gaseous emissions is **Low**.

9.9 Risk assessment – breach of containment (hazardous material storage)

9.9.1 Description of hazardous materials storage

Spills and or leaks from the containers and pipelines may result in hazardous materials entering the environment and causing contamination of the soil, groundwater or nearby marine environment.

9.9.2 Identification and general characterisation of emission

Various types and quantities of hazardous materials are stored onsite including hydrocarbons (condensate and refrigerants) and other process chemicals. Large quantities of hazardous materials located at the GTP are described in the table below.

Table 38: Types and quantities of significant volumes of hazardous materials stored at the GTP.

Material description	Quantity
Condensate	4 x 38,000 m^3
LNG	2 x 180,000 m^3
MEG	4 x 2,403 m^3 lean-MEG
	4 x 4,719 m^3 rich-MEG
aMDEA	2,792 m^3
HCl	319 m^3
NaOH	319 m^3
Ethane	602 m^3
Propane	2,443 m^3
Diesel	7 x 110 m^3 and 2 x 160 m^3 tanks

The waste transfer station receives, stores, and handles liquid wastes including hydrocarbons, paints, resins, acids, alkalis and other chemicals. These waste streams are usually received in small containers and stored in concrete or temporary bunds.

The bridging WWTP contains also tanks for the storage and treatment of sewage. There are three treatment trains consisting of equaliser tanks, anoxic and aerobic treatment tanks, membrane bioreactor tanks, aerobic digester tanks, and chemical dosing tanks.

9.9.3 Description of potential adverse impact from the emission

Spills of hazardous materials such as hydrocarbons, acids, raw/treated sewage and other chemicals may result in a direct loss of habitat and contamination of land at the location of the spill. Contamination of the marine environment can also occur if materials drain overland towards the coast. Containment leaks can result in groundwater contamination and the migration of contaminants towards marine waters. If undetected, containment breaches or leaks can result in long-lasting contamination.

Nutrients released from the discharge of raw and treated sewage can also result in eutrophication of marine waters.

The GTP is located directly adjacent to the marine environment with condensate tanks situated approximately 250 m from the shore. Groundwater at the GTP flows towards the coast. The waste transfer station is situated further inland (approximately 2 km from the coast).

Hydrocarbons and other chemicals stored onsite can be toxic to terrestrial, marine and subterranean fauna. A number of subterranean fauna species have been recorded within 1 km of the GTP site. The Blind Gudgeon, which is listed as vulnerable under the EPBC Act, was recorded approximately 5.5 km south-west of the GTP site.

9.9.4 Criteria for assessment

Relevant land and groundwater quality assessment criteria include:

- Australian Water Quality Guidelines (ANZECC & ARMCANZ 2000) provides fresh and marine water criteria; and
- Assessment and Management of Contaminated Sites (DER, 2014) provides ecological and human health assessment levels for soil.

General provisions of the EP Act make it an offence to cause or allow pollution. The *Environmental Protection (Unauthorised Discharges) Regulations 2004* specifies hazardous materials, including acids, alkalis and hydrocarbons that must not be discharged to the environment.

9.9.5 Applicant controls

The TSEMP developed under MS 800 specifies design criteria for managing the storage of hydrocarbons and other hazardous materials. Additional controls for managing liquid waste storage and handling (e.g. waste received at the waste transfer station) are described in the *Solid and Liquid Waste Management Plan*. A summary of these and other controls specific to the above storage facilities are set out in Table 39 below.

Table 39: Applicant proposed controls for storage of hazardous materials

Site infrastructure	Description
Controls for breach of containment (hazardous materials storage)	
LNG and condensate storage	• Tanks designed to relevant standards (i.e. American Petroleum Institute Standard 650 *Welded Steel Tanks for Oil Storage* and Australian Standard 1940:2017 *The storage and handling of flammable and combustible liquids* (AS 1940:2017). • The foundations of the condensate tanks are constructed with a high-density polyethylene (HDPE) internal liner, and leak detection and corrosion protection systems to prevent corrosion of the tank floor. • Condensate tanks are located within a 4.5 m high bund with each bund designed to contain the volume of the contained tanks plus 10%. • No corrosive or cryogenic fluids are stored in the condensate tanks or associated loading equipment. • A tank filling system is used during operation of the tanks that includes level indicators and alarms.
MEG, HCl, and NaOH storage tanks	• Designed to AS 1940:2017. • Designed with secondary containment, cathodic protection, overfill protection alarms, and leak detection.
aMDEA storage tank	• Designed with secondary containment, overfill protection alarms, and leak detection systems.
Diesel storage facility	• Bulk transfer lines are fitted with dry break couplings and tanks fitted with appropriate spill and leak detection devices. • The 110 kL tanks are double skinned and constructed in accordance with AS 1940:2017. • The two 160 kL tanks are located in a concrete bund with a 1 m high wall.

Site infrastructure	Description
Controls for breach of containment (hazardous materials storage)	
Liquid waste storage at the waste transfer station	• Hazardous materials are stored in concrete bunds with a collection sump, or in portable bunds, in accordance with AS 1940:2017 and the *Dangerous Good Safety Act 2004* and subsidiary legislation. • An inventory of hazardous materials is maintained. • Materials are appropriately segregated. • Transfer of liquid waste only occurs in bunded areas. • Materials are packaged, segregated, and handled in accordance with legal requirements and relevant standards. • Spill kits are available onsite.
Bridging WWTP	• Tanks are fitted with alarms to prevent overfill. • Regular inspections are carried out on tanks and pipes to identify integrity issues. Integrity of pipes and fittings are also tested periodically. • The bridging WWTP is situated within a bunded area to capture potential spills/leaks and potentially contaminated stormwater. The bund is connected via a locked valve to the stormwater drainage system. See Section 9.12 for further detail on the stormwater drainage system.
General	• Bunds associated with hazardous materials storage are either connected to the stormwater drainage system at the GTP which captures, treats and appropriately disposes of spills. Material captured in isolated bunds is transferred to the stormwater drainage system as required. • Groundwater monitoring is conducted in accordance with the TSEMP (condition 8 of MS 800) to assist with detection of contamination. • The Stormwater Holding Pond which waste from the Class 2 drainage system, including potentially contaminated stormwater, is lined and a freeboard maintained to ensure overtopping does not occur. • The Oily Water Sump that receives separate hydrocarbons from the Liquid Waste Facility is lined to prevent seepage and a freeboard maintained to ensure overtopping does not occur

9.9.6 Key findings

The Delegated Officer has reviewed the information regarding hydrocarbon storage and has determined that:

1. Infrastructure controls (i.e. containment infrastructure, leak detection, etc.) as described in the TSEMP developed under MS 800 were constructed in accordance with the relevant works approval and significantly reduce the likelihood of impact occurring.
2. Environmental monitoring (e.g. groundwater and subterranean fauna) is undertaken in accordance with the TSEMP and can provide early detection of potential environment impacts.
3. The site is registered as a Major Hazard Facility and storage of environmentally hazardous materials above placard quantities is regulated under the *Dangerous Goods Safety Act 2004* by the Department of Mines, Industry Regulation and Safety (DMIRS).
4. Unauthorised discharges of environmentally hazardous materials are subject to the *Environmental Protection (Unauthorised Discharges) Regulations 2004* and the general provisions of the EP Act relating to causing pollution and environmental harm also apply.

9.9.7 Consequence

Spills and leaks of minor quantities of hazardous materials to the environment (e.g. minor hydrocarbon spill) may cause low level on-site impacts or minimal localised off-site impacts. The Delegated Officer considers the consequence of this event to be **Minor**.

Major spills resulting from a large containment breach or leaks that remain undetected for

extended periods of time can result in extensive long-term contamination. Terrestrial and subterranean fauna on Barrow Island is considered to have high conservation value. The Delegated Officer considers the consequence of this type of event to be **Major**.

9.9.8 Likelihood of Risk Event

Taking into consideration the applicant controls, the Delegated Officer has determined that minor or major containment breach/spill/leak resulting in hazardous materials entering the environment will only occur in exceptional circumstances. Therefore, the likelihood is considered to be **Rare.**

9.9.9 Overall rating of hazardous materials storage

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of a minor containment breach is **Low** and a major containment breach is **Medium**.

9.10 Risk assessment – Fugitive dust

Concrete waste (Type 1 Inert Waste) produced during the transition from construction to operation of the GTP is stored on the Premises at a designated concrete waste depot located within the construction footprint of the GTP. Concrete waste stored at the depot has been stockpiled and separated into pre-cast surplus, cast in-situ (unreinforced), and cast in-situ (reinforced) concrete.

Dust can have adverse impacts on the health of flora and fauna through deposition and inhalation.

No crushing or reprocessing of the concrete waste will occur. Pre-cast and in-situ concrete has been manufactured to the appropriate standard and are not expected to contain asbestos or other hazardous materials. Concrete items will either be re-used in the GTP (such as cyclone tie downs and fill/construction materials) or removed from the island for re-use or disposal.

Dust emissions are not expected to be significant given that there will be minimal handling of concrete waste and no crushing or re-processing will occur on site.

9.10.1 Consequence

The Delegated Officer has determined there will be minimal on-site impacts from fugitive dust and therefore the consequence of fugitive dust is considered to be **Slight**.

9.10.2 Likelihood of Risk Event

The Delegated Officer has determined that the likelihood health impacts to vegetation and fauna occurring will be **Rare**.

9.10.3 Overall rating of fugitive dust

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of fugitive gaseous emissions is **Low**.

9.11 Risk assessment – inadequate waste containment

9.11.1 Description of odour and litter

The waste transfer station receives general waste such as plastics, paper and cardboard, aluminium cans, and putrescible wastes (such as food scraps) generated on the Premises. Hazardous wastes including hydrocarbons and chemicals are also received. Waste is sorted

and consolidated prior to removal off island. Inadequate containment of waste can result in the generation of odour and dispersal of litter via wind and rain.

9.11.2 Identification and general characterisation of emission

Waste is generally segregated at source prior to transfer to the waste transfer station for efficient processing in the following waste reception areas:

- General sorting and bin loading;
- Putrescible waste sorting and compacting area;
- Waste sorting and baling area; and
- Dangerous goods area.

The waste transfer station is designed to receive the following types and volumes of waste. The quantities of waste received at the waste transfer station between April 2016 and April 2017 are also provided below.

Table 40: Waste types and quantities received at the Waste Transfer Station

Waste Type	Design capacity	Total quantity received in 2016-2017 period[1]
Inert waste Type 1	3,000 tonnes per month	2,406 tonnes
Inert waste Type 2	120 tonnes per month	68.3 tonnes
Putrescible waste	2,400 tonnes per month	6,831 tonnes
Hazardous waste such as chemical and/or other controlled wastes, including, but not limited to: • Asbestos (Special Waste Type 2); • Waste oil, including lube oil; • Chemical residues, acids, sealants, solvents and cleaning products; • Paints, thinners and coatings; • Medical wastes; • Batteries including: lead acid and dry cell; • Electronic and electrical waste; • aMDEA-contaminated materials, including waters, pads, and other absorbents, soils, and LNG plant consumables; • MEG-contaminated materials including waters, pads, and other absorbents, soils, and LNG plant consumables; • Molecular sieve material contaminated with hydrocarbons and other feed gas contaminants; • Other process chemicals used within the routine operation of the LNG plant. • Obsolete chemicals associated with construction, commissioning, startup, and operations phases.	3,800 tonnes per month	11,261 tonnes

Note 1: Volumes of waste reported in the 2016-2017 Annual Environmental Report for Licence L8751/2013/1 and are the total volume of waste received between April 2016 and April 2017.

9.11.3 Description of potential adverse impact from the emission

Uncontained litter can cause fauna injury or death as a result of ingestion or strangulation. Uncontained putrescible waste can also generate odour that attracts fauna. Population dynamics of native species may be altered through the provision of additional food sources which may promote breeding of opportunistic species and increase competition for resources

with other species.

9.11.4 Applicant controls

This assessment has reviewed the controls set out below:

- Waste is segregated at source where practicable to minimise handling at the waste transfer station and potential for waste dispersal. Waste is transferred directly to the relevant area for processing as it is received onsite.
- Waste containers are clearly identified for the designated waste stream.
- The putrescible waste sorting and compacting area and the waste sorting and compacting area are fully enclosed sheds to contain waste with doors kept closed when not in use to prevent fauna entering.
- Putrescible waste is processed as soon as practicable to minimise odour which may attract fauna. Putrescible waste residue on the ground following sorting and processing within the putrescible waste sorting and compacting area is cleaned and removed on a regular basis (and at the end of each working day).
- Putrescible waste is either refrigerated, compacted or processed through rotary food waste dyers which reduces odour. Waste is transferred into sealed containers for disposal off island at an approved facility.
- The general sorting and bin loading area is covered and enclosed on three sides by concrete push-up walls. Netting is installed at the open face to contain waste within the sorting area and is removable to allow vehicle movements in and out of the area. Netting is also installed between the walls and the roofs to prevent windblown waste.
- The site is enclosed by a 2.4m high fauna proof fencing including gates that are locked at night to prevent unauthorised access. The fence is inspected on a regular basis.
- Waste containers and trucks are regularly cleaned to prevent odour.
- Waste receptacles which contain material that may create windblown rubbish and attract fauna will be covered and closed at all times and secured to resist severe weather conditions.
- The waste sorting buildings are cyclone rated to ensure adequate containment of waste during a cyclone when high winds and rain increase the potential for waste dispersal.

9.11.5 Key findings

The Delegated Officer has reviewed the information regarding litter and has found:

1. Condition 30 of MS 800 requires the Applicant to implement the *Solid and Liquid Waste Management Plan* which specifies that "*waste receptacles and/or tanks that may attract fauna or generate windblown rubbish will be covered or closed*".

9.11.6 Consequence

Barrow Island is a Class A Nature Reserve with a high conservation value. Terrestrial fauna occurring on the island includes 5 species listed under the *Wildlife Conservation Act 1950* and EPBC Act. The Delegated Officer considers that impacts associated with waste handling at the waste transfer station could have short term impacts to an area of high significant due to the potential for injury or death of local fauna and shifts in population dynamics. Therefore, the Delegated Officer considers the consequence to be **Major**.

9.11.7 Likelihood of Risk Event

The Delegated Officer has determined that impacts to fauna will probably not occur in most circumstances to the rigorous controls in place by the Applicant. Therefore, the Delegated Officer considers the likelihood to be **Unlikely**.

9.11.8 Overall rating of litter

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall risk rating is **Medium**.

9.12 Risk Assessment – discharge to land of contaminated stormwater

9.12.1 Description of discharge to land of contaminated stormwater

Stormwater at the Premises has the potential to become contaminated with hydrocarbons, sediments, hazardous chemicals and wastes leading to contamination of land through direct contact or infiltration into soils.

Stormwater at the GTP, bridging WWTP, and diesel storage facility is managed via the stormwater drainage system (SDS) which manages inflows from stormwater run-off, process water, and firewater. The SDS segregates stormwater into four classes:

- Class 1: Contaminated run-off;
- Class 2: Potentially contaminated run-off consisting of areas designated to have a lower likelihood of contamination compared to Class 1 areas.
- Class 3: On-site uncontaminated runoff;
- Class 4: Intercepted off-site uncontaminated runoff.

Contaminated stormwater is directed to the liquid waste facility for disposal via deep well injection while treated or uncontaminated stormwater is discharged offsite. An overview flow diagram of the SDS is shown in Figure 6.

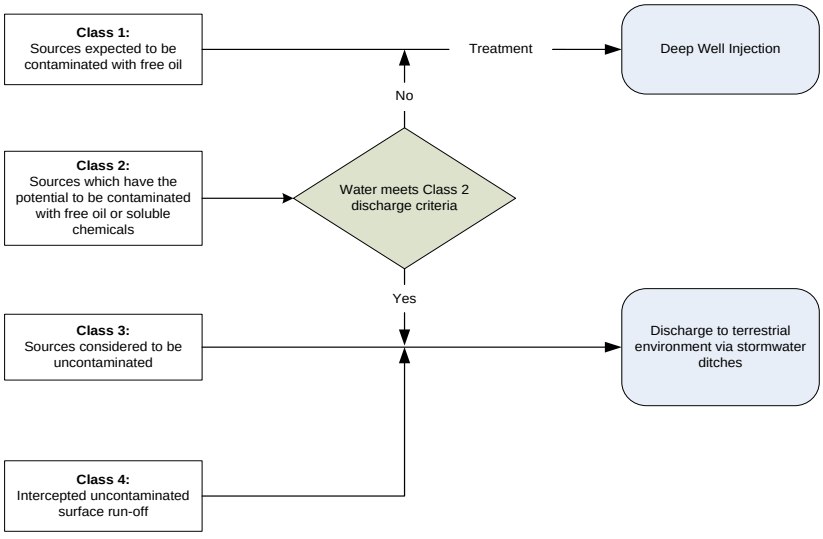

Figure 7: Overview flow diagram of the SDS

Stormwater at the waste transfer station is managed independently through a series of permanent and temporary bunds. Should stormwater captured in bunds require disposal it can be collected and transferred to the liquid waste facility.

9.12.2 Identification and general characterisation of emission

Class 1: Contaminated runoff

Class 1 wastewater primarily consists of contaminated runoff from areas of the GTP which are deemed to be always or frequently contaminated (e.g. equipment base plates). Some infrequent, small flows of contaminated process waters also drains into the Class 1 contaminated drainage system.

Class 2: Potentially contaminated runoff

Class 2 wastewater primarily consists of stormwater runoff that has the potential to be contaminated. This includes first flush (25 mm) stormwater runoff from Class 2 potentially contaminated catchment areas. In addition to potentially contaminated runoff, the Class 2 system also receives uncontaminated process water such as demineralised water, potable water, service water, and condensed water.

Wastewater from the holding pond is discharged to the environment via the Class 3 on-site uncontaminated drainage system if environmental criteria (shown in Table 41) are met.

Wastewater from the stormwater holding pond that meets the water quality discharge limits may also be extracted for the stormwater holding pond for reuse within the GTP site or surrounding areas. The Applicant has implemented controls to ensure that the water quality criteria is met prior to discharge.

Class 3: On-site uncontaminated runoff

Class 3 water consists of on-site uncontaminated runoff and overflow (post first flush volumes) from the Class 2 drainage system.

Class 4: Intercepted off-site uncontaminated runoff

The Class 4 off-site uncontaminated drainage system comprises off-site drainage channels that have been intercepted as a result of the location of the GTP. Off-site uncontaminated run-off from around the GTP site is captured and diverted by an open drain and transported via pipelines for discharge to the terrestrial environment.

Waste transfer station

Stormwater may become contaminated if it comes into contact with waste received at the waste transfer station including hazardous materials such as hydrocarbons and chemicals, and general wastes such as food and other putrescibles which are a source of nutrients.

9.12.3 Description of potential adverse impact from the emission

Discharge of stormwater containing hydrocarbons, sediment and a high salt content may result in a direct loss of habitat and contamination of land. Contamination of the marine environment can also occur as materials drain overland towards the coast.

Hydrocarbons and wastes that are acidic, alkaline or have a high salt content can be toxic to terrestrial, marine and subterranean fauna and flora. Sediment may smother vegetation resulting in habitat loss.

9.12.4 Criteria for assessment

Relevant land and groundwater quality criteria include:

- Australian Water Quality Guidelines (ANZECC & ARMCANZ 2000) provides fresh and marine water criteria; and
- Assessment and Management of Contaminated Sites (DER 2014) provides ecological and human health assessment levels for soil.

General provisions of the EP Act make it an offence to cause or allow pollution. The

Environmental Protection (Unauthorised Discharges) Regulations 2004 specifies that hazardous materials, including acids, alkalis and hydrocarbons must not be discharged to the environment.

The Applicant has developed water quality criteria for discharges from the stormwater drainage system (Table 41) that consider relevant environmental guidelines and local environmental quality.

Table 41 Water quality criteria for discharge to terrestrial environment

Water quality parameter	Discharge criteria
Total petroleum hydrocarbons	10 mg/L
pH	6 - 9
Total suspended solids	500 mg/L
Electrical conductivity	18,000 µS/cm @ 25°C

9.12.5 Applicant controls

Management of the discharge to the environment of potentially contaminated surface water, stormwater run-off or firewater associated with the operation of the GTP is via the stormwater drainage system. The system has been designed to ensure that contaminated stormwater, uncontaminated runoff, and process waters are collected and routed for appropriate treatment or discharge. The aim of the stormwater drainage system design is to segregate areas of different contamination risk.

The key design feature of the stormwater drainage system is the use of appropriate paving or concrete. While a number of areas within the GTP are sealed, the GTP maximises unpaved areas to facilitate infiltration of uncontaminated water. Paved areas include those areas subject to potential contamination by spillages and areas subject to load bearing. Paving in areas of potential spillage is graded to the appropriate class of drainage.

Additional design controls that have been reviewed during this assessment are set out in Table 42 below.

Table 42: Applicant's/Licence Holder's proposed controls for stormwater discharge

Site infrastructure	Description
Class 1 drainage network	• Contaminated runoff is piped to an oily water sump for treatment in an oily water separator unit prior to being pumped to the liquid waste facility for disposal via deep well injection

Site infrastructure	Description
Class 2 drainage network	• The Class 2 potentially contaminated run-off is routed to a concrete lined stormwater holding pond. • The stormwater holding pond has an oil skimming device for removing any free-floating oil. • Level indicators are set to trigger when the pond reaches 90% capacity (i.e. 600mm freeboard remaining). • Water is tested and discharged to the environment provided it meets the relevant criteria. • If water does not meet the criteria, it is disposed of in accordance with the solid and liquid waste management plan (i.e. disposed of down well or removed from the island). • Visual maintenance checks are undertaken twice daily and maintenance issues identified are recorded.
Class 3 drainage network	• Flows are directed to a series of unlined stormwater ditches and then discharged to the environment at a number of locations along the southern and northern boundaries of the GTP. • Open drainage system to reduce suspended sediment in water being discharged to the environment. • Design of the drainage system to mirror the natural hydrological setting.
Class 4 drainage network	• Off-site uncontaminated stormwater is diverted away from the GTP.
Waste transfer station	• Cut-off berms are installed and the ground has been graded to divert clean stormwater around the site. • The general sorting and bin loading area is covered with partial walls on three sides to minimise stormwater ingress. The putrescible waste sorting and compacting area are in fully enclosed sheds and doors can be closed during inclement weather to prevent stormwater ingress. All three waste sorting areas drain to a local collection sump. • Dangerous goods (liquids) are stored in separate finger bunds which drain to collection sumps, or stored in suitable secondary containment (bunds). Potentially contaminated stormwater in the sumps or bunds is manually removed and is either disposed of down well (if it meets the specifications) or taken off-island for disposal. • The main processing and storage areas are concrete hardstand which drain to an oily water separator (see blue section shown in Figure 8). Treated water from the oily water separator is either reused in vehicle wash down, disposed of via deep well injection, or removed from island for disposal to an approved facility. Other areas drain to the environment and are generally used for storing non-hazardous material or empty containers. Any hazardous material stored in these areas are placed in storage bunds. • Potentially contaminated stormwater or wastewater from the waste sorting & compacting area, putrescible waste and compacting area and vehicle wash down is collected in 25,000 litre storage tanks. The system collects first flush stormwater (the first 25 mm). Wastewater collected in tanks is either transferred to the bridging WWTP for treatment, disposed of via deep well injection, or removed from island for disposal to an approved facility. • Spill kits are present and spills cleaned up as soon as practicable. • Wash water from the vehicle wash down bay drains to a collection sump and spray barriers are installed to contain any overspray.
General	Environmental monitoring programs, including groundwater, flora and fauna monitoring, are carried out in accordance with the TSEMP developed under MS 800 to identify potential impacts to terrestrial and subterranean environment.

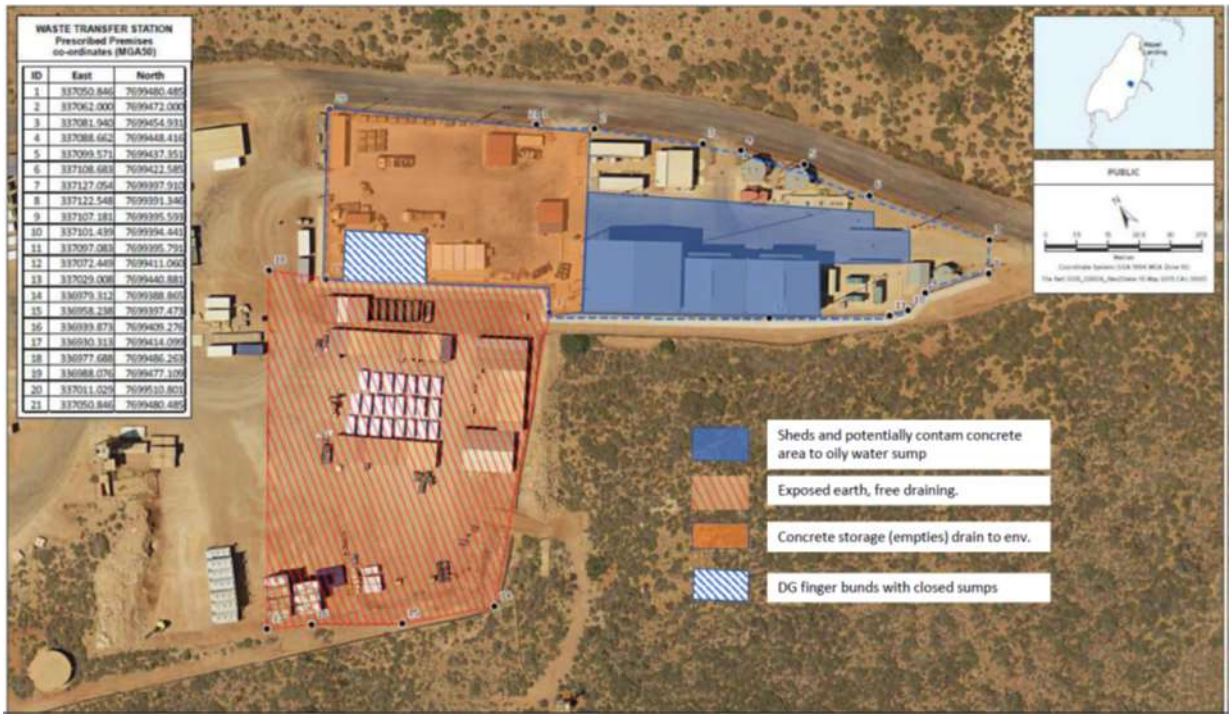

Figure 8: Waste Transfer Station drainage

9.12.6 Consequence

The Delegated Officer has determined that stormwater discharged from the stormwater holding pond may result in minimal off-site impact. Therefore, the Delegated Officer considers the consequence to be **Slight**.

9.12.7 Likelihood of Risk Event

Considering the Applicant controls, the Delegated Officer has determined that the likelihood of stormwater discharges resulting in environmental harm will be **Rare**.

9.12.8 Overall rating of discharge of stormwater

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of stormwater discharges is **Low**.

9.13 Risk assessment – deep well injection of liquid wastes

9.13.1 Description of deep well injection of liquid wastes

Comingled liquid wastes from the liquid waste facility containing hydrocarbons, aMDEA and other additives are disposed of via deep injection well to the Flacourt Formation. The shallow surface formations and the water table identified as subterranean fauna habitat are geologically isolated from the deeper Flacourt Formation which receives liquid waste via deep well injection. Under normal operating conditions, factors that could cause impact to the characteristics of the shallow aquifer and the stygofauna present during deep well injection include:

- Fracturing of the receiving formations and overlaying confining units resulting in penetration of liquid waste into the near-surface aquifer; and
- Injection into a receiving environment that is not isolated from the shallower aquifers by adequate confining layers.

Liquid wastes may also be discharged to ground or to the near-surface aquifer in the event of a mechanical integrity failure in the wells.

9.13.2 Identification and general characterisation of discharge

The PWD wells are designed with capacity to inject water at peak rates in excess of 6,360 m^3/day, which is the maximum expected rate following infrequent cyclonic rainfall. Under normal operation, the injection rate is expected to be much lower. Furthermore, the system has been designed with 100% operational redundancy with each well capable of injecting the entire system load if the other well is out of service. Although the PWD wells are the primary injection point for liquid wastes, the injection wells associated with the temporary wastewater injection plant (TWIP), which inject wastewater into the same formation, provide additional capacity if required and can be used as a contingency should the PWD wells be unavailable.

Liquid waste volumes are dominated by produced water from the Gorgon and Jansz gas fields. This waste stream is generated every day that gas is produced from the gas fields, and is expected to contribute approximately 53% of the total input in the PWD wells (Untreated wastewater from the Bridging WWTP may also be injected down well in instances should the plant experiences upset conditions or breakdown. These events are expected to be infrequent and over short periods and should not significantly alter the composition of waste disposed of down well, noting that the Bridging WWTP accounts for a small percentage of the waste stream.

Table 43). Given that produced water accounts for the majority of waste to be disposed of down well, the characteristics of the comingled liquid waste is expected to be dominated by the produced water characteristics.

Currently, treated wastewater from the Bridging WWTP is also disposed of via deep well injection. The primary injection point for the disposal of treated sewage is the TWIP. The Permanent WWTP has been constructed and will eventually replace the Bridging WWTP. Once this occurs, produced formation water will account for approximately 78% of liquid waste disposed of down well.

Untreated wastewater from the Bridging WWTP may also be injected down well in instances should the plant experiences upset conditions or breakdown. These events are expected to be infrequent and over short periods and should not significantly alter the composition of waste disposed of down well, noting that the Bridging WWTP accounts for a small percentage of the waste stream.

Table 43: Waste streams expected to be disposed of down well

Waste stream	Components of the waste stream	Frequency of waste generation	Volume (approx. m^3 per annum)	Percentage of total waste stream (%)
Produced water from the Gorgon and Jansz gas fields	MEG, H_2S, hydrocarbons and BTEX compounds	Continuous during operations	814,000	53
Bridging WWTP effluent *(temporary infrastructure to be replaced by the permanent WWTP)*	Nutrients, total suspended solids, *E. coli*	Continuous during operations	505,525	33
Permanent WWTP effluent *(future discharge not subject of this licence as not yet commissioned)*	Nutrients, total suspended solids, *E. coli*	Continuous during operations	131,000	8

Waste stream	Components of the waste stream	Frequency of waste generation	Volume (approx. m^3 per annum)	Percentage of total waste stream (%)
Runoff from the Class 2 drainage system	Hydrocarbons and BTEX compounds	Infrequent – event driven	57,000	4
Runoff from the Class 1 drainage system	Hydrocarbons	Infrequent – event driven	26,000	2
Process Liquid Wastes – Routine Operations		Intermittent	7,000	0.5
Chemical fluid wastes from the MEG Flash Separator Recycle Loop	*MEG, MDEA and corrosion inhibitor*			
Process water from the condensate stabilisation trains	*MEG and MDEA*			
Condensed water from the Dehydration Pre-cooler, Instrument Air Package and CO_2 compression system	*No or trace contaminants*			
Demineralised water when draining the Heating Medium System	*Dosed with oxygen scavenger and corrosion inhibitor*			
Water vapour from the Hydrochloric Acid Tank	*Neutralised with caustic*			
Process Liquid Wastes – Maintenance, Shutdowns and Turnaround		Infrequent – event driven	<2,000	<0.5
Chemical fluid waste when draining the Chemical Cleaning Tank in the MEG circuit	*Citric acid and trace MEG*			
Backflush water from the CO_2 injection wells	*Water from the Dupuy Formation containing carbonic acid and solid fines*			
Demineralised wash down water from the AGRU	*MDEA*			
Demineralised tempered water from various process equipment	*Corrosion inhibitor or biocide*			
Wash water from the gas turbines and GTGs	*Washing detergent, metals and sulphur*			
Other Wastes *(includes intermittent inputs from sources not directly connected to the Liquid Waste Facility or injection wells and requiring manual disposal such as wastewater from oily water separators and stormwater pumped from containment bunds*				

9.13.3 Description of potential adverse impact from the emission

Liquid wastes permeating the surface aquifer may result in contamination of the groundwater system with hydrocarbons, chemicals and nutrients contained in the waste stream impacting

subterranean fauna. Subterranean fauna on Barrow Island is considered to be of high conservation significance.

Well failures may result in surface discharges of liquid waste that can contaminate surrounding land directly impacting local vegetation and terrestrial fauna present in the area. Runoff can enter drainage channels and drain towards to the marine environment, located 500 m from the PWD wells, impacting marine fauna and flora. Surface discharges may also seep into groundwater systems that support subterranean fauna.

9.13.4 Criteria for assessment

There no environmental criteria applicable for the Flacourt Formation. Water quality is highly alkaline and saline, and is saturated with hydrocarbons. The formation is has no beneficial use and does not support any significant environmental values.

Criteria used for assessing the acceptability of liquid waste discharged to the Flacourt Formation are based on operational targets to ensure that the mechanical integrity of the wells is maintained.

Triggers for environmental monitoring (groundwater and subterranean fauna) are specified in the TSEMP developed under MS 800.

9.13.5 Applicant controls

The permeability of sands within the Barrow Group Formation is very high allowing injection at high rates without inducing the high pressure gradients in the vicinity of the injection well, reducing the potential of fractures within the reservoir. The mineralogy of the formation is stable, with low potential for adverse reactions between the injected water and the sandstone matrix. The porosity and permeability of the formation are not expected to be reduced through precipitation or deposition of minerals from the injected water.

Modelling indicated that fracturing of the receiving formations and confined layers is not likely except when the temperature of injection water is low (i.e. 10 °C). Under normal operating conditions the temperature of the injection water is expected to be approximately 40 °C and therefore fracturing due to low temperatures is unlikely.

The shallow groundwater formations are protected by three cemented casing strings as well as injection tubing. Cathodic protection is also installed to limit casing corrosion. Well construction reports demonstrating sound design and construction, and that the target formation has been drilled, were submitted to the DMIRS.

The wells have been designed to ensure that mechanical integrity is maintained, and programs are in place to provide assurance of ongoing well operability including, but not limited to:

- Monitoring of individual wand pressure downstream of choke, A and B annulus pressure, and liquid flow rate;
- Wellhead maintenance program;
- Wellhead and tree visual inspections; and
- Valve inspections and maintenance.

Data from continuous monitoring of well injection pressure, temperature and flow rate provides real time information to the Applicant. Any deviations from expected well behaviour can be detected and investigated rapidly to ensure well integrity is maintained.

Monitoring of the A annulus pressure is expected to be the most immediate and reliable indicator of a loss of integrity in the injection tubing. Should a leak develop in any part of the tubing string, the fluid in the tubing will encounter fluid in the A annulus. The tubing and A annulus will then be hydraulically connected, and the annulus pressure will rise. This will be immediately detectable by the pressure gauge on the A annulus. This being the case, a high pressure alarm

threshold for the A annulus pressure has been set to allow deviations to be quickly recognised so that corrective action can be initiated. Any non-routine operations where the injected fluid temperature is significantly different to normal may cause the annulus pressure to change. This will be considered when investigating any indications of high annulus pressure.

Continuous monitoring of volumetric flow rate, wellhead pressure, annulus pressure, flowline pressure and temperature at the PWDs is required to detect any deviation in operation performance that may indicate issues with well integrity. This data will also feed into longer term reservoir management, which requires an accurate understanding of the cumulative injection volume over time. Analysis of reservoir pressure trends as a function of cumulative injection volume assists with confirming the size and connectivity of the injection reservoir. Spot sampling occurs on a monthly basis for pH, total suspended solids and total petroleum hydrocarbons with targets set for parameters deemed essential to maintaining the integrity of the wells (Table 44).

Some solids will be settled out of the liquid waste in the disposal water tanks prior to being passed through filters for disposal to the PWD wells. Oil skimmers are also present at the disposal water tanks to remove hydrocarbons to achieve operational performance criteria.

Table 44: Water quality parameters to be monitored and specified targets.

Water quality parameter	Unit	Target
Total petroleum hydrocarbons	ppm	200
pH	pH units	100
Total suspended solids	ppm	6-9

Periodic monitoring of the superficial aquifer will be conducted as per the TSEMP, which has been developed in accordance with condition 8 of MS 800, to identify if the aquifer is being impacted by injection activities. The TSEMP requires long-term trends in groundwater characteristics to be analysed to understand any impacts to groundwater (and subsequently impacts to stygofauna habitat inferred from such changes) attributable to the Premises. Monitoring is undertaken at both “At Risk Sites” (sites predicted to be impacted by the Premises) and “Reference Sites”. MS 800 requires that a statistically valid ecological monitoring program to detect any material or serious environmental harm to the ecological elements outside the terrestrial disturbance footprint is established. The analytical suite associated with the monitoring program, which is subject to review and change, includes:

- Field parameters such as depth to water, conductivity, temperature, pH, dissolved oxygen and redox potential;
- Total dissolved solids;
- Metals;
- Total recoverable hydrocarbons;
- Solvents;
- Halogenated benzenes;
- Aromatic hydrocarbons; and
- Volatile organic compounds.

Monitoring was undertaken during the construction phase of the Premises on a quarterly basis to provide baseline groundwater monitoring. The monitoring frequency may be extended to annually once the Premises is fully operational. Annual reporting is required under MS 800.

9.13.6 Key findings

The Delegated Officer has reviewed the information regarding deep well injection and has found:

1. The permanent disposal wells are not located within a petroleum lease area and are therefore not regulated under the *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* and the *Petroleum Pipelines (Environment) Regulations 2012* (WA).
2. Disposal of wastewater via deep well injection is in accordance with the Solid and Liquid Waste Management Plan developed under condition 30 of MS 800.
3. Monitoring operating parameters such as flow, wellhead pressure, A annulus pressure, B annulus pressure and temperature well integrity is essential for maintaining well operability and integrity.
4. Monitoring well integrity is a commitment of the Solid and Liquid Waste Management Plan although parameters to be monitored are not specified in the plan. Triggers for operating parameters are set internally under operating plans.
5. Groundwater monitoring and reporting is undertaken in accordance with MS 800 and provides early detection of potential environmental impacts.

9.13.7 Consequence

The Delegated Officer has determined that fracturing of the formation and confining layers and a mechanical well integrity failure causing liquid wastes to enter the surface aquifer or discharge directly to ground has potential to cause mid to long term or permanent impact to an area of high conservation value. Therefore, the Delegated Officer considers the consequence of this type of event occurring to be **Major**.

9.13.8 Likelihood of Risk Event

Considering the applicant controls for maintaining well integrity and the potential for the liquid waste to breach the confined Flacourt Formation, the Delegated Officer has determined that the likelihood of environmental impact associated with the deep well injection of liquid waste is **Low**.

9.13.9 Overall rating of deep well injection of liquid wastes

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of deep well injection is **Moderate**.

9.14 Summary of acceptability and treatment of Risk Events

A summary of the risk assessment and the acceptability or unacceptability of the risk events set out above, with the appropriate treatment and control, are set out in Table 45 below. Controls are described further in Section 10.

Table 45: Risk assessment summary

	Description of Risk Event			Applicant controls	Risk rating	Acceptability with controls (conditions on instrument)
	Emission	**Source**	**Pathway/ Receptor (Impact)**			
1.	Combustion gases	GTGs, GTs, flares, heating medium heaters	Air/wind to sensitive receptor causing environmental impacts	Infrastructure and management controls	Minor consequence Unlikely **Medium risk**	Acceptable subject to regulatory controls
2.	Mercury	GTGs, GTs, flares, heating medium heaters, AGRU vents	Air/wind to sensitive receptor causing environmental impacts	Infrastructure and management controls	Slight consequence Rare **Low risk**	Acceptable
3.	H_2S and BTEX compounds	AGRU vents	Air/wind to sensitive receptor causing environmental impacts	Infrastructure and management controls	Slight consequence Rare **Low risk**	Acceptable subject to regulatory controls (MS 800)
4.	Ozone (O_3)	Secondary pollutant (not a direct emission)	Air/wind to sensitive receptor causing environmental impacts	Infrastructure and management controls	Minor consequence Unlikely **Low risk**	Acceptable subject to regulatory controls (MS 800)
5.	Fugitive gaseous emissions		Air/wind to sensitive receptor causing environmental impacts	Infrastructure and management controls	Slight consequence Rare **Low risk**	Acceptable
6.	Breach of containment (minor)	Condensate and other chemical storage	Direct discharge or leaching causing environmental impacts	Infrastructure and management controls	Minor consequence Rare **Low risk**	Acceptable

	Description of Risk Event			Applicant controls	Risk rating	Acceptability with controls (conditions on instrument)
	Emission	**Source**	**Pathway/ Receptor (Impact)**			
7.	Breach of containment (major)	Condensate and other chemical storage	Direct discharge or leaching causing environmental impacts	Infrastructure and management controls	Major consequence Rare **Medium risk**	Acceptable subject to regulatory controls (MS 800)
8.	Fugitive dust	Concrete waste storage	Air/wind to sensitive receptor causing environmental impacts	Management controls	Minor consequence Rare **Low risk**	Acceptable
9.	Uncontained waste	Waste Transfer Station	Direct impacts on fauna	Infrastructure and management controls.	Major consequence Rare **Medium risk**	Acceptable subject to Applicant controls
10.	Discharge to land (contaminated stormwater)	Contaminated stormwater	Directed stormwater to terrestrial environment causing impacts on water quality and visibility.	Infrastructure and management controls.	Minor consequence Rare **Low risk**	Acceptable subject to Applicant controls
11.	Deep well injection of liquid waste	Liquid Waste Facility	Indirect discharge to groundwater	Infrastructure and management controls.	Major consequence Rare likelihood **Medium Risk**	Acceptable subject to Applicant controls

10. Regulatory controls

A summary of regulatory controls determined to be appropriate for the Risk Event is set out in Table 46. The risks are set out in the assessment in section 10 and the controls are detailed in this section. DWER will determine controls having regard to the adequacy of controls proposed by the Applicant. The conditions of the Licence will be set to give effect to the determined regulatory controls.

Table 46: Summary of regulatory controls to be applied

		Controls (references are to sections below, setting out details of controls)						
		10.3 General	**10.1.1 & 10.4.1 Emissions**	**10.4.1 Infrastructure & equipment**	**10.4.1 Emissions monitoring**	**10.3.1 & 10.5.1 Monitoring input & outputs**	**10.5.1 & 10.2 Process Monitoring**	**10.1.1, 10.2, 10.3.2, 10.4.2 & 10.5.2 Reporting**
Risk Items (see risk analysis in section 9)	**Combustion gases**		●		●	●		
	H_2S and BTEX compounds						●	●
	Uncontained waste	●				●		●
	Discharge to land (contaminated stormwater)		●	●	●			●
	Deep well injection of liquid waste		●			●	●	●

10.1 Licence controls – combustion gases

10.1.1 Specified emissions

Condition 2 specifies the emission points for point source emissions to atmosphere. Emission targets have been set for major emission sources (i.e. GTGs, GTs and Heating Medium Heaters) in the Air Quality Management Plan (Table 34) and as such, no limits have been set on the Licence to avoid duplication. These targets are applicable to equipment running at high loads (>55% load). Until the CO_2 compression and injection system is operational, the GTGs are not operating at full load and may not achieve the targets specified in the Air Quality Management Plan. The CO_2 compression and injection system is expected to be online at the end of 2018.

10.1.1 Monitoring

Monitoring requirements have been imposed through condition 3 to demonstrate compliance with the emission targets and design specifications outlined in the Air Quality Management Plan and to verify emission estimates that formed the basis for the air quality modelling. Pollutants to be monitoring include NOx and CO. Existing monitoring data has demonstrated that emissions

of PM_{10}, SOx and VOCs are negligible and therefore are not included in the monitoring requirements.

The methods for monitoring are consistent with those proposed by the Applicant and are considered appropriate. Conditions 5 and 6 have been included to require monitoring to be undertaken in accordance with Australian Standard 4323.1 or the relevant parts of the CEMS Code, and for all laboratory sampling and analysis to be undertaken by a NATA accredited laboratory. These conditions are required to ensure the monitoring data is reliable and accurate.

The existing licence for LNG Train 1 specified quarterly stack testing of the GTG and GTs. The Applicant has requested that quarterly testing be amended to annual testing for these emission sources given that emissions verification data demonstrates compliance with the abovementioned air quality targets and model inputs. Despite the availability of some emissions verification data, there is still some uncertainty regarding emissions from these sources given that:

- Limited data is available for the GTGs (only one testing event) to demonstrate that design specifications and air quality targets have been met as GTGs were operating on low loads during the majority of the period when emissions verification testing was undertaken;
- Monitoring results provided by the manufacturer (Figure 4) indicate that emissions from the GTs may exceed design criteria post tuning of the dry low NOx burners; and
- The Applicant is proposing to implement upgrades on the GTs which will increase emissions. This increase has not been verified through emissions monitoring.

Noting the above, the Delegated Officer considers that quarterly stack is appropriate until steady state operations have been achieved (i.e. the CO_2 compression and injection system is fully operationla) and the GT upgrades are complete.

Power demand will dictate the number of GTGs operational at any one time, and the Applicant cannot guarantee that all three GTGs will be operational during each quarter and at the time of scheduled testing. Under normal circumstances, it is expected that only two of the GTGs will be operational while one is on standby. GTGs may also be unavailable for testing during scheduled or unplanned maintenance. To accommodate these operational requirements, the Licence requires that sampling is carried out on each GTG on a quarterly basis if they are operational. It is expected that the Applicant will plan to test each GTG at least twice during the annual period.

The requirement to sample emissions to air “if operating” also applies to the GTs. This is to account for unplanned equipment trips coinciding with the scheduled emissions testing program resulting in emissions not being tested if one (or more) of the GTs not operating. The Applicant has indicated that the likelihood of this occurring is low.

Other environmental monitoring programs are in place as per commitments under MS 800 to monitor impacts on vegetation and fauna.

10.1.1 Process monitoring

Stack testing is required on the GTGs on a quarterly basis if they are operational at the time of scheduled testing, with the aim of testing each GTG at least twice per year. Condition 3 is included on the Licence requiring the Applicant to monitor the fuel consumption of the GTGs to verify their operating frequency and the number of units being tested each quarter. Should the data show that the operation of the GTGs does not correlate with the units being tested, the Licence conditions may be reviewed.

No stack testing is proposed for the heating medium heaters due to the low frequency of operation (i.e. they are only expected to operate when the Frame 7 GTs are offline or when duty heat from the WHRUs is not sufficient to meet demand). Regular maintenance programs are in

place to ensure efficient operation of the heating medium heaters to maintain emissions at the design specifications. Fuel consumption of the heating medium heaters is required to be monitored under Condition 3 to verify the low operating frequency. Should data indicate that the equipment is operating on a more frequent basis, the risk assessment may need to be reviewed.

Stack testing is not required from the flares. However, the volume of gas flared is required to be monitored under Condition 3 to verify predicted and assessed outputs.

10.1.1 Reporting

Results of stack testing and process monitoring are required to be submitted in an Annual Environmental Report required by Condition 19.

Ambient monitoring is a requirement of the Air Quality Management Plan and as such these requirements are not duplicated in the Licence conditions. DWER may request copies of ambient air quality monitoring data to review trends in ground level concentrations and ensure that the risk assessment and Licence conditions remain appropriate and relative to the environmental risk.

10.2 Licence controls – H_2S & BTEX compounds

Ambient air quality monitoring will continue in accordance with MS 800 to confirm ambient air quality criteria are being achieved. The DWER may review this data to inform future risk assessments. No stack testing is required on the AGRU vents, however the volume of gas vented to atmosphere is required to be monitored under condition 18 and reported in the Annual Environmental Report to verify outputs align with those predicted and assessed.

10.3 Licence controls – uncontained waste

The assessment has determined that there is an acceptable risk based on the type, rate and specification of waste, as well as the processes carried out. Therefore, condition 10 specifies the types of waste, volumes of waste, and processes to which waste is subjected to at the waste transfer station.

The Delegated Officer notes that controls are in place to prevent the escape of windblown waste from the Premises and the access or infestation of fauna. The *Solid and Liquid Waste Management Plan* specifies that containers will be enclosed wherever practicable to prevent fauna ingress and therefore this specific requirement has not been duplicated on the Licence. No additional conditions are included on the licence.

10.3.1 Monitoring

Monitoring of the types and quantities of waste received at the waste transfer station is required under Condition 11 to verify waste limits specified under Condition 10 have been met. Monitoring waste outputs ensures that all waste is accounted for when removed from the Premises.

10.3.2 Reporting

Data collected in accordance with Condition 19 is required to be reported to the DWER in the Annual Environmental Report.

10.4 Licence controls - discharge to land (contaminated stormwater)

10.4.1 Emission limits

In assessing the risks, the Delegated Officer has determined that the management and discharge of stormwater to the environment is acceptable subject to the Applicant's controls being conditioned on the Licence.

Condition 7 specifies the emission point for the discharge of water from the Class 2 stormwater holding pond to land.

The *Solid and Liquid Waste Management Plan* developed under condition 30 of MS 800 does not provide detailed management measures for the individual waste stream (e.g. volumes, monitoring frequencies, etc.) but rather provides general management actions for the storage, handling, treatment and disposal of waste. The plan stipulates that detailed waste management measures will be captured within secondary approvals such as the Licence. As such, condition 8 has been included on the Licence specifying water quality criteria for the discharge of waste to the environment.

10.4.1 Emission monitoring

Monitoring requirements to ensure emission limits are met are specified in condition 9.

Wastewater from the stormwater holding pond that meets the water quality discharge limits may be discharged to the surrounding environment into the Class 3 drainage system, via discharge points other than that specified in the Licence. Stormwater may also be extracted from the stormwater holding pond for reuse within the GTP site or surrounding areas. Licence conditions have not been applied to these non-standard discharges as they can be appropriately managed under the *Solid and Liquid Waste Management Plan*. Discharges are also subject to the provisions of the *Environmental Protection (Unauthorised Discharges) Regulations 2004*.

Groundwater monitoring to identify groundwater contamination is undertaken in accordance with the TSEMP developed under condition 8 of MS 800. To avoid duplication, no conditions relating to groundwater monitoring are included on the Licence.

10.4.1 Infrastructure and equipment

Condition 14 has been added to the licence to ensure the Applicant maintains sufficient freeboard on the stormwater holding pond and oily water sump to prevent overflows during extreme weather conditions.

10.4.2 Reporting

Data collected in accordance with condition 14 is required to be reported to DWER in the Annual Environmental Report. Visual inspections of the system are undertaken twice daily as per internal operating procedures. The Delegated Officer notes that formal records for the purposes of reporting conditions are only generated if the visual inspection identifies a potential maintenance issue.

10.5 Licence controls – deep well injection of liquid waste

10.5.1 Monitoring

Disposal of wastewater down well is in accordance with the *Solid and Liquid Waste Management Plan* developed under condition 30 of MS 800. The Delegated Officer has determined that discharge of liquid wastes down well is acceptable subject to the Applicant's controls.

One of the key controls is ensuring that well integrity is maintained. As such, conditions are included on the Licence regarding the monitoring of the quality of the waste disposed down well for parameters considered critical in maintaining well integrity and operability (i.e. pH, total suspended solids and total petroleum hydrocarbons). The condition also requires monitoring of other parameters considered critical indicators of well integrity (e.g. annulus pressure, temperature, etc.). Monitoring well integrity is a commitment of the *Solid and Liquid Waste Management Plan* with triggers for the above parameters set internally under operating plans.

Groundwater monitoring and reporting is required under MS 800 and not duplicated in this Licence.

10.5.2 Reporting

Data showing quantities and types of waste disposed of down well is required to be reported to the DWER in the Annual Environmental Report. Process monitoring data is required to be provided to the DWER if requested.

11. Determination of Licence conditions

The conditions in the issued Licence in Attachment 1 have been determined in accordance with the *Guidance Statement: Setting Conditions*.

The *Guidance Statement: Licence Duration* has been applied and the issued Licence expires in 20 years from date of issue.

Table 47 provides a summary of the conditions to be applied to this Licence.

Table 47: Summary of conditions to be applied

Condition Ref	Grounds
Emissions 1	These conditions are valid, risk-based and consistent with the EP Act.
Discharges to air including monitoring 2, 3, 4, 5 and 6	
Discharges to land including monitoring 7, 8 and 9	
Waste acceptance, handling and disposal 10, 11, 12 and 13	
Infrastructure and Equipment 14	These conditions are valid, risk-based and contain appropriate controls.
Records / Reporting 15, 16, 17, 18 and 19	These conditions are valid and are necessary administration and reporting requirements to ensure compliance.

The DWER notes that it may review the appropriateness and adequacy of controls at any time and that, following a review, DWER may initiate amendments to the licence under the EP Act.

12. Applicant's comments

The Applicant was provided with the draft Decision Report and draft issued Licence on 29 May 2018. The Applicant provided comments which are summarised, along with DWER's response, in Appendix 4.

13. Conclusion

This assessment of the risks of activities on the Premises has been undertaken with due consideration of a number of factors, including the documents and policies specified in this Decision Report (summarised in Appendix 1).

Based on this assessment, it has been determined that the Issued Licence will be granted subject to conditions commensurate with the determined controls and necessary for administration and reporting requirements.

Jonathan Bailes

Senior Manager, Process Industries
Delegated Officer under section 20 of the *Environmental Protection Act 1986*

Appendix 1 Key documents

	Document title	In text ref	Availability
1.	Gorgon Project Emissions Verification Report: LNG Trains 1, 2 and 3 and Associated Facilities (W5178/2012/1)	Chevron 2017a	DWER records
2.	Application form: Works Approval / Licence / Renewal Amendment / Registration	Chevron 2017b	DWER records
3.	Gorgon Project – Application for a Licence to Operate LNG Trains 1 to 3 and their Associated Facilities (Ref: ABU170900173), 20 October 2017	Chevron 2017c	DWER records
4.	Chevron's response to DWER's request for further information (Ref: ABU171200551)	Chevron 2017d	DWER records
5.	Works Approval W5178/2012/1 – Gorgon Gas Development Gas Treatment Plant Part 2	W5178/2012/1	DWER records
6.	Works Approval W4818/2010/1 – Gorgon Gas Treatment Plant Part 1	W4818/2010/1	DWER records
7.	Works Approval W5152/2012/1 – Gorgon Project Bridging Wastewater Treatment Plant	W5152/2012/1	DWER records
8.	Works Approval W5037/2011/1 – Gorgon Gas Temporary Power Station	W5037/2011/1	DWER records
9.	Works Approval W4635/2010 – Gorgon Gas Development Bridging WWTP	W4635/2010	DWER records
10.	Works Approval W4827/2010/1 – Gorgon Gas Development Waste Transfer Station	W4827/2010/1	DWER records
11.	Licence L8751/2013/1 – Gorgon Gas Development Waste Transfer Station	L8751/2013/1	DWER records
12.	Licence L8794/2013/1 – Gorgon Gas Temporary Power Station	L8794/2013/1	DWER records
13.	Licence L8479/2010/2 – Gorgon Project Bridging Wastewater Treatment Plant	L8479/2010/2	DWER records
14.	Licence L8894/2015/1 – Liquid Waste Facility	L8894/2015/1	DWER records

	Document title	In text ref	Availability
15.	Licence L8952/2016/1 – Gorgon Gas Development (Train 1)	L8952/2016/1	DWER records
16.	Ministerial Statement 800	MS 800	Accessed at www.epa.wa.gov.au
17.	EPA, 2009. Gorgon Gas Development Revised and Expanded Proposal: Barrow Island Nature Reserve, Report and Recommendations of the Environmental Protection Authority (Report 1323)	Report 1323	
18.	Chevron Australia Pty Ltd, 2012. *Gorgon Project Waste Transfer Station Works Approval Amendment Application – Supporting Document*	Chevron 2012	DWER records
19.	Chevron Australia Pty Ltd, 2013. *Waste Transfer Station (Stage 1) License Application under the Environmental Protection Act 1986*.	Chevron 2013	DWER records
20.	Chevron Australia Pty Ltd, 2014. *Barrow Island: Waste Transfer Station License L875/2013/1 Amendment Application*	Chevron 2014a	DWER records
21.	Chevron Australia Pty Ltd, 2014. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Terrestrial and Subterranean Environment Protection Plan*	Chevron 2014b	Accessed at www.chevronaustralia.com
22.	Chevron Australia Pty Ltd, 2014. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Terrestrial and Subterranean Environment Monitoring Program*	Chevron2014c	
23.	Chevron Australia Pty Ltd, 2016. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Air Quality Management Plan*	Chevron 2016a	
24.	Chevron Australia Pty Ltd, 2016. *Gorgon Gas Development and Jansz Feed Gas Pipeline: Solid and Liquid Waste Management Plan*	Chevron 2016b	
25.	Department of Environment and Conservation (NSW), 2005. *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales,* Department of Environment and Conservation, Sydney	DEC NSW 2005	Accessed at http://www.environment.nsw.gov.au

	Document title	In text ref	Availability
26.	DER, July 2015. *Guidance Statement: Regulatory principles.* Department of Environment Regulation, Perth.	DER 2015a	accessed at www.dwer.wa.gov.au
27.	DER, October 2015. *Guidance Statement: Setting conditions.* Department of Environment Regulation, Perth.	DER 2015b	
28.	DER, August 2016. *Guidance Statement: Licence duration.* Department of Environment Regulation, Perth.	DER 2016a	
29.	DER, February 2017. *Guidance Statement: Risk Assessments*. Department of Environment Regulation, Perth.	DER 2017a	
30.	DER, February 2017. *Guidance Statement: Decision Making*. Department of Environment Regulation, Perth.	DER 2017b	
31.	DWER, April 2018. Landfill Waste Classification and Waste Definitions 1996 (as amended 2018). Department of Water and Environmental Regulation, Perth	DWER 2018	
32.	Denis, M.S., Song, X., Lu, J.Y. and Feng, X (2003) Atmospheric gaseous elemental mercury in downtown Toronto, *Atmospheric Environment*, 40 (4016-4024)	St. Denis *et at*, 2006	Accessed at http://www.sciencedirect.com
33.	Safe Work Australia, 2013. Workplace Exposure Standards for Airborne Contaminants.	SWA 2013	Accessed at www.safeworkaustralia.gov.au
34.	WHO, 2000. *Air Quality guidelines for Europe, 2nd Edition*, WHO Regional Publications, European Series, No. 91, WHO Regional Office of Europe, Copenhagen, Denmark	WHO 2000	Access at http://www.euro.who.int
35.	WHO, 2003. *Elemental Mercury and Inorganic Mercury Compounds: Human Health Aspects, Concise International Chemical Assessment Document 50,* WHO Marketing and Dissemination, Geneva, Switzerland	WHO 2003	Accessed at http://www.who.int
36.	WHO, 2005. *Air Quality Guidelines, Global Update 2005*, WHO Regional Office of Europe, Copenhagen, Denmark	WHO 2005	Access at http://www.euro.who.int

Appendix 2 Summary of incidents and complaints

DWER reference	Incident description	Incident/Complaint date
15508	Chevron as the operators of the joint venture Gorgon Gas Project advised DWER that contractors had cleared 332m^2 in two separate locations. A Letter of Warning was issued to Chevron and the investigation closed	June 2009
26392	On 30 September 2012 a bushfire, probably ignited from hot debris caused by blasting from the Gorgon construction project, burnt approximately 1.9 hectares of vegetation on Barrow Island, outside of Gorgon Project tenure. The fire was extinguished within an hour using Gorgon Joint Venture and WA Oil Barrow Island Joint Venture emergency response and construction personnel. No regulatory notices were issued.	September 2012
34244	Chevron reported that 870L of untreated effluent overflowed from the 600EP wastewater treatment plant. Corrective actions were taken by Chevron.	May 2014
38733	Chevron reported that 13,000L of Hydrochloric Acid was released to a containment bund. No discharge to the environment occurred.	November15
38814	Chevron reported that 7500L of Hydrochloric Acid was released to a containment bund. No discharge to the environment occurred.	December 15
44994	A complaint was received alleging that acid gas from the Train 1 AGRU was being vented via Vent 6 (MEG Flash Gas Vent) rather than Vent 1 and subsequently bypassing the MRU. The investigation has been closed and no action was taken.	May 2017

Appendix 3 Summary of comments on the application from licence from stakeholders

Summary of comments	DWER response
The Licence does not conflict with any aspects of the project regulated under the *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* or the *Petroleum Pipeline (Environment) Regulations 2012.*	No response required.
Objection was raised to granting the licence for a 20 year period suggesting that this would significantly reduce opportunities for community scrutiny, transparency and public input. Concern was raised that there would be no automatic trigger for the licence to be reviewed and updated to ensure it continues to meet contemporary standards. A licence period of three years was requested.	The Licence duration has been determined in accordance with *Guidance Statement: Licence Duration*, taking into account: (a) the duration of other statutory approvals, such as planning approvals; (b) the level of risk of harm to public health and the environment posed by the premises; (c) whether the premises has been subject to recent environmental assessment; and (d) matters relevant to the efficient operation of the licensing regime. As stated in *Guidance Statement: Risk Assessment*, DWER will undertake periodic reviews of the instrument and relevant risks when appropriate to do so having regard to relevant matters including: (a) incident or event reporting under section 72 of the EP Act; (b) relevant reporting and information submitted in accordance with regulatory instruments; (c) the period since the last review of the prescribed premises; (d) new information which is relevant to the risk assessment for the prescribed premises; (e) compliance inspections; (f) complaints received; and (g) enforcement action taken. There will be opportunity for public input at the end of the review and at any time that the licence is amended prior to the end of the 20 year duration.

Summary of comments	DWER response
It was noted that there are significant environmental risks associated with geo-sequestration including direct impacts associated with high concentrations of CO_2, potential for CO_2 to leak from the confining reservoir and impacts associated with the release of greenhouse gas emissions. It was suggested that these risks were not properly examined as part of the Part IV assessment process and that there is a lack of operational control or environmental risk management relating to the CO_2 Injection System in the Ministerial Conditions and therefore operation of the geo-sequestration facility should be captured under the Licence. Comment was also made regarding the delayed operation of the CO_2 compression and injection system resulting in additional CO_2 being vented to atmosphere. Considering the above, licence conditions were recommended as follows: • Conditions mirroring those in MS 800; • Noting the additional venting of CO_2 due to delays to the operation of the CO_2 compression and injection system, provision of a practicality test for the purpose of compliance with condition 26 of MS 800 which specifies that the Applicant should implement all practical measures to inject 80% of CO_2 calculated over a five year rolling average; • Conditions to ensure the proper construction and operation of the facility to ensure it remains operational to achieve the above target; and • Requiring the cessation of LNG production should the above target be at risk of not being met.	Appendix 3 of EPA Report 1323 summarises the key environmental risks associated with the Gorgon Project that were assessed and conditioned (where required). These include: • Risks to fauna from leaks associated with the CO_2 compression and injection system; and • Global impacts from greenhouse gas emissions. In their report, the EPA considered that risks to fauna populations associated with leaks could be adequately regulated through existing conditions (i.e. condition 26 of MS 800). It was also determined that emissions of greenhouse gases in instances when the CO_2 compression and injection system is not operational could be managed through existing conditions (conditions 25 and 26 of MS 800) and State and Federal management strategies. DWER *Guidance Statement: Setting Conditions* states that "*Conditions* [on a licence] *will not unnecessarily duplicate requirements imposed on licenses directly by the EP Act or another written law*". Noting the above, the Delegated Officer considers that MS 800 is the primary regulatory instrument for ensuring that the injection target specified in condition 26 is achieved. As such, conditions relating to CO_2 emissions or geo-sequestration have not been duplicated on the Licence. In addition to regulatory controls implemented under Part IV of the EP Act, construction and operation of the CO_2 compression and injection system is regulated through the following legislation: • *Barrow Island Act 2003* – Approval to dispose of CO_2 via the injection system was granted under section 13 of the *Barrow Island Act 2013* and is subject to conditions. These include conditions relating to the composition of injected CO_2, CO_2 injection rates and volumes, and monitoring and incident reporting. The Applicant is also required to comply with the CO_2 Disposal Management Plan (Chevron, 2009) which forms the basis of the approval application. • *Petroleum Pipelines Act 1969* – The CO_2 compression and injection system is subject to commitments outlined in the Carbon Dioxide

Summary of comments	DWER response
	Injection System Pipeline and Wells Operations Environment Management Plan which has been developed and approved in accordance with the *Petroleum Pipelines (Environment) Regulations 2012*. The plan identifies risks associated with CO_2 injection (including environmental impacts associated with leaks of the CO_2 reservoir above and below ground) and describes control measures in place to manage them. Operation of the CO_2 compression and injection system has not yet commenced and therefore the Delegated Officer has determined that potential risks associated with the operation of the CO_2 compression and injection system (such as leaks) are outside the scope of this Licence and have not been assessed. In its assessment of any future applications received for the operation of the CO_2 compression and injection system, DWER will consider the above regulatory controls and *Guidance Statement: Setting Conditions* in determining if additional regulatory controls are required on the Licence. Additionally, on 30 April 2018, the EPA announced that Condition 26 of MS 800 would be subject to inquiry under s 46 of the EP Act. The assessment will review and define the commencement date for compliance with the injection target of 80% calculated over a five year rolling average. In the event that the amount of CO_2 injected falls significantly below the target, the Ministerial Statement provides for the ability to offset the shortfall.

Appendix 4 Summary of applicant's comments on risk assessment and draft conditions

Condition	Summary of Licence Holder comment	DWER response
Definitions	Requested that definitions are included for waste types specified in condition 10 (i.e. Inert Waste Type 1, Inert Waste Type 2, Special Waste Type 1 and Hazardous Waste).	Definitions were inserted which make reference to the Landfill Waste Classification and Waste Definitions 1996 (DWER 2018).
	Requested a definition of "Liquid Waste" similar to the definition use for "wastewater" to provide additional clarity under condition 10.	The term "Liquid Waste" has been removed from the licence as it is considered to be adequately captured by the term "Hazardous Liquid Waste" as referenced in Condition 10.
1	Amend Table 2 to read "Emissions which arise from the Primary Activities set out in Schedule 2 including specific emissions" to ensure that Chevron are permitted to have general emissions from the specified emission points.	Not accepted as the condition already applies to other types of emissions from the specified emission points.
8	Requested a footnote inserted into Table 5 to allow in-field non-NATA sampling for parameters required to be monitored.	Not accepted as Table 14 (Schedule 3) allows sampling and analysis to be carried out in accordance with "Licence Holder approved internal laboratory procedures". These procedures have been submitted and reviewed by DWER and deemed suitable for the analysis required.
10 (Table 6)	Requested amendments to clarify that hazardous solid and liquid waste is not stored or handled in the same manner. Unlike hazardous liquid waste received at the Waste Transfer Station, hazardous solid waste is not always handled or stored within the bunded area at the Waste Transfer Station but is stored with appropriate containment where required (i.e. stored in skip bins on a hardstand). It was requested that the specifications relating to hazardous waste in Table 6 are amended to read: "Receipt, handling, consolidation and sorting, and storage of hazardous solid waste is within hardstand areas and/or within appropriate secondary containment at the Waste Transfer Station. Receipt, handling, consolidation and sorting, and storage of hazardous liquid waste within a bunded area at the Waste Transfer Station (Schedule 1: Premises map) prior to disposal:	The wording within Table 6 has been amended to provide clarification. The Delegated Officer considered that management of hazardous solid waste is reasonable for preventing hazardous material entering the environment. In the unlikely event that operational controls fail (i.e. containers and/or skip bins are damaged causing release of material), discharge of hazardous material to the environment is subject to the UDR and general provisions of the EP Act regarding causing pollution and environmental harm.

Condition	Summary of Licence Holder comment	DWER response
10 (Table 6)	The Applicant raised concern that the condition does not capture storage of waste in other areas of the Premises (e.g. hazardous solid waste stored in skip bins at the GTP).	It is noted that waste generated in other areas are stored in appropriate containers such as skip bins, bunds, etc. prior to relocation to the Waste Transfer Station for consolidation. The risk assessment has identified that the environmental risk is primarily associated with the bulk handling and storage of waste at the Waste Transfer Station and therefore regulatory controls have been applied to activities at the Waste Transfer Station. The licence does not restrict the storage of waste in other areas of the Premises, which is subject to the UDR and general provisions of the EP Act regarding causing pollution and environmental harm.
10 (Table 6)	The Applicant noted that Liquid Waste is only disposed of down well if it meets the relevant quality specifications. If it does not meet these specifications it is taken off Barrow Island for disposal. It was requested that the table be amended for clarity.	The licence specifies the disposal end points for waste on the island (i.e. disposal via deep well injection or discharge to the environment via the Stormwater Holding Pond). Offsite disposal is not regulated through the licence as it is subject to other legislation and controls such as the *Environmental Protection (Controlled Waste) Regulations 2004*.
11 and 12	The Applicant requested the removal of condition 12 “Waste input monitoring” indicating that waste input monitoring is not required as waste is generated on the same Premises (i.e. the Gorgon LNG Project).	The conditions primarily relate to storage and handling of waste at the Waste Transfer Station. Monitoring of inputs is required to verify that limits specified under condition 10 are met. Output monitoring ensures that all waste removed from site is accounted for. The conditions have been amended to remove ambiguity.
11 and 12	Removal of requirement to monitor input and output of “Liquid Waste” as this is duplicated in condition 13 (Table 15)	Accepted.
14	Requested the minimum freeboard requirements be amended from 300mm to 600mm to align with operational requirements.	Accepted.

Condition	Summary of Licence Holder comment	DWER response
19	Amended wording of the conditions relating to reporting results collected under conditions 3 and 9 confirming that the format for reporting monitoring results is: • A summary of annual results provided in tabulated format; and • A minimum of three years data (where available) provided in time series graphs.	Monitoring data for each monitoring location is to be provided over a minimum three year period (where sufficient data allows) in both tabulated format and time series graphs in Microsoft Excel. This is the minimum requirements for submission. A separate table showing results for the relevant annual period can also be provided if the Applicant prefers but is not required.
19	Requested the removal of the requirement to submit copies of original monitoring, laboratory and analysis reports submitted by third parties in the Annual Environmental Report. The Applicant indicated that these reports can be submitted on request.	The requirement has been retained for monitoring of emissions to air given the monitoring is carried out by third-parties for the Applicant. Monitoring reports provide useful context and information relating to the monitoring carried out. The requirement has been removed for monitoring of emissions to land and deep well disposal as this monitoring is carried out by the Applicant.
Table 13	Reduce the averaging period for monitoring volumetric flow rate, NOx and CO at GTG1-5 and GT1 – GT3 from 60 minutes to 30 minutes to align with testing methodologies.	Accepted. The Delegated Officer considers this change to be consistent with contemporary testing methodologies.
Table 13	Requested that wording of monitoring frequency for monitoring of emissions from GT1- GT3 is amended to include “if operating”. This is to account for unplanned equipment trips coinciding with the scheduled emissions testing program resulting in emissions not being tested if one (or more) of the GTs not operating. The Applicant has indicated that the likelihood of this occurring is low.	Accepted.
Table 13	The Applicant requested that testing methods specified in Table 13 include wording “or any other method” to capture new methods that are developed in the future that are comparable to US EPA methods.	Not accepted. Testing methods are specified in the licence to ensure that approved contemporary methods are used. Alternative testing methods would require review by DWER prior to endorsement as an approved testing method.

Condition	Summary of Licence Holder comment	DWER response
N/A	The Applicant provided information regarding a planned upgrade at the GTP relating to the installation of additional instrument air compressors. The stormwater drainage system will be modified to include the upgrade in the Class 1 drainage system.	No amendments to the licence conditions required as the upgrades will be incorporated into the existing stormwater capture and treatment system as described in the Decision Report.
N/A	The Applicant identified the need for a contingency disposal option of untreated sewage waste from the WWTP in the event of plant breakdown or upset conditions. The Applicant requested that during these events, untreated sewage, or partially untreated sewage, is disposed of via deep well injection. These events are expected to be infrequent for short periods while the plant is repaired and are not expected to significantly impact the composition of waste disposed of down well.	No amendments to the licence conditions required. The Delegated Officer considers that there will be no significant change to the environmental risk associated with disposal of waste via deep well injection, as the composition of waste will not alter significantly, and the disposal of untreated, or partially untreated waste, will be required infrequently for short periods.