Western Sydney Green Gas Project - Environmental Impact Statement

Jemena Gas Networks (NSW) Limited

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DOCUMENT TRACKING

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SUBMISSION OF AN ENVIRONMENTAL IMPACT STATEMENT (EIS)

State Significant Development: Section 4.12 (8).

EIS Prepared by:

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In Respect of:	Eco Logical Australia Pty Ltd	
Development Application:	SSD-10313	
Applicant Name:	Jemena Gas Networks (NSW) Limited	
Application Address	Level 16, 567 Collins St Melbourne, Victoria	
Lot No. DP No.	194 - 202 Chandos Road, Horsley Park NSW	
Land to be Developed:	Lot	DP
	1	499001
	3	1002746

Environmental Impact Statement

This Environmental Impact Statement (EIS) assesses the potential environmental impacts associated with the proposed Western Sydney Green Gas Project in accordance with the Secretary's Environmental Assessment Requirements, issued to the proponent on 12 June 2019.

I certify that I have overseen the preparation of the contents of this Statement and to the best of my knowledge:

- It has been prepared in accordance with Schedule 2 of the *Environmental Planning and Assessment Regulation 2000*
- It contains all available information that is relevant to the environmental assessment of the development to which the statement relates
- The information contained in this Statement is neither false nor misleading.

Name:	**Daniel Magdi**
Signature:	D. Magdi
Date:	6 December 2019

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Abbreviations

Abbreviation	Description
AEMO	Australian Energy Market Operator
AGIG	Australian Gas Infrastructure Group
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
AHIP	Aboriginal Heritage Impact Permit
APGA	Australian Pipelines & Gas Association
ARENA	Australian Renewable Energy Agency
ARENA Act	*Australian Renewable Energy Agency Act 2011*
AS	Australian Standards
ASME	American Society of Mechanical Engineers
BC Act	*Biodiversity Conservation Act 2016*
BCD	Biodiversity Conservation Division within Department of Planning, Industry and Environment
BDAR	Biodiversity Development Assessment Report
Biosecurity Act	*Biosecurity Act 2015*
CCS	Carbon Capture and Storage
CIV	Capital Investment Value
COAG	Council of Australian Governments
COP21	21st Conference of the Parties
DC	Direct Current
DEM	Desktop Elevation Model
DoIIS	Department of Industry, Innovation and Science
DPIE	Department of Planning, Industry and Environment
DSM	Digital Surface Model
DTIRIS	Department of Trade & Investment Regional Infrastructure and Services
EGP	Eastern Gas Pipeline
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESCP	Erosion and Sediment Control Plan
ESD	Ecologically Sustainable Development

Abbreviation	Description
FCC	Fairfield City Council
FLEP	Fairfield Local Environmental Plan 2013
FM Act	*Fisheries Management Act 1994*
GAMAA	Gas Appliance Manufacturers Association of Australia
GHG	Greenhouse Gas
GS Act	*Gas Supply Act 1996*
Hazardous and Offensive Development SEPP	*State Environmental Planning Policy No. 33 – Hazardous and Offensive Development*
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HIPAP	Hazardous Industry Planning Advisory Paper
HRS	Hydrogen Delivery Refuelling Station
Infrastructure SEPP	*State Environmental Planning Policy (Infrastructure) 2007*
IPART	Independent Pricing and Regulatory Tribunal
ISO	International Organisation for Standards
Jemena	Jemena Gas Networks (NSW) Ltd
KFH	Key Fish Habitat
LALC	Local Aboriginal Land Council
LGA	Local Government Area
LIDAR	Light Detection and Ranging
MNES	Matters of National Environmental Significance
MSDS	Material Safety Data Sheets
NGA	National Greenhouse Accounts
NPfI	Noise Policy for Industry
NPW Act	*National Parks and Wildlife Act 1974*
NRAR	Natural Resources Access Regulator
NSW	New South Wales
P2G	Power to Gas
PCT	Plant Community Types
PEM	Proton Exchange Membrane
PFD	Process Flow Diagram
PHA	Preliminary Hazard Assessment
Pipelines Act	*Pipelines Act 1967*
PMF	Peak Maximum Flood
POEO Act	*Protection of the Environment Operations Act 1997*
RMS	Roads and Maritime Service

Abbreviation	Description
RO	Reverse Osmosis
Roads Act	*Roads Act 1993*
RSWMP	Regional Strategic Weed Management Plans
SAR	Sodium Absorption Level
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheet
SEARs	Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SHR	State Heritage Register
SIS	Safety Instrumented System
SMP	Stakeholder Management Plan
SSD	State Significant Development
State and Regional Development SEPP	*State Environmental Planning Policy (State and Regional Development) 2011*
UNFCCC	United Nations Framework Convention on Climate Change
WM Act	*Water Management Act 2000*
WSGG Project	Western Sydney Green Gas Project
WSP	Western Sydney Parklands
WSP Act	*Western Sydney Parklands Act 2006*
WSP SEPP	*State Environmental Planning Policy (Western Sydney Parklands) 2009*
WSPT	Western Sydney Parklands Trust

Executive Summary

Introduction

This Environmental Impact Statement (EIS) has been prepared for Jemena Gas Networks (NSW) Limited (Jemena) to support a State Significant Development application (SSD) to build and operate a trial Power to Gas (P2G) project to transform renewable electrical energy into a combustible gas (hydrogen), within Horsley Park, New South Wales. The proposal is referred to as the Western Sydney Green Gas Project (WSGG Project). The WSGG Project is located at 194 - 202 Chandos Road, Horsley Park, within the Fairfield City Council (FCC) Local Government Area (LGA).

Jemena, together with its related bodies corporate Jemena Eastern Gas Pipeline (1) Pty Ltd and Jemena Eastern Gas Pipeline (2) Pty Ltd, own the Horsley Park high pressure gas facility, which is comprised of the Jemena Gas Network as well as a number of pressure let down and pipeline pigging facilities, for the Eastern Gas Pipeline (EGP), Jemena Trunkline, Sydney Primary Loop and local secondary network. When referencing the Horsley Park site within this document, the site is referred to as the Jemena Horsley Park Facility. The Jemena Horsley Park Facility is not located on Crown Lands.

This EIS has been prepared under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) (SSD-10313), in accordance with the Secretary's Environmental Assessment Requirements (SEARs), dated 12 June 2019, and the requirements of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation).

The Proposal

Jemena proposes to undertake the WSGG Project, a power to gas (P2G) facility to transform renewable electrical energy into a combustible gas, hydrogen, which is either injected at up to 2% by volume into the Sydney secondary gas distribution network, supplied to a microturbine to generate electricity for export back to the grid, or potentially supplied to an adjacent hydrogen refuelling station (HRS) for bus refuelling. The P2G process will involve producing hydrogen from water using electrolysis, with a by-product from the electrolysis process being oxygen, which will be released directly into the atmosphere. Hydrogen is a renewable resource and is neither a hydrocarbon nor greenhouse gas. The electrolysis process will also produce wastewater as a by-product, with a mild salinity of approximately 500 ppm.

The WSGG Project has been designed for a production capacity 100 m^3/h of hydrogen gas with a 500kW electrolyser, using purchased green electricity. The WSGG Project includes a gas fuelled generator (microturbine) that will initially be run on natural gas, then converted to use hydrogen as its fuel source in late 2020, demonstrating a completely renewable source of electricity production. The WSGG Project will be designed with provisions for future expansion to double its hydrogen production capacity should the proposed HRS proceed (GPA Engineering 2019b). This potential future expansion has been included in the assessments undertaken for this EIS.

The WSGG Project will require the construction of a production facility (P2G Plant) and additional associated equipment, together comprising the following:

- Electrolyser (including final water treatment, electrolyser stack, purification & cooling systems)
- Hydrogen buffer store (buried carbon steel pipeline)

- Hydrogen gas control panel
- Hydrogen gas grid injection panel (to supply the Secondary Mains)
- Hydrogen microturbine
- Hydrogen refuelling station (HRS) (optional future scope)
- Site control hut
- Power grid connection, including transformer.

The P2G Plant will be located within the boundaries of the Jemena Horsley Park Facility, with the self-contained electrolyser package being installed and operated outdoors. The main works area for the P2G Plant will be within the northern portion of the existing facility, and will consist of a water tank, waste water sump, control hut, electrolyser package, gas and injection panel package, gas generator package, and upgrading the existing outer security fencing. Immediately adjacent to the P2G Plant will be the future HRS, upgraded access route for buses, and the underground hydrogen buffer storage.

Statutory Position

The WSGG Project has a capital investment value estimated to be above $15 million. Under the *State Environmental Planning Policy* (SEPP) *(State and Regional Development) 2011* (State and Regional Development SEPP), development that has a capital investment value of more than $10 million on land identified as being within the Western Sydney Parklands (WSP) on the Western Sydney Parklands Map within the meaning of *State Environmental Planning Policy (Western Sydney Parklands) 2009* (WSP SEPP) is classified as State Significant Development and requires approval under Part 4 of the EP&A Act through the preparation of an EIS.

The WSGG Project is wholly within Jemena's Horsley Park Facility which is currently used as a gas network facility. The proposal site is surrounded by WSP to the west, rural land to the east, Austral Bricks plant to the north and Chandos Road to the south. In accordance with the WSP SEPP, the land in which the proposal site is situated is unzoned.

The NSW Minister for Planning is the consent authority for SSD applications. This EIS has been prepared in accordance with the requirements of Division 4.7 of the EP&A Act, Schedule 2 of the EP&A Regulation and the SEARs, dated 12 June 2019.

Consultation

Stakeholder and community consultation has been undertaken for the WSGG Project since 2018 in accordance with a Stakeholder Management Plan (SMP) developed specifically for the WSGG Project. Jemena has consulted with the local community, stakeholders from the wider area and relevant government departments and agencies in order to understand and respond to concerns during the design and assessment process leading to this SSD application.

Activities that have taken place are listed below:

- Identification and consultation (ongoing) with adjoining and potentially affected landowners within a 500 m radius of the facility.

- Broader community consultation through a dedicated project website, social media platforms including YouTube, Twitter, Facebook and LinkedIn. Jemena will hold a community information session and BBQ offsite at the Horsley Park Community Hall during early December 2019.
- Notification of the WSGG Project to the Deerubbin Local Aboriginal Land Council.
- FCC consultation, including emergency management council.
- Consultation with Australian Government Departments, agencies and Members of Parliament.
- Consultation with NSW State Government departments and agencies, including but not limited to the NSW Department of Planning, Industry and Environment (DPIE), Western Sydney Parklands Trust (WSPT) and Sydney Water.
- Consultation with industry bodies and other organisations.
- Media coverage at the local, regional and national level.

Consultation activities remain ongoing at the time of preparing this EIS and will continue through the approvals process and construction phase of the project, as outlined within the WSGG Project SMP and this EIS.

Environmental Assessment

This EIS has been undertaken to assess potential environmental impacts for a range of issues identified through the consultation process and site investigations. All potential environmental constraints associated with the Site have been identified and are responded to within this EIS.

Air Quality

An Air Quality Impact Assessment was undertaken by Benbow Environmental (2019) to determine the likely air quality and Greenhouse Gas (GHG) impacts of the WSGG Project. The WSGG Project will have three sources of emissions to air, including the gas generator (microturbine), electrolyser and a buffer store blowdown vent. Future sources may also include an additional electrolyser and a hydrogen refuelling and dispensing station. An analysis was completed on all sources of emissions, with the potential impacts considered to be very low to low.

Odour and dust were also considered within the Air Quality Impact Assessment, with potential impacts to be minimised through air quality mitigation measures. Overall, the air quality impacts from the WSGG Project are expected to be very low and will not cause a negative impact on the health or environment of the surrounding area.

Greenhouse Gas (GHG) Emissions have been assessed with this EIS, with both direct and indirect emissions assessed and were categorised into three broad scopes. Scope One (all direct GHG emissions); Scope Two (Indirect emissions from consumption of purchased electricity, heat or steam); and, Scope Three (other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope Two, outsourced activities, waste disposal, etc.).

Overall, the estimated annual greenhouse emission for the WSGG Project is 0.000019 Mt CO2-e. Therefore, the annual contribution of greenhouse emissions from the current proposal in comparison to the Australian greenhouse emissions in 2017 is approximately 0.000000004%.

Hazards and Risk

The WSGG Project is being developed in accordance with a range of international and Australian regulations, standards and best practice guidelines that will assist to ensure that the design, construction and operation of the facility is safe.

A Preliminary Hazard Assessment (PHA) was undertaken by GPA Engineering (2019c) to quantitatively determine the level of risk associated with the WSGG Project facility. The PHA was prepared in accordance with Hazardous Industry Planning Advisory Paper (HIPAP) 6: Guidelines for Hazard Analysis (DP&E 2011), and the risk criteria outlined in HIPAP 4: Risk Criteria for Land Use Planning (DP&E 2011).

The PHA identified three hazardous materials to be assessed: hydrogen, natural gas and oxygen.

The results of these analyses determined that the scenarios with the highest potential consequence were those which have the potential for offsite consequences. The main hazard identified was a loss of containment of hydrogen. The calculated frequency of potential risk for the WSGG Project was assessed to be below the tolerable risk target for 'active open space areas' and therefore not a credible risk once controls are introduced. If the vehicle refueller proceeds, this will be achieved through incorporating a firewall into the final design (GPA Engineering 2019c).

A Downstream Impact Assessment was prepared by GPA Engineering (2019d) to identify the potential impacts from the WSGG Project to the distribution network downstream of the injection point at the Horsley Park Trunk Receiving Station. The downstream assessment found that all natural gas and hydrogen blends are compliant with the national standard AS 4564-2011. At the target blending percentage of 2% and the shutdown limit of 10% the limits stipulated in AS 4564-2011 are within the allowable range for the expected range of natural gas compositions (GPA Engineering 2019d).

Waste

Waste impacts associated with the WSGG Project have been assessed for both the construction phase and operation phase of the project. Construction waste will be classified in accordance with the Waste Classification Guidelines (EPA 2014), and if required disposed of lawfully at a licensed waste facility.

Potential impacts from construction waste generation include:

- Minor spills from hazardous fuel and chemical use can be an environmental issue. However, in the context of the materials and equipment utilised on this project, are typically small in scale and localised only. On site spill kits will be utilised to contain and remove any contaminated materials. Used spill kits shall be disposed of at a licenced waste facility.
- Minor pollution of the environment from other general wastes (e.g. packaging). Waste of this type will be collected and disposed of or recycled in appropriate on-site bins.
- Wastewater generated from the purification process. This will comprise of slightly elevated levels of minerals typically found in mains water only, without addition of any other substances.

Operational waste from the WSGG Project includes wastewater generated through the purification process for the electrolyser. As per the construction phase, it will be comprised of slightly elevated levels of minerals typically found in mains water only. Jemena is still assessing the options for wastewater removal, however the following measures, either individually or in combination, are being considered:

- Truck the wastewater offsite to a licenced facility for disposal.
- Reuse the wastewater for irrigation, pending regulatory approval.
- Treat and reuse the part of the wastewater within the facility. This may include options such as further concentrating the wastewater for disposal and reusing the treated portion of the water for on-site washing or septic systems.

Noise and Vibration

An assessment was undertaken by Marshall Day Acoustics Pty Ltd (2019) to investigate potential noise and vibration impacts from the construction phase and operation of the WSGG Project.

The assessment of the construction phase has been undertaken in accordance with the requirements of the EPA *Interim Construction Noise Guidelines* and EPA's *Assessing Vibration: A technical Guideline*. Where the "noise affected" management level is predicted to be exceeded during construction, the Interim Construction Noise Guidelines requires that all feasible and reasonable work practices be employed. These shall be assessed in conjunction with the current and upcoming works and implemented to comply with the Guidelines. Where it is predicted that the "highly noise affected" management level will be exceeded, respite periods may need to be considered, such as limiting these works from the early and late portions of the allowable daily window.

Examples of noise mitigations provided by the Guidelines include:

- Pre-emptive actions such as:
  - Including noise mitigations and considerations in construction tender.
  - Ensure equipment selection and servicing is appropriate prior to work starting (e.g. selecting hydraulic and electric equipment over petrol or diesel).
  - Liaising with local residents and providing advance notification for upcoming noisy activities.
- Limiting noisy activities to 9 am to 12 pm Monday to Saturday and 2 pm to 5 pm Monday to Friday.
- Construction Temporary barriers for specific activities.
- Minimising non-essential noise such as radios, local announcement system, truck horns etc.

The assessment of operational phase has been undertaken in accordance with the requirements of the NSW EPA's *Noise Policy for Industry* (NPfI). The operational noise assessment has been based on:

- Operational noise limits determined in accordance with the NPfI, accounting for existing background noise levels at neighbouring sensitive locations.
- Predicted noise levels for the WSGG Project based on the proposed site layout and noise generating equipment.
- A comparison of the predicted noise levels with the criteria derived in accordance with the NPfI.

Preliminary modelling found that the noise contribution from operation of the microturbine may give rise to noise levels exceeding the NPfI Project trigger levels at night. The mitigation proposed is limitation of operation between 7am and 10 pm only, to comply with noise level trigger levels.

Visual

The proposed location of the WSGG Project is in a predominantly flat landscape, with elevation ranging from between 60 – 70 m above sea level, which is typical of the rural landscape of Western Sydney. A desktop spatial assessment was therefore undertaken to determine potential sensitive receivers in proximity to the facility, which may have a direct line of sight to the blowdown pipe which is the highest point on the site.

A line of site assessment was undertaken to determine the visual impact rating for sensitive receivers surrounding the WSGG Project. The line of site assessment identified three (3) sensitive viewing locations that will have a low impact rating and have a clear line of site of the blowdown pipe. It was concluded that these impacts are already mitigated through the existing distance between the sensitive receivers and the WSGG Project facility.

Traffic and Transport

A traffic impact assessment was prepared by TTM (2019) which investigated the traffic aspects associated with the WSGG Project. The scope of this assessment included:

- Review of concept design plans
- Assessment of the proposed development layout of the site with respect to Council, Traffic, Access, Parking and Servicing requirements
- Swept path analysis for proposed design
- Determination of the likely traffic generation for the proposed development and identification of potential traffic impacts on the local road network.

It was determined that the traffic generation resulting from the WSGG Project is relatively minor and not of a level normally associated with unacceptable traffic implications in terms of road network capacity, efficiency and/or traffic related environmental effect.

A dilapidation report will be developed prior to commencement of construction (and again after construction). A construction traffic management plan will be put into place to ensure that traffic impacts are managed and mitigated during construction.

Biodiversity

Section 7.9 (2) of the BC Act states that a SSD Application must be accompanied by a Biodiversity Development Assessment Report (BDAR) unless the Planning Agency Head and the Environment Agency Head determine that the proposed development is not likely to have any significant impact on biodiversity values.

ELA undertook a site visit, which determined that no significant biodiversity values were present within the proposal site therefore, no impact on biodiversity value will occur as a result of the proposed development. ELA then prepared a BDAR waiver request on behalf of Jemena. The BDAR waiver request was submitted to the DPIE on 29 August 2019. On 11 September 2019 DPIE confirmed that a waiver was granted. Therefore, submission of a BDAR is not required.

Aboriginal Heritage

A search of the NSW OEH's (now the Biodiversity and Conservation Division (BCD) within DPIE) Aboriginal Heritage Management Information System (AHIMS) was undertaken of 9 September 2019 to identify whether any registered Aboriginal sites were present within, or adjacent to, the Project area. The AHIMS search identified 61 Aboriginal sites recorded in or near the proposal site and no Aboriginal places.

An Aboriginal Due Diligence Assessment for the Jemena Horsley Park Facility was undertaken by Biosis Pty Ltd in 2014 in accordance with the requirements of the Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales (DECCW 2010) for this same study area, although for different proposed works. As the previous report covered impacts to the entire lot, the conclusions and recommendations presented within it are relevant to the current WSGG Project.

There is a recorded AHIMS site (45-5-2567) located approximately 20-30 m to the west of the western boundary of the proposal site. The WSGG Project will not impact upon AHIMS site 45-5-2567, as it is recorded outside of the Project area. There are no potential impacts to unrecorded archaeological deposits because the potential for intact deposits of Aboriginal objects were assessed to be low.

Historic Heritage

Searches of relevant heritage databases were undertaken on 9 September 2019 in order to determine if any places of historical significance are located within or in proximity to the study area. The results of the searches indicated that there are no known items of historical heritage significance located within or in proximity to the Project area.

Water and Land

The WSGG Project is located on gently undulating land, declining gradually towards the northwest. Observations from site indicate that the site drains to the north and east of the facility, across the Jemena Horsley Park Facility area and thence to Eastern Creek. The ground surfaces both inside and outside the existing facility upslope and downslope from the proposed work location and feature continuous and dense grass cover.

As the facility is located on raised ground relative to Eastern Creek and located near the top of the catchment, it is unlikely that it will be subject to significant flood levels affecting the whole site, with the western edge of the site possibly slightly inundated during a peak maximum flood.

The Jemena Horsley Park Facility is not located on flood-prone land and no excavations will penetrate below 2 m. Therefore, are unlikely to impact on local groundwaters. Water application to the land from electrolyser outputs will not pose any rise to soils or impose additional water stress to the environment.

The risk to surface and groundwater is considered very low.

Social and Economic

To identify the social benefits or impacts of the WSGG Project, the outcomes of the community consultation, as well as findings presented in the COAG Energy Council's National Hydrogen Strategy issues papers, prepared for the National Hydrogen Strategy, where assessed.

The community consultation undertaken for the project found two main social concerns (safety/health and noise), and one main economic concern (decrease in land value). The findings presented in the COAG Energy Council's issues papers identified key issues and impacts that are perceived by the community regarding an emerging hydrogen industry, including carbon emissions, safety and water consumption (social), and increased consumer costs (economic).

This EIS has considered the social and economic impacts relating to the outcomes of the community consultation, as well as findings presented in the COAG Energy Council's issues papers, prepared for the National Hydrogen Strategy. The findings are as follows:

- Carbon emissions – The WSGG Project is aimed at proving the technology so that future development of large-scale green hydrogen production can be achieved, which will further enhance Australia's renewable energy capability and ensure a low carbon future for industry and community. Further, the WSGG Project will purchase green electricity for hydrogen production and, once the generator package is converted to run on hydrogen in late 2020, will have no associated Scope 1 or 2 emissions.
- Safety – The WSGG Project is being developed in accordance with a range of international and Australian regulations, standards and best practice guidelines that will assist to ensure that the design, construction and operation of the facility is safe. A PHA was undertaken to identify, assess and mitigate potential risks associated with the project.
- Water Consumption – The WSGG Project will use mains water but is investigating ways to maximise the value of water used (such as using reject water for irrigation) and will also incorporate provisions to potentially trial the use of recycled water, which will further enhance the green nature of the hydrogen production industry within Australia.
- Noise – Noise has been assessed within this EIS and has concluded that any predicted exceedances are unlikely to be intrusive when considering existing noise on site. Additionally, since all construction work is restricted to take place only during the daytime, and the microturbine is intended to operate during day and evening hours only, there will be no construction or operational noise impacts to sensitive receivers at night.
- Increased consumer costs – The Australian Gas Infrastructure Group (AGIG) has suggested that costs for hydrogen production may potentially reach price parity with domestic natural gas markets that are exposed to global markets by 2030. Additionally, costs associated with the WSGG Project will not be passed on to consumers.
- Decrease in land value – The WSGG Project is proposed to be constructed and operated wholly within the Jemena Horsley Park Facility boundary. Therefore, it is not anticipated that the value of lands surrounding the facility will decrease as a result of the proposal going ahead.

Infrastructure

The Jemena Horsley Park Facility is connected to two major pipelines which supply the Sydney and NSW gas network. These pipelines are:

- The Central Trunk Pipeline – this pipeline is located underground and passes under the south-western corner of the Jemena Horsley Park Facility. The facility's outlet is connected to the pipeline underground
- The Eastern Gas Pipeline – runs underground along the north-south alignment of the Jemena Horsley Park Facility's western extent. The pipeline enters the facility from its north-western corner

The existing infrastructure will remain un-impacted by the WSGG Project. The proposal will marginally increase the amount of high-pressure gas within the Jemena Horsley Park Facility, however, injection into the existing infrastructure will not exceed the design pressures of the facility. As the proposed blending concentration will be significantly less than 10 mol%, modifications to the existing infrastructure are not anticipated.

Construction of the proposed WSGG Project will occur while the existing Jemena Horsley Park Facility is operational. Construction activities will be monitored closely to ensure that the existing pipeline infrastructure is not impacted.

Water which will be fed through the electrolyser and converted into hydrogen gas will be supplied from the existing water main which fronts the facility and/or RO quality recycled water. Up to 1,600L/day or 0.58ML/a of purified water is required to be delivered to the electrolyser inlet, which has a feed yield of approximately 75%. This process will therefore require 2,135 L/day of mains water and generate approximately 535 L/day of wastewater. This water demand is not expected to significantly increase the load on existing systems.

The conversion of water into hydrogen gas will utilise purchased green electricity as an energy source. In order for the WSGG Project to meet its proposed production of 52,600 kg/yr of hydrogen, an estimated 6GWh electricity is required. This can be supplied by the existing electrical network infrastructure without need for addition or modification, beyond the installation of a utility switching station, underground cabling connection and on-site client owned HV Switchgear & Transformer. No significant impacts on power infrastructure are anticipated.

Cumulative Impacts

Cumulative impacts have been considered as part of this EIS for any other significant developments that are known to be currently proposed within the near vicinity of the proposal site at this time. One significant development is known to be proposed, Austral Brick Co Pty Ltd is proposing to upgrade the existing Plant Two at 780 Wallgrove Road, Horsley Park, which has been included within the cumulative impact assessment for the WSGG Project.

The cumulative impact assessment has assessed the cumulative potential impacts for hazards and risks, air quality, noise and vibration, traffic, and soil and water. This will be supplied via a new power connection, with a two-way meter to allow for grid export and import metering. An on-site substation with 2.5MVA distribution transformer will be installed within the site perimeter fencing. No significant impacts on power infrastructure are anticipated.

Environmental Management

The WSGG Project will be designed, constructed, operated and decommissioned in accordance with the requirements of:

- Relevant legislation.
- Conditions of consent.
- Commitments provided in this EIS.

Project Justification

Residual risks following the application of mitigation strategies identified in this EIS are shown to be generally low or medium and can be reasonably managed. The reasons for justifying the WSGG Project are demonstrated within this EIS and accord with environmental, social and economic considerations, as well as the principles of Ecologically Sustainable Development (ESD). Potential benefits associated with the WSGG Project are a reduction in greenhouse gas emissions, reduced reliance on non-renewable energy sources, aiding in the decarbonisation of the energy sector and positive outcomes for the local community. On this basis the WSGG Project is strongly justified.

Conclusion

Environmental impacts associated the construction, operation and decommissioning of the WSGG Project are compliant with the requirements for SSD under the EP&A Act and other relevant State and Commonwealth legislation. Potential environmental impacts are relatively minor and can be appropriately managed through the application of identified mitigation strategies and ongoing stakeholder consultation. The overall impact of the WSGG Project would therefore be beneficial in terms of State and regional environmental and economic planning objectives and is also in line with the principles of ESD.

1. Introduction

1.1 Purpose of this Document

This Environmental Impact Statement (EIS) has been prepared on behalf of Jemena Gas Networks (NSW) Limited (Jemena) to support a State Significant Development application (SSD) to build and operate a trial Power to Gas (P2G) project to transform electrical energy into a combustible gas (hydrogen). The gas will be injected into the Sydney secondary gas distribution network and potentially supplied to an adjacent hydrogen bus refuelling facility, within Horsley Park, New South Wales (NSW). The proposal is referred to as the Western Sydney Green Gas Project (WSGG Project).

The proposed WSGG Project is within the Horsley Park high pressure gas facility, located at 194 - 202 Chandos Road in Horsley Park and is located within the Fairfield City Council (FCC) Local Government Area (LGA) and Western Sydney Parklands (WSP).

Jemena, together with its related bodies corporate Jemena Eastern Gas Pipeline (1) Pty Ltd and Jemena Eastern Gas Pipeline (2) Pty Ltd, own the Horsley Park high pressure gas facility, which is comprised of the Jemena Gas Network as well as a number of pressure let down and pipeline pigging facilities, for the Eastern Gas Pipeline (EGP), Jemena Trunkline, Sydney Primary Loop and local secondary network. When referencing the Horsley Park site within this document, the site is referred to as the Jemena Horsley Park Facility.

Under the *State Environmental Planning Polic*y (SEPP) *(State and Regional Development) 2011* (State and Regional Development SEPP), development that has a capital investment value of more than $10 million on land identified as being within the WSP on the Western Sydney Parklands Map within the meaning of *State Environmental Planning Policy (Western Sydney Parklands) 2009* (WSP SEPP) is classified as “SSD” and requires approval under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) through the preparation of an EIS. The WSGG Project has a capital investment value of $15 million AUD. As such, this EIS has been prepared under Part 4 of the EP&A Act (SSD-10313), in accordance with the Secretary’s Environmental Assessment Requirements (SEARs), dated 12 June 2019 (**Appendix A**), and the requirements of Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation).

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Matters of National Environmental Significance (MNES) are protected. The EPBC Act requires approval for significant impacts upon MNES to be approved by the Commonwealth Minister for the Environment. The EPBC Act and impacts to MNES have been considered within this EIS and are discussed in **Section 7**.

1.2 Project Overview

Jemena proposes to undertake the WSGG Project, a power to gas (P2G) facility to transform renewable electrical energy into a combustible gas, hydrogen, which is either injected at up to 2% by volume into the Sydney secondary gas distribution network, supplied to a microturbine to generate electricity for export back to the grid, or potentially supplied to an adjacent hydrogen refuelling station (HRS) for bus refuelling. The P2G process will involve producing hydrogen from water using electrolysis, with a by-product from the electrolysis process being oxygen, which will be released directly into the atmosphere.

Hydrogen is a renewable resource and is neither a hydrocarbon nor greenhouse gas. The electrolysis process will also produce wastewater as a by-product, with a mild salinity of approximately 500 ppm.

The objective of the WSGG Project is to test and demonstrate P2G technology in the gas distribution network to aid in the transition to a low or zero carbon gas network and facilitate the development of commercially viable systems (GPA Engineering 2019a). The WSGG Project comprises the construction of a P2G hydrogen production facility, which will perform the following key functions (GPA Engineering 2019a):

- Convert mains water and/or Reverse Osmosis (RO) quality recycled water into hydrogen gas using purchased green electricity through electrolysis.
- Store hydrogen gas in a buried on-site steel pipeline (buffer store); to use for hydrogen gas storage and for injection management.
- Control and safely manage hydrogen gas pressures, temperatures and flow rates for injection into Jemena's secondary gas pipeline network.
- Provide a hydrogen microturbine generator to convert stored hydrogen into electrical energy.

1.2.1 The Proponent

Jemena is the sole proponent for the proposed WSGG Project. Table 1 outlines key details relevant to the proposed WSGG Project.

Table 1: Proponent details

Proponent Details	
Proponent Full Name	Jemena Gas Networks (NSW) Limited
Postal Address	Level 16, 567 Collins St, Melbourne, Victoria
ABN	87 003 004 322

1.2.2 Project Location

Jemena, together with its related bodies corporate Jemena Eastern Gas Pipeline (1) Pty Ltd and Jemena Eastern Gas Pipeline (2) Pty Ltd, owns the Horsley Park high pressure gas facility, which is comprised of the Jemena Gas Network as well as a number of pressure let down and pipeline pigging facilities, for the EGP, Jemena Trunkline, Sydney Primary Loop and local secondary network.

The Jemena Horsley Park Facility is located at 194 – 202 Chandos Road, Horsley Park (Lot 1 DP 499001 and Lot 3 DP 1002746) (Figure 1). The hydrogen facility, dispenser and bus turning circle will be located on Lot 1 DP499001. The turning circle will extend across the narrow access route on Lot 3 DP 1002746, utilising the existing access route to the Jemena EGP facility. The Jemena Horsley Park Facility is not located on Crown Lands.

1.2.2.1 Land Ownership

Table 2 outlines the land ownership details of Jemena's Horsley Park Facility.

Table 2: Land ownership

Land Ownership Details	
Lot 1 DP 499001	Jemena Gas Networks (NSW) Limited
Lot 3 DP 1002746	Jemena Eastern Gas Pipeline (1) Pty Ltd and Jemena Eastern Gas Pipeline (2) Pty Ltd

Figure 1: Proposed WSGG Project location

1.2.2.2 Catchment

Eastern Creek runs parallel to the west of the proposal site. Eastern Creek is a tributary of South Creek, which flows to the Hawkesbury River. The proposal is located within the upper Eastern Creek catchment, which is part of the Hawkesbury Catchment (**Figure 2**).

1.2.2.3 Land Uses

The site is wholly within Jemena's Horsley Park Facility which is currently used as a gas network facility. The proposal site is surrounded by WSP to the west, rural land to the east, Austral Bricks plant to the north and Chandos Road to the south.

In accordance with the WSP SEPP, the land in which the proposal site is situated is unzoned. Clause 11 (1-3) of the WSP SEPP states:

> *(1) The following development may be carried out on land in the Western Parklands without consent, but only if it is carried out by or on behalf of a public authority:*
>
> *amenity facilities; community facilities; depots; entertainment facilities; environmental facilities; environmental protection works; function centres; information and education facilities; kiosks; public administration buildings; recreation areas; recreation facilities (outdoor); restaurants or cafes; roads; signage (for directional, informative, or interpretative purposes); ticketing facilities.*
>
> *(1A) Development for the purposes of extensive agriculture, other than farm buildings, may be carried out on public land in the Western Parklands without consent unless the land is in an environmental conservation area as shown on the Environmental Conservation Areas Map.*
>
> (2) *Any development not specified in sub clause (1) or (3) or permitted without consent by sub clause (1A), may be carried out in the Western Parklands only with consent.*
>
> (3) *Development for the purposes of residential accommodation is prohibited in the Western Parklands.*

The project proposal therefore may be carried out in the WSP only with consent.

1.2.2.4 Conservation Areas

The project site is not located within a mapped Environmental Conservation Area, as defined within the WSP SEPP (Figure 3).

Figure 2: Catchment areas in relation to the proposal site

Figure 3: Environmental Conservation Areas, in accordance with the WSP SEPP

1.2.3 Capital Investment Value

The expected Capital Investment Value (CIV) of the project is approximately $15 million AUD.

The Australian Renewable Energy Agency (ARENA) was established by the Australian Government in 2012 under the *Australian Renewable Energy Agency Act 2011* (ARENA Act) to aid in the improvement and competitiveness of renewable energy in Australia (ARENA 2017).

The Advancing Renewables Program run by ARENA helps fund activities that provide the following outcomes:

- Reduce the cost of renewable energy
- Increase the value of renewable energy
- Improve technology and commercial readiness for renewable energy technologies
- Reduce or remove barriers to renewable energy uptake
- Increase skills, capacity and knowledge relevant to renewable energy technologies.

As part of the Advancing Renewables Program, ARENA have provided up to $7.5 million AUD in funding for the WSGG Project[1].

1.3 Environmental Assessment Process

The EP&A Act and EP&A Regulation provide the frameworks for the assessment of the environmental impact of development proposals in NSW and include provisions to ensure that the potential environmental impacts of a development are assessed and considered in the decision-making process.

In accordance with Part 2, Clause 8 of the State and Regional Development SEPP, development is declared to be SSD for the purposes of the EP&A Act if:

a. the development on the land concerned is, by the operation of an environmental planning instrument, not permissible without development consent under Part 4 of the Act, and

b. the development is specified in Schedule 1 or 2.

In accordance with Schedule 2(5) of the State and Regional Development SEPP, development is declared to be SSD when:

Development that has a capital investment value of more than $10 million on land identified as being within the Western Parklands on the Western Sydney Parklands Map within the meaning of State Environmental Planning Policy (Western Sydney Parklands) 2009.

As the proposal will have a capital investment value of more than $10 million and is on land subject to the WSP SEPP, the proposed development is considered SSD. As such, the proposal is subject to

[1] The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

assessment and determination under Part 4, Division 4.7 of the EP&A Act and, in accordance with Section 4.38 of the EP&A Act, approval from the Minister of Planning is required.

Following submission of a preliminary environmental assessment (GPA Engineering 2019a), which broadly described the proposal and potential environmental impacts, the Planning Secretary issued SEARs on 12 June 2019 (**Appendix A**). This EIS has been prepared to address these requirements.

1.4 Structure of this Document

This EIS has been prepared in accordance with the EP&A Act, EP&A Regulation, the SEARs and all other relevant legislation to support the application for approval. The purpose of this EIS is to:

- provide the consent authority with sufficient information, in regard to the benefits and potential environmental impacts of the proposal, to make an informed decision
- provide the community with sufficient information about the proposal
- provide measures to reduce any potential environmental impact associated with the proposal.

The structure of the EIS is outlined in Table 3.

Table 3: EIS structure

Chapter	Chapter Name	Content
1	Introduction	Project overview.
2	Needs and Options Considered	Strategic needs for the proposal, proposal objectives, alternatives considered, justification and Ecologically Sustainable Development (ESD).
3	Description of the Proposal	Description of the proposal design, construction activities, operation and ancillary facilities.
4	Statutory and Planning Framework	Review of applicable local, State and Commonwealth legislation and policies.
5	Stakeholder and Community Consultation	Provides an overview of the stakeholder and community consultation undertaken to date, and a summary of future consultation during the approval process.
6	Hazards and Risk Assessment	Provides an initial environmental risk assessment for potential impacts relating to the project. A summary of the Preliminary Hazard Analysis (PHA) is also provided.
7	Environmental Assessment	Assessment of potential environmental impacts including air quality, waste, noise and vibration, visual, traffic and transport, biodiversity, Aboriginal heritage, historic heritage, water and land, social and economic, infrastructure and cumulative impacts.
8	Environmental Management	Recommended environmental mitigation measures and residual environmental risk assessment.
9	Conclusion	Provides a summary of the overall potential environmental impacts associated the construction, operation and decommissioning of the WSGG Project and statement confirming the proposal is compliant with the requirements for SSD under the EP&A Act and other relevant State and Commonwealth legislation.
10	References	References used throughout this assessment.

2. Needs and Options Considered

2.1 Strategic Need for the Proposal

2.1.1 Climate Change and the Paris Agreement

The Paris Agreement was agreed to under the United Nations Framework Convention on Climate Change (UNFCCC) at the 21st Conference of the Parties (COP21) in Paris in 2015. The Paris Agreement is a framework requiring all involved countries to take climate action from 2020 onwards, with the aim of achieving the following outcomes (DoEE 2019):

- Inhibit global average temperatures increasing by 2°C and aim to keep warming below 1.5°C above pre-industrial levels
- Set mitigation targets from 2020 and review every 5 years
- Increase transparency and accountability in countries' action plans and progress
- Promote action to increase resilience to climate impacts
- Support developing countries in implementing the Agreement.

As part of the Paris Agreement, the Australian Government has a 2030 target to reduce economy-wide emissions by 26-28% below 2005 levels. In order to meet this target, hydrogen may play an important role in decarbonising the gas network.

One of the main challenges with transitioning to renewable energy is the ability to store electricity from wind and solar into a chemical fuel. P2G technology allows this energy to be converted into hydrogen fuel, which can then be stored for months at a time and converted back to electricity when required.

2.1.2 National Hydrogen Strategy (Council of Australian Government Energy Council, 2019)

As both the production and utilisation costs of renewable energy continue to decrease, and Carbon Capture and Storage (CCS) technologies continue to improve, hydrogen is emerging as a major economic opportunity to aid in the transition to low-emissions sources of energy (COAG Energy Council 2019a). The Commonwealth Department of Industry, Innovation and Science (DoIIS) recognises this and is currently developing a National Hydrogen Strategy. Ahead of the draft National Hydrogen Strategy, the Council of Australian Governments (COAG) Energy Council, on behalf of the DoIIS, has released nine issues papers outlining the benefits, challenges, risks and potential role of policies and actions in transitioning to a hydrogen economy.

The COAG Energy Council acknowledges that the production, transport and storage technologies for hydrogen are yet to be tested as part of a viable large-scale supply chain. Therefore, significant levels of new investment will be needed to successfully commercialise and scale a global hydrogen industry (COAG Energy Council 2019b). The WSGG Project is therefore a trial, to test and demonstrate P2G technology to obtain key learnings to enable later development of commercially viable systems.

2.2 Proposal Objective

The growing demand for the decarbonisation of the Australian energy sector provides many opportunities for the gas transmission and distribution network in NSW. However, there are still many challenges, mainly the uptake in renewable power generation, requiring further development and testing on a commercial level. The objective of the WSGG Project is to therefore test and demonstrate P2G technology in the gas distribution network to facilitate the development of commercially viable systems in the future (GPA Engineering 2019b). Jemena aims to achieve the following objectives as part of the WSGG Project:

- **Cost reduction** - to prove that P2G technology can become a feasible renewable hydrogen application in the future. The trial will allow Jemena to:
  - model, test and develop different control modes of operation of an electrolyser to identify the most viable modes of operation
  - test and develop the value chain for hydrogen production, storage, transportation, delivery and use
  - develop and trial market opportunities for customers.
- **Risk reduction** - to understand the technical and regulatory barriers prohibiting the commercial implementation of P2G technology. The trial will therefore also allow Jemena to:
  - test and verify the impacts of blending up to 2% by volume of hydrogen into a natural gas stream
  - develop and prove a methodology to control gas injection into a natural gas stream
  - assist in the development of new safety standards and requirements regarding P2G technology.
- **Promote renewables** - to showcase alternative options to conventional energy supply. The trial will allow Jemena to:
  - demonstrate an ability to produce renewable gas
  - work with both existing and potential customers of renewable gas and incorporate consumer feedback
  - determine the demand and market size for renewable gas applications.

2.3 Alternatives and Options Considered

The WSGG Project is anticipated to run for a minimum of 5 years and will act as an indicator for the viability of proposed future technologies and will help to gain an understanding of whether implementation of similar systems can be utilised to adhere to commercial demands. Two alternatives to the WSGG Project were considered (GPA Engineering 2019a), these include:

- Do-Nothing Approach
- Full scale development of a power to gas facility, which will utilise renewable energy to power the plant

Consideration of these two options is discussed below.

2.3.1 Do-Nothing Approach

The premise of the WSGG Project is to establish an understanding of P2G technologies, which will encourage the development of future hydrogen facilities. As it stands, the WSGG Project will confer no immediate economic benefit. However, by doing nothing, there is no opportunity to gain an understanding of alternative gas distribution technologies, which is deemed an important step in moving toward a reduced emissions network.

There is a risk that in order to reduce the effects of climate change and move towards a decarbonised society, fossil fuel reserves may become stranded resources therefore, turning existing investments into stranded assets (i.e. assets that suffer from unanticipated or premature devaluations). The proposal therefore also provides a potential solution to prevent Jemena's gas distribution network from becoming a stranded asset in the future.

2.3.2 Full-scale Development

Full-scale development of a P2G facility is not currently practical, as prior to the WSGG Project, no true assessment of the applicability of such technologies has been undertaken. In order for full scale development to be considered, installation, operational functionality and whether these technologies can be designed to be fit for purpose need to be assessed at an appropriate scale. Prior to development of a permanent P2G facility, projects such as the WSGG Project are necessary to determine whether power network requirements can be met in regard to the above factors. Therefore, temporary facilities are currently the preferred option.

2.4 Justification of the Proposal

Hydrogen may play an important role in decarbonising the gas network in order to help the Australian Government meet economy-wide emissions targets and is emerging as a major economic opportunity to aid in the transition to low-emissions sources of energy (COAG Energy Council 2019a). P2G technology allows renewable energy to be converted into hydrogen fuel, which can then be stored for months at a time and converted back to electricity when required or used as a conventional heating fuel. The proposed WSGG Project is a trial of P2G technology, aimed at testing and demonstrating P2G which will enable further development of commercially viable systems.

The proposed WSGG Project will occur within the boundaries of an existing Jemena facility, and will meet the objective of minimising the potential for environmental impact and community disruption, which is demonstrated in the following sections.

2.5 Ecologically Sustainable Development

The EP&A Act identifies four key principles to assist in the achievement of ESD, these are:

- The precautionary principle
- Inter-generational equity
- Conservation of biological diversity and ecological integrity
- Improved valuation and pricing incentive mechanisms

2.5.1 Precautionary Principle

The precautionary principle states that:

If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

The potential for environmental impact has been considered throughout the design and development of the WSGG Project. The potential impacts identified through the SEARs and Environmental Risk Assessment (**Section 7.3**) have been assessed as accurately as possible, using appropriate specialists in relevant disciplines where required. The assessment process involved computer modelling, scientific research, analysis and interpretation of the potential environmental impacts associated with the WSGG Project during the construction, operational and decommissioning phases.

This process has enabled the impacts of the WSGG Project to be predicted with a reasonable degree of certainty. All predictions, however, contain a degree of variability and uncertainty, which reflects the nature of the environment. Where there has been any uncertainty in the prediction of impacts throughout the EIS process, a conservative approach has been adopted to ensure the worst-case scenario has been predicted in the assessment of impacts.

The WSGG Project is consistent with the precautionary principle in that where there was uncertainty, conservative overestimates where used, examples include:

- The noise and vibration assessment considered two operational scenarios, a continuous noise scenario and a maximum event scenario, of which the maximum event scenario is only likely to occur very occasionally and will not be considered a regular occurrence.
- Where potential threats to the environment have been identified, mitigation measures have been developed to minimise such impacts.
- Monitoring will be undertaken, if required, as a precautionary measure to reduce the effect of any uncertainty regarding the potential for environmental damage.

2.5.2 Inter-generational Equity

The principle of inter-generational equity states that:

The present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

The objective of the WSGG Project is to demonstrate that the creation of hydrogen gas using renewable electricity is safe and non-polluting, and that the injection of hydrogen gas into the mains gas pipeline at low levels for use by the community will help to reduce dependency on hydrocarbons/greenhouse gases. As such, the project wholly fits in line with this principle as it has been deemed a necessary step in decreasing societal reliance on carbon-based energy sources. In turn, the addition of new hydrogen gas facilities which may result from the WSGG Project will reduce overall greenhouse gas emissions and human contribution towards climate change, which stands to have a major impact on future generations.

2.5.3 Conservation of Biological Diversity and Ecological Integrity

The principle of the conservation of biological diversity and ecological integrity states that:

Conservation of biological diversity and ecological integrity should be a fundamental consideration.

The conservation of biological diversity and ecological integrity has been considered and integrated at all stages of the proposal. The WSGG Project will occur within the boundaries of an existing gas facility and will not require the removal of any features of significant biological diversity and ecological integrity.

2.5.4 Improved Valuation, Pricing and Incentive Mechanisms

The environment has conventionally been considered a free resource, with the true cost to the environment not factored into cost of production or use of the resource. This principle involves placing a monetary or social value on the environment that ultimately increases its value in order to decrease future exploitation.

The WSGG Project recognises and makes use of the inherent value of hydrogen gas. This project will trial the conversion of abundant, renewable natural resources (renewable energy such as sunlight and wind) into valuable and valued commodities (gas and electricity).

3. Description of the Proposal

3.1 Overview

The WSGG Project will require the construction of a production facility (P2G Plant), which will house the following (GPA Engineering 2019b):

- Electrolyser (including final water treatment, electrolyser stack, purification & cooling systems).
- Hydrogen buffer store (buried carbon steel pipeline).
- Hydrogen gas control panel.
- Hydrogen gas grid injection panel (to supply the Secondary Mains).
- Hydrogen microturbine.
- Hydrogen refuelling station (HRS) (optional future scope).
- Site control hut.
- Power grid connection, including transformer.

The WSGG Project will also require site piping and structural works, and site civil works, including a hardstand, foundations and footings. The existing access Jemena's Horsley Park Facility will also be used and upgraded.

3.2 Proposal Site

The proposed WSGG Project will be developed within Jemena's Horsley Park Facility, which is located at 194 – 202 Chandos Road, Horsley Park (Lot 1 DP 499001 and Lot 3 DP 1002746) (Figure 1). The hydrogen facility, dispenser and bus turning circle will be located on Lot 1 DP499001. The turning circle will extend across the narrow access route on Lot 3 DP 1002746, utilising the existing access route to the Jemena EGP facility.

3.3 Key Features of the Proposal

The WSGG Project has been designed for a production capacity 100 Nm^3/h of hydrogen gas with a 500 kW Proton Exchange Membrane (PEM) electrolyser using purchased green electricity. Produced hydrogen gas will be injected into the existing natural gas distribution network at up to 2% by volume via a dedicated injection control panel. The WSGG Project also includes a gas-fuelled generator package (microturbine) that will initially be operated on natural gas to generate power on site. The microturbine will be converted to operate using hydrogen as its fuel source in late 2020. The WSGG Project will consist of several distinct modules that have been designed to meet the overall objectives of the project. A flow diagram of the modules is presented in Figure 4 and includes:

- Electrolyser Package
- Gas Panel Package
- Gas Fuelled Generator Package
- HRS Package (potential future scope)
- Hydrogen Cylinder Filling Package (potential future scope)
- Storage Pipeline
- Natural Gas Network Injection Package

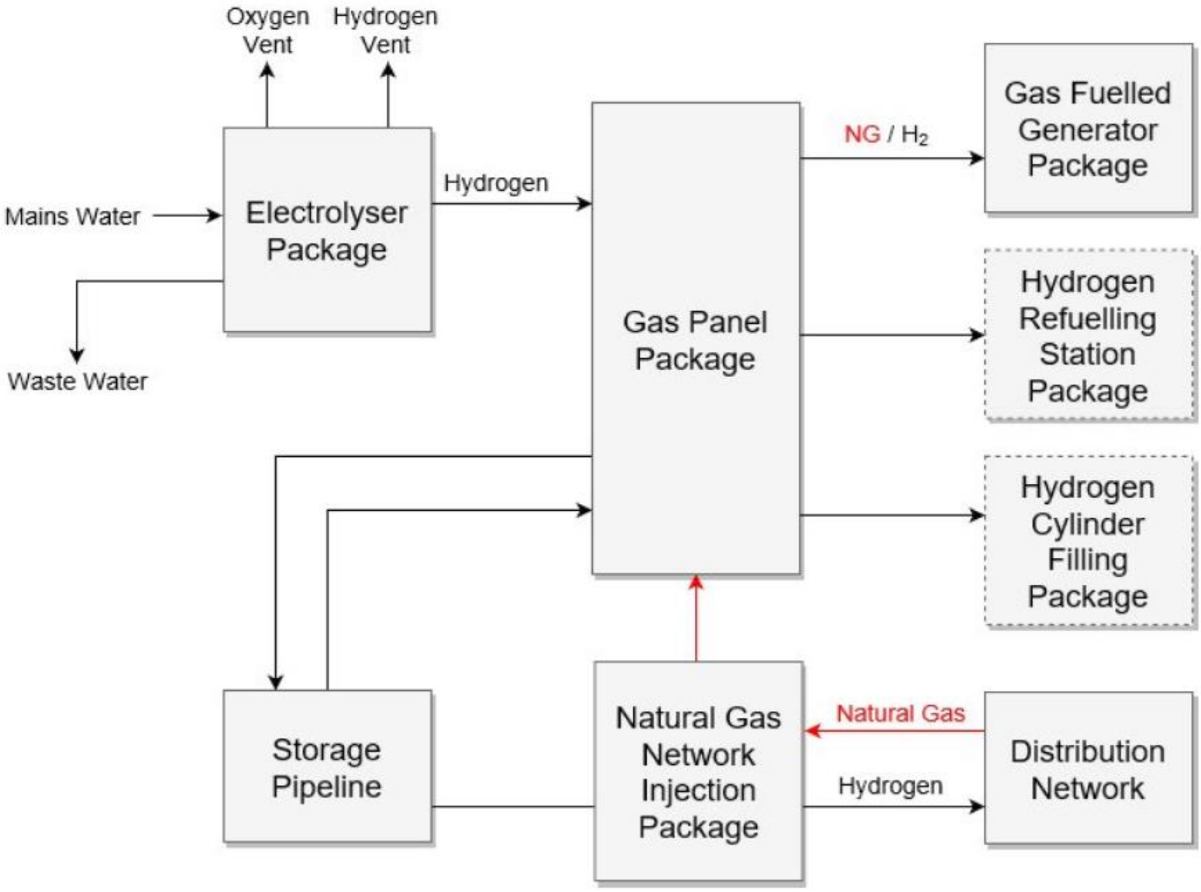

Figure 4: Flow diagram of the WSGG Project facility (GPA Engineering 2019b)

The electrolyser package will contain several internal modules. To produce hydrogen, potable water from the Sydney Water mains and/or RO quality recycled water will firstly be supplied to the demineralised water supply and polishing system. The demineralised water will then be sent to the gas generation system where it is pressurised and split into both hydrogen and oxygen molecules via electrolysis (GPA Engineering 2019b).

The oxygen gas is then sent to the vent system to atmosphere and the hydrogen gas is sent to the hydrogen purification system. The hydrogen gas then passes through a reactor bed and absorption system, which removes any residual oxygen and water. The purified hydrogen gas is then directed to the hydrogen storage pipeline (GPA Engineering 2019b). The purified hydrogen can then be:

- injected into the natural gas distribution network via the gas panel package;
- used as a fuel source for the generator package; and
- directed to the hydrogen refuelling station, hydrogen cylinder filling package or to other users in the future.

3.3.1 Site Layout

The site layout proposed for the WSGG Project is shown in **Figure 5.** The P2G Plant will be located within the boundaries of the Jemena Horsley Park Facility, with the self-contained electrolyser package being installed and operated outdoors. The main works area for the P2G Plant will be within the northern portion of the existing facility, and will consist of a water tank, waste water sump, control hut, electrolyser package, gas and injection panel package, gas generator package, and upgrading the existing outer security fencing.

Immediately adjacent to the P2G Plant will be the new turning circle, provisions for the future HRS, access route for buses to use the future HRS (which may include an appropriate perimeter fence and security measures to accommodate separation requirements for the general public), and the underground hydrogen buffer storage (**Figure 5**).

Available on-site utilities include process water and power. The proposed water feed for the electrolyser is a mains water feed located at the front of the site (to the south) and/or RO quality recycled water. The proposed electrical connection is located at the front of the site; however, a new power cable and transformer will need to be installed as part of the WSGG Project.

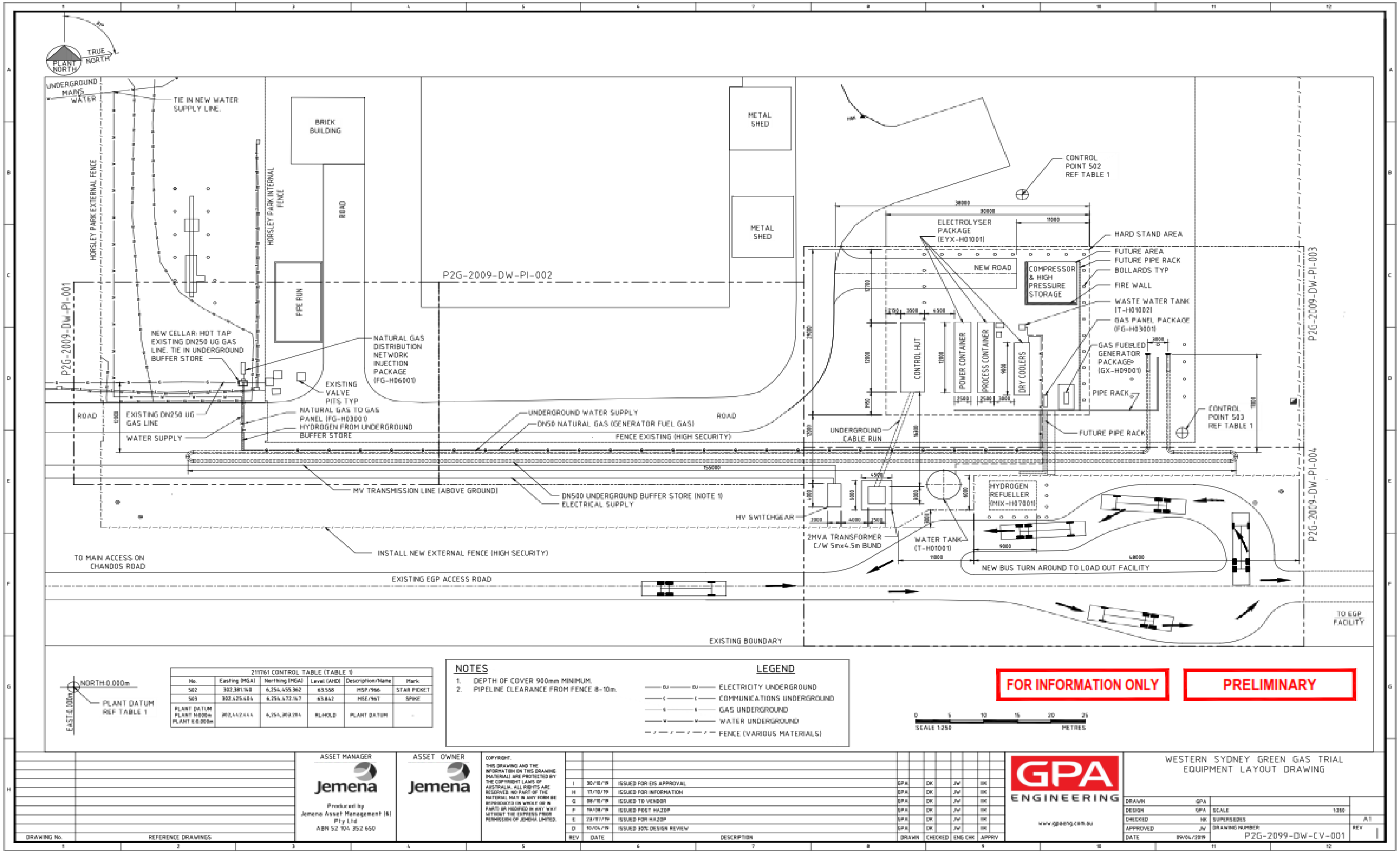

Figure 5: Site layout (GPA Engineering 2019b)

3.3.2 Gas Panel

The hydrogen systems that will form the WSGG Project facility consist of the electrolyser, HRS, hydrogen-powered generator (natural gas powered to start, with a transition to hydrogen gas powered within 12 months), hydrogen connection to natural gas grid for injection, and a hydrogen buffer storage pipeline. The hydrogen systems will be connected at a central 'Gas Panel', which will include actuated and manual valving to direct flow to and from these various components mentioned above (GPA Engineering 2019b).

The gas panel will comprise fully welded (wherever possible) SS316 tubing and pipe and will also including the natural gas supply to the generator (Figure 6 – Figure 8). The following connections shall apply to the gas panel:

- Inlet from electrolyser
- Inlet from buffer store pipeline via the electrolyser
- Inlet from gas grid injection panel
- Outlet to microturbine generator (natural gas powered to start, with a transition to hydrogen gas powered within 12 months)
- Outlet to hydrogen refuelling station (GPA Engineering 2019b).

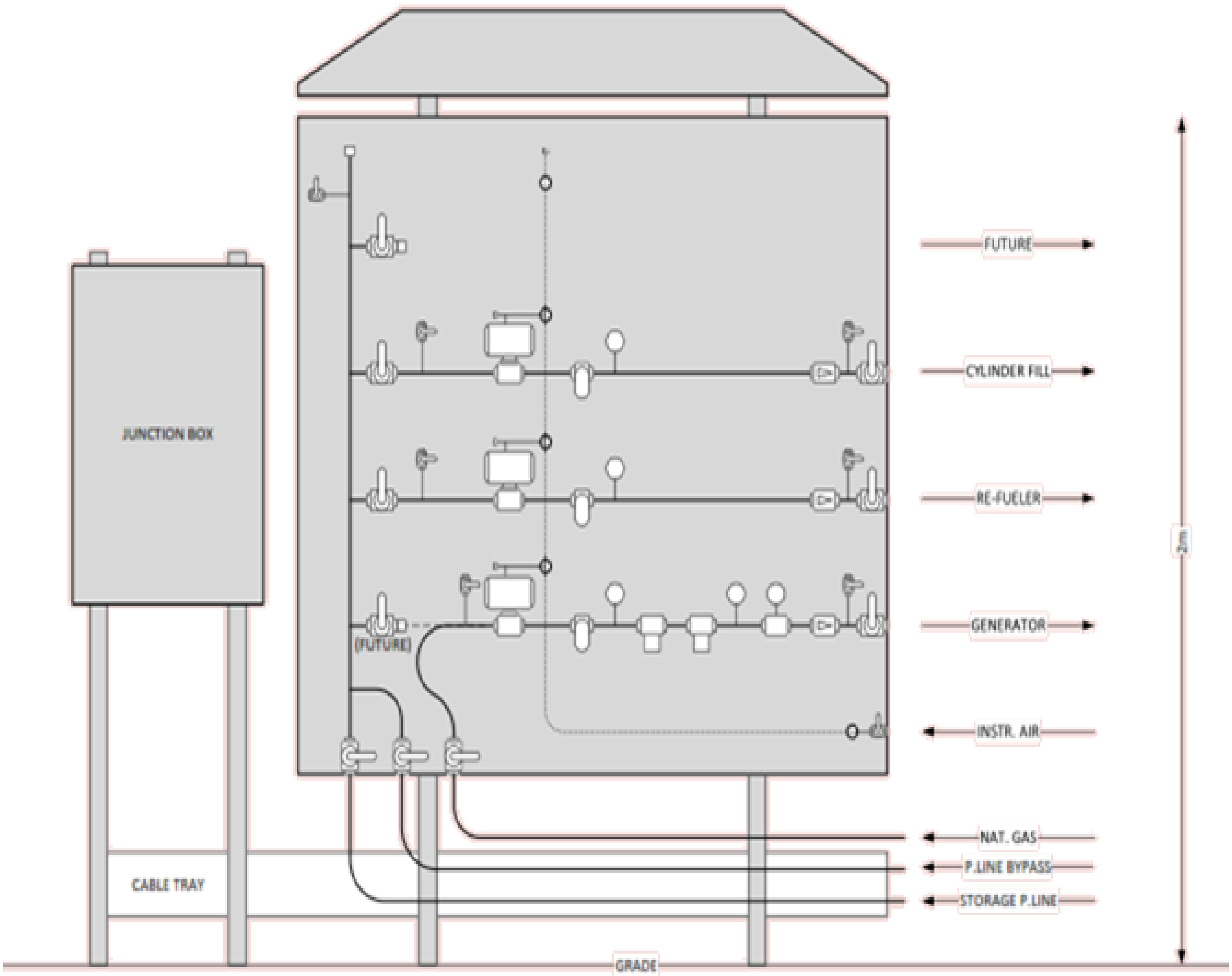

Figure 6: Gas panel diagram (Main Gas Panel) (GPA Engineering 2019b)

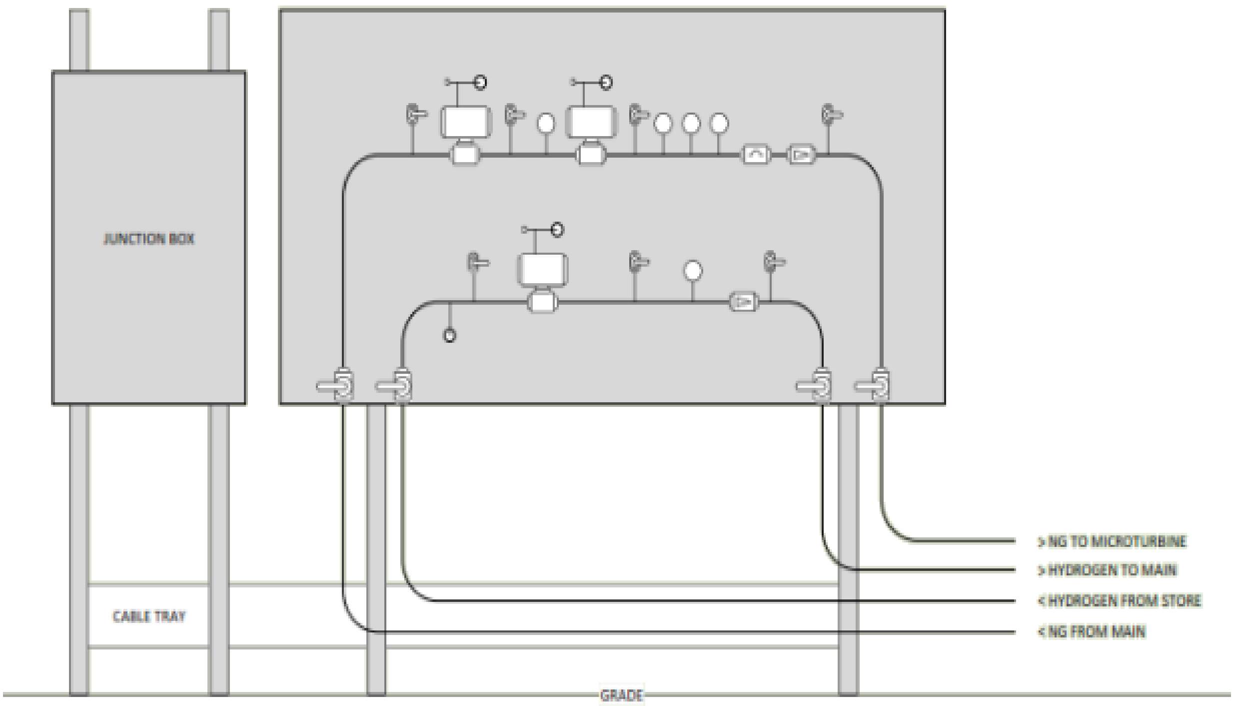

Figure 7: Gas panel diagram (Secondary Main Injection / Withdrawal Skid - Front) (GPA Engineering 2019b)

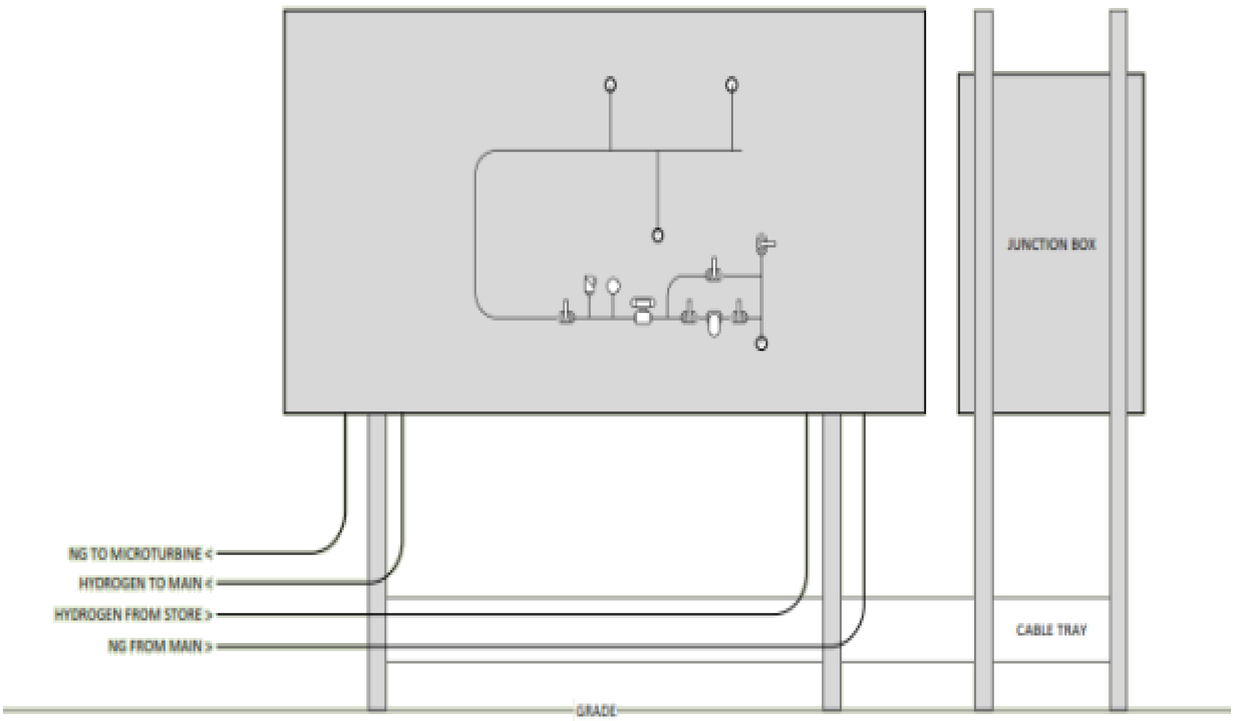

Figure 8: Gas panel diagram (Secondary Main Injection / Withdrawal Skid – Reverse Side – Instrument Gas) (GPA Engineering 2019b)

3.3.3 Electrolyser

The purpose of the electrolyser package is to convert the feed water into hydrogen, which is achieved by electrolysis. Electrolysis is the splitting of water into its constituents, hydrogen and oxygen, by applying a direct current (DC) (GPA Engineering 2019b).

This package uses a PEM type electrolyser. There are a number of steps required for this process, which are outlined below:

- Mains water and/or RO quality recycled water is treated via a water pre-treatment system to further remove contaminants from the water stream to the electrolyser. Approximately 30% of the water is rejected from the pre-treatment system and is directed to an in-ground sump.
- The treated water (RO permeate) is fed into through the PEM electrolysis stack where it disassociates into hydrogen and oxygen via electrolysis. The hydrogen permeates through a membrane and the oxygen is vented to atmosphere.
- A closed loop dry cooler is used to circulate cool water through the stack to control the temperature.
- The produced hydrogen is further purified via drying and removal of trace levels of oxygen to meet the quality requirements for hydrogen fuel cells. Hydrogen can then be used in refuelling, power generation, blended into the gas distribution network, or stored in the buried pipeline (GPA Engineering 2019b).

Figure 9 and Figure 10 provide the overview of the electrolyser package. The electrolyser will be a self-contained unit, operated from a control panel inside the control hut and remote shutdown from the Jemena control room. Physical access to the unit will be via key entry (GPA Engineering 2019b).

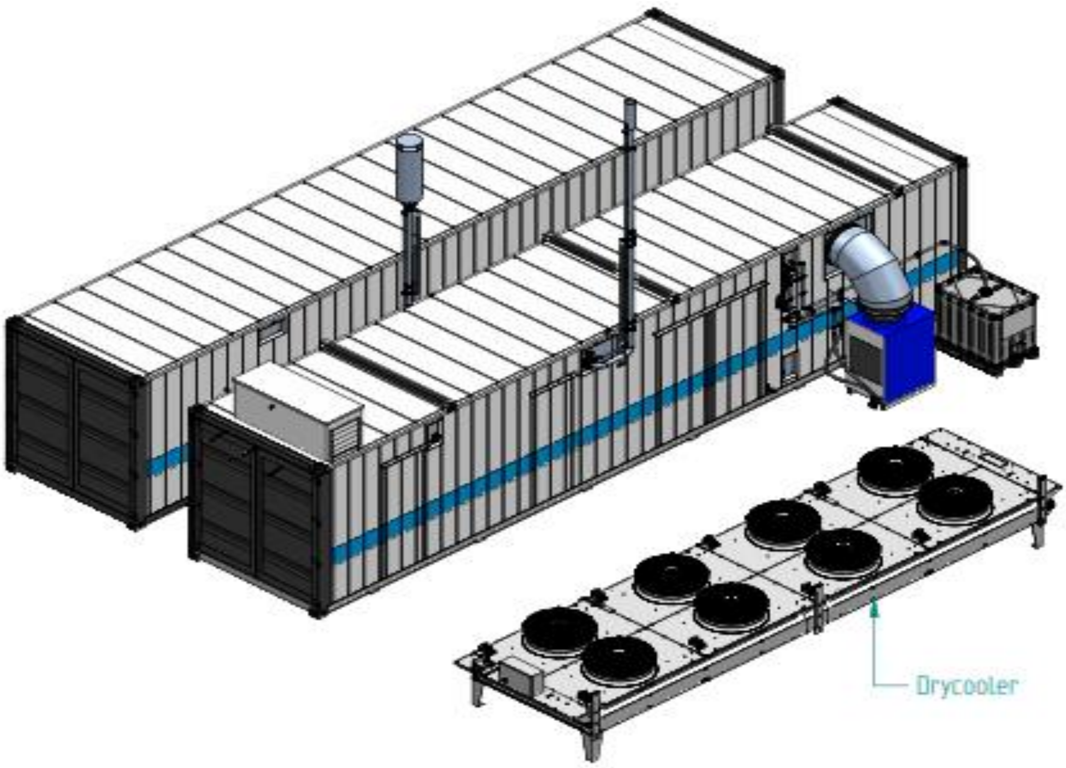

Figure 9: Electrolyser Package (GPA Engineering 2019b)

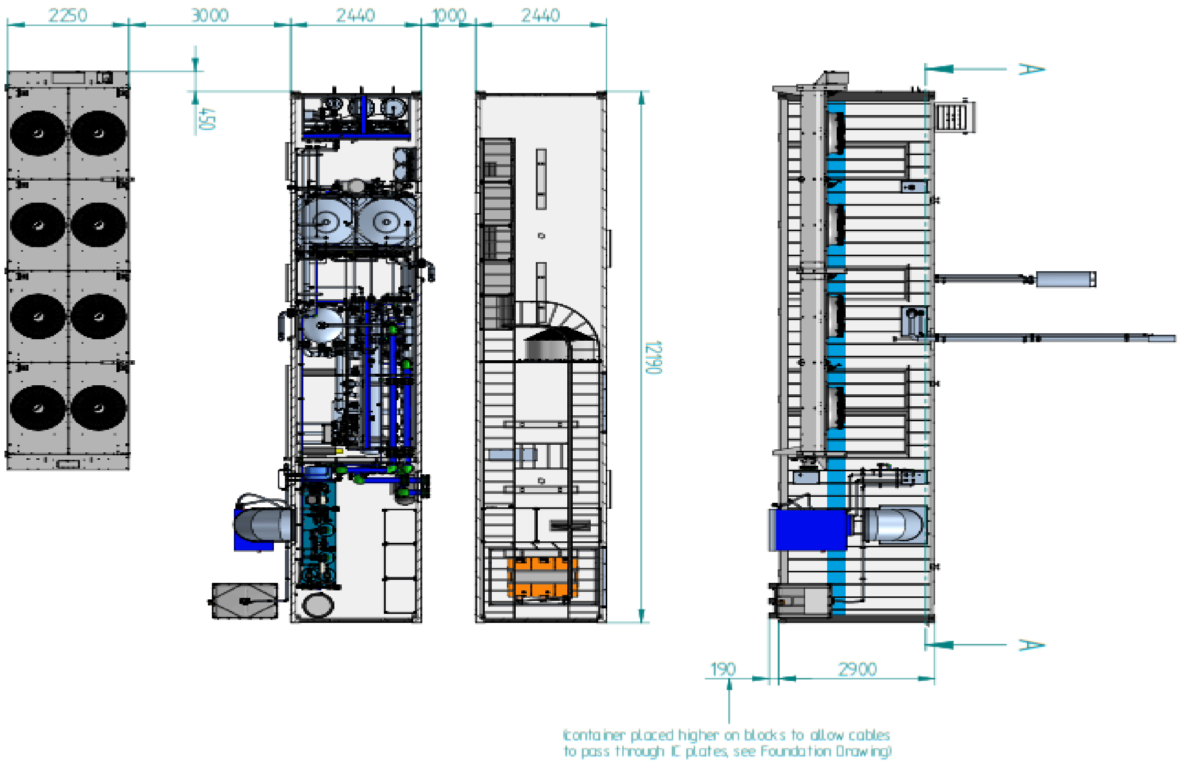

Figure 10: Electrolyser – General Overview (GPA Engineering 2019b)

Table 4 provides an overview of the major electrolyser elements.

Table 4: Major electrolyser systems (GPA Engineering 2019b)

Component	Purpose
RO Water treatment	The purpose of the water treatment system is to provide water at a quality that is suitable for use in the electrolyser stack. This package is a RO system that provides ASTM D193 Type II De-ionised water.
Stack	The stack is the main feature of the process. The stack takes the water from the water treatment system and using direct current splits the water into its constituents, hydrogen and oxygen. This system uses a PEM type electrolyser that uses a polymer membrane to separate the hydrogen and oxygen. The PEM process produces hydrogen at a pressure of approximately 3MPa.
Purification	The produced hydrogen still has small amounts of water vapour and contaminants that need to be removed. The purification system is a series of knock out vessels and filters designed to purity the hydrogen to a quality which is suitable for use in a fuel cell (International Organisation for Standards (ISO) 14687:2018)
Power supply	The power supply takes in the incoming grid connected 415VAC power and transform and rectifies it to the required ~120 VDC. A step-down transformer and rectifier, which is located inside the power container of the electrolyser system, is used to correct the power to the required input conditions.
Dry cooler	When hydrogen is produced in the stack, excess energy not used in the conversion process is converted into heat energy. This large amount of heat energy is required to be removed from the stack to avoid overheating and damage to the stack. The dry cooler takes heated water from the stack and flow it through a closed cooler loop. The dry coolers in this instance are a fan type which are located outside the electrolyser container.

While no Australian standards (AS) currently exist for electrolysers, ISO 22734-1:2008 outlines the minimum performance, safety and technical requirements for electrolysers. The package procured as part of this project will conform to this internationally recognised standard. Additionally, this standard is being considered for adoption in Australia by ME-093 (Hydrogen Technologies Australian Standard Committee) (GPA Engineering 2019b).

Generally, the materials used from piping and pressure equipment in hydrogen service in this package are stainless steel (316SS). This material is recognised as being suitable for hydrogen service and at the design pressure (3MPa) is resistant to any materials related risks such as embrittlement (GPA Engineering 2019b).

3.3.4 Buffer Store

A buffer store will be provided, in order to accumulate hydrogen inventory, so that sufficient quantity is available when required. High-pressure storage will be provided as part of the HRS, which provides a differential pressure so that, throughout filling, the refueller can deliver gas at an appropriate rate and temperature (GPA Engineering 2019b).

This additional buffer store provides the following functions, relevant to the scope of the project:

- Balance the fixed flow rate of the electrolyser with the varying flow rate of the natural gas, thus allowing for a fixed ratio of blended hydrogen in natural gas (to a maximum of 2% hydrogen by volume)
- Allow for soft start/stop of electrolyser and injection into the network
- Allow for hydrogen to continue to be generated when natural gas demand is low
- Allow the HRS to recharge, when the electrolyser is not operational, and at a faster rate than the electrolyser provides
- Develop knowledge about the operation of a hydrogen storage system
- Demonstrate use of a pipeline as energy storage from renewable generation (Figure 11) (GPA Engineering 2019b).

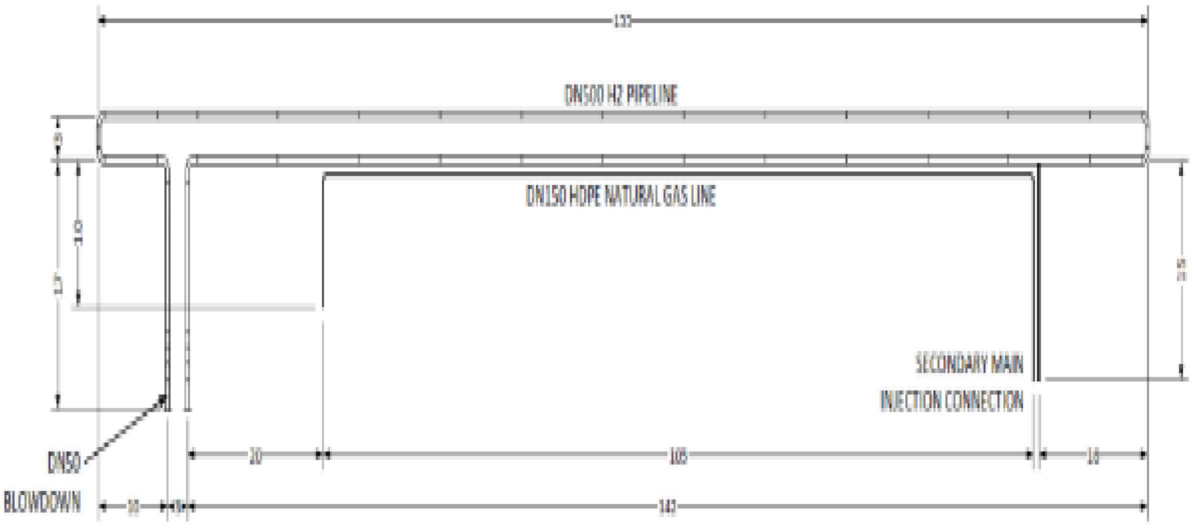

Figure 11: Buffer storage

The buffer storage will be provided via an on-site buried pipeline. The buried pipeline will be located entirely on Jemena-controlled land, within a fenced and secure area. The buried pipeline will be designed in accordance with AS 2885.1 and will also simultaneously meet the design requirements of American Society of Mechanical Engineers (ASME) B31.12 suitable for hydrogen pipelines. The design will use a low design factor to mitigate the risk of hydrogen embrittlement (GPA Engineering 2019b).

3.3.5 Generator Set

The purpose of the Generator Set (microturbine) is to demonstrate and trial its application as a grid connected back-up application and grid “battery” when used in conjunction with the electrolyser (Figure 12). The fuel supply for the generator set comes initially from the natural gas mains network, before being converted to hydrogen fuel supplied from the buffer store (GPA Engineering 2019b) within a year.

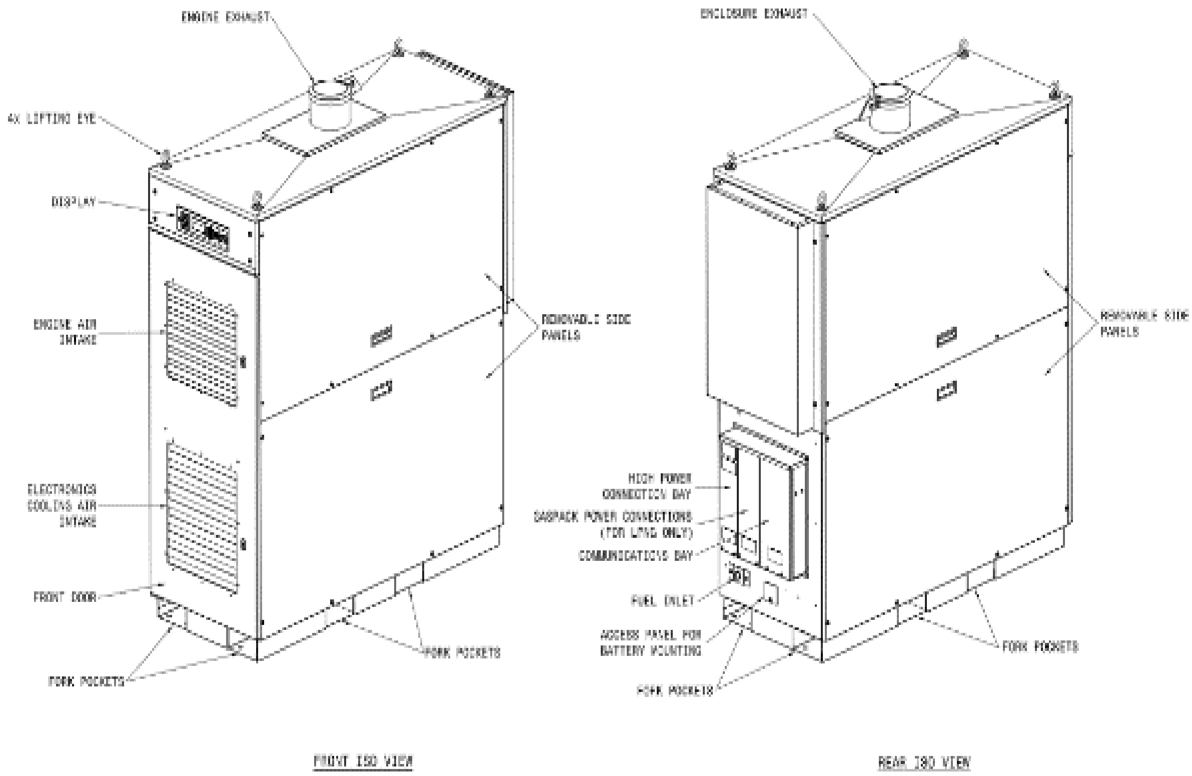

Figure 12: Microturbine (GPA Engineering 2019b)

3.3.6 Hydrogen Refuelling Station

The HRS is designed for filling a vehicle with hydrogen fuel. The refueller at the Jemena site will provide hydrogen to heavy duty vehicles, specifically buses. This HRS will provide the following functions, relevant to the scope of the project:

- Develop knowledge of and demonstrate hydrogen fuel cell vehicle refuelling
- Provide sufficient capacity to refill three heavy vehicles (35MPa) with approximately 30kg of hydrogen each per day (GPA Engineering 2019b).

Figure 13 provides a typical process flow diagram (PFD) for hydrogen refuelling.

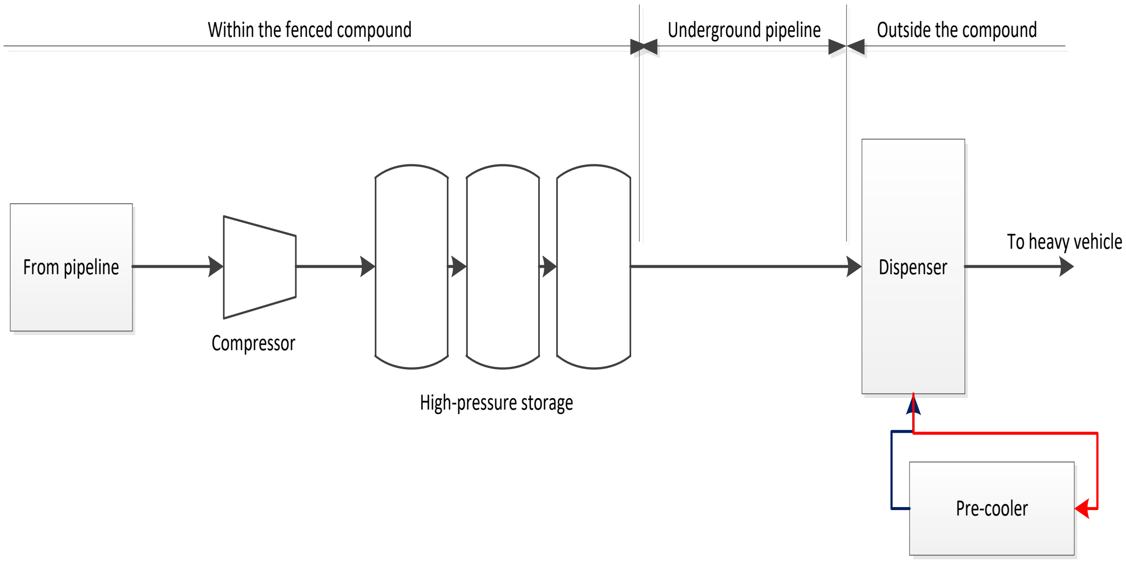

Figure 13: Typical high-pressure storage and cascade refuelling system PFD (GPA Engineering 2019b)

Table 5 lists the major components of the HRS. The compressor and high-pressure store will be located within the Jemena Horsley Park Facility high security fence, in a compound bordered by firewalls on both sides to mitigate offsite consequences. The refuelling dispenser will be located remote from the package, outside the Jemena Horsley Park Facility outer fence, within a re-fuelling bay adjacent the turning circle, and may include an appropriate perimeter fence and security measures to accommodate separation requirements for the general public (GPA Engineering 2019b).

Table 5: Major components of the HRS (GPA Engineering 2019b)

Component	Purpose
Compressor	The HRS compressor uses hydrogen produced from the electrolyser or stored in the buffer storage, at the input pressure (varying 0.6-3MPa) and compresses it up to the storage pressure of approximately 100MPa. A number of different compressors can be used to achieve the necessary compression. Customary types are piston, compressed air, diaphragm or ionic compressors, which are selected according to the design of the refuelling station (capacity utilisation, energy consumption, cost-effectiveness, etc.).
Storage	The HRS storage is a collection of cascading cylinders that store a nominal amount (typically 100kg). Storing hydrogen at high pressure means that it can be used on demand and fill times can be equivalent to a conventional petrol or diesel vehicle. High-pressure storage tanks, with pressure stages of 80 MPa to 100 MPa respectively, are used to refuel the customer vehicle. The hydrogen from the low-pressure buffer storage pipeline can be transferred via a high-pressure compressor to the high-pressure storage tank.
Pre-cooler	The HRS pre-cooler is required to cooling the hydrogen gas when it is being transported from the storage to the vehicle, via the dispenser. Due to the negative JT cooling effect of hydrogen (one of the three known elements to have this property) hydrogen gas heats up significantly on decompression. This is unlike natural gas which will cool on decompression. The SAE J2601 fuelling protocol, which covers hydrogen vehicle refuelling, aims to ensure that a vehicle’s hydrogen tank does not heat up above 85°C even during fast refuelling.

Component	Purpose
	Since hydrogen is compressed during refuelling, it heats up. Depending on ambient temperature, fuel delivery temperature and target pressure in the vehicle tank, precooling (normally) is necessary to stay in within the limits (overpressure/overheat) of the vehicle's fuel storage system. For 70 MPa refuelling hydrogen is generally precooled to –40°C (according to SAE J2601). Higher precooling temperatures are possible but may lead to longer refuelling times.
Dispenser	Refuelling itself is carried out using the dispenser, a device or machine to pump liquid or gaseous fuels into the vehicle. The dispenser includes the fuelling nozzle, which delivers the compressed hydrogen into the vehicle's pressure tank. It is designed for the pressure of the hydrogen tank, i.e. 35 MPa or 70 MPa. The user interface, which contains various displays showing pressure, fill level or measured quantity for this project will be remotely monitored.

3.4 Construction Activities

Construction activities for the WSGG Project will be undertaken over an approximate four-month period. Construction will predominantly occur within the WSGG Project boundaries, however there may be a need to temporally access Western Sydney Parklands Trust (WSPT) land adjacent to the WSGG Project site during construction. Consultation with WSPT will be undertaken if access via WSPT land is required during construction.

3.4.1 Site Preparation and Environmental Management

Prior to the commencement of construction, erosion control devices and sediment traps will be installed to minimise the potential for sedimentation of the nearby watercourses. Erosion control measures will be implemented in accordance with 'the Blue Book' (or similar) Managing Urban Stormwater, Soils and Construction Vol 1 and 2A (Landcom 2004 and DECC 2008).

3.4.2 Below Ground Pipework, Conduits and Penetrations

The main buffer store pipeline will be buried below ground. Buried conduits will be required to service power, instrumentation and water utilities (GPA Engineering 2019b).

3.4.3 Slabs and Hard Standing

All items of the plant facility will be installed on concrete slabs or hardstands. The entire site, other than the concrete footings will consist of gravel, on top of a vegetation membrane. The size of the P2G Plant facility is approximately 20 m x 22 m (GPA Engineering 2019b).

The WSGG Project facility will consist of the following:

- Electrolyser (including final water treatment, electrolyser stack, purification & cooling systems)
- Hydrogen buffer store (no associated hardstand)
- Hydrogen gas control panel
- Hydrogen gas grid injection panel (to supply the Secondary Mains)
- Hydrogen microturbine
- Hydrogen refuelling station (HRS) (optional future scope)
- Site control hut
- Power grid connection, including transformer.

The above ground plant will be constructed on reinforced concrete pads, raised 100 mm above surrounding ground, with penetrations for electrical power from the transformer, natural gas lines, mains water inlet, wastewater outlet, hydrogen gas conduits and instrumentation and control conduits for the gas panel. The concrete pads will be fitted with four boltable dovetail twist locks (GPA Engineering 2019b).

3.4.4 Buildings and Structures

A control and monitoring system will also be installed within a 20 ft. demountable hut, equipped with air conditioning, lighting and basic furnishings to allow for four persons. A gas control panel will also be installed within a semi-enclosed structure with three walls and a semi-enclosed roof to allow for ventilations (GPA Engineering 2019b).

3.4.5 Fencing and Access

The existing 'outer' fence of the Jemena Horsley Park Facility will be upgraded to the Jemena EGP facility specifications, 2.4m high anti-climb mesh with tiger tape barbed wire top. Gate access will be provided at emergency exit points to be determined during detailed design. All gates will be equipped with switches (GPA Engineering 2019b).

Access to the potential future HRS will be via the exiting access road to the EGP facility, which will be upgraded to include a new turning circle for heavy vehicles (i.e. water tanker or buses). If the proposed future HRS is developed, an appropriate perimeter fence and security measures to accommodate separation requirements for the general public will be undertaken.

3.4.6 Signage

Additional signage will be installed for new above and below ground pressure containing equipment, power systems and cables detailing operational and safety requirements (GPA Engineering 2019b).

3.5 Operation

The operation of the P2G Plant will be undertaken by remote telemetry to observe and monitor performance of the plant 24 hours a day by a Control Room. The site will be occasionally staffed by operators during normal working hours (7:00 am – 6:00 pm Monday to Friday), and in the event of equipment failure the system is designed to automatically isolate, and not impact upon the existing natural gas facilities (GPA Engineering 2019b).

The remote telemetry system will provide data via Supervisory Control and Data Acquisition (SCADA), which in turn will alert the control room staff of the condition of the site prompting a response in line with the response sheet for the site (GPA Engineering 2019b).

3.5.1 Commissioning

The WSGG Project commissioning will follow a Commissioning Plan to be developed during the detailed design. The plant design will consider commissioning requirements as well as acceptance criteria to ensure system outlet gas is fuel cell grade hydrogen (GPA Engineering 2019b).

3.5.2 Operation

The WSGG Project facility will incorporate both manual (local) and automatic (both local and remote) features that will allow plant and equipment to be operated safely and efficiently. The facility will be capable of the following independent operating modes:

- Electrolyser
    - Manual on – with safety trips and interlock
    - Automatic – multiple operating modes
    - Off – Isolated
- Secondary network injection
    - Process control – designed to inject into network under controlled condition
    - Off – Isolated
- Generator Set
    - Manual on – with safety trips and interlocks
    - Automatic – multiple operating modes
    - Off – Isolated (GPA Engineering 2019b).
- HRS (operate on demand)

Other modes of operation are likely to be developed for test and demonstration purposes once the WSGG Project facility is operational. Automatic operation of both the electrolyser and generator will be set to allow for market arbitrage based on spot pricing or grid voltage as well as simulated scenarios (GPA Engineering 2019b).

The primary objective of the control system during operation will be to provide control over processing functions, protect plant, equipment and personnel, and enable simple and reliable plant shutdown, depressurisation, and isolation of equipment. The WSGG Project facility will be occasionally manned, with minimal operator involvement required, including for start-up, shutdown, and restart. The systems shall therefore monitor and control the facilities on a continuous basis under all operating and environmental conditions (GPA Engineering 2019b).

The WSGG Project facility will be provided with a local Programmable Logic Controller (PLC) designed to control all major process functions, and a safety instrumented system (SIS) that will shut down (trip) a range of equipment and equipment packages, and close major isolation valves during emergency events or process trips. Hydrogen gas quality will be measured by a gas analyser, with data visible to the facility SCADA to enable plant adjustments to be made, if necessary (GPA Engineering 2019b).

3.5.3 Maintenance

Maintenance of the P2G Plant will be conducted on a 3-monthly basis following a prescribed methodology that will be identified within an Operating and Maintenance manual for the site. This covers maintenance checks designed to identify performance and condition of the major equipment items involved with the P2G Plant (GPA Engineering 2019b).

Operating and maintenance procedures and design of plant have been developed cognisant of *Work Health and Safety Regulation 2017* that governs the design of plant and documentation where operator and public safety is concerned. Specific Jemena requirements are covered in Jemena Safe Design of Structures Guideline JEM PR 0012 (GPA Engineering 2019b).

3.5.4 Decommissioning

Upon completion of the WSGG Project, a decision will be made by Jemena for continued operations or to decommission the WSGG Project facility. If decommissioning is to be undertaken, the below (Table 6) will be actioned at the project's end of commercial operation.

Table 6 Decommissioning actions

Equipment	Decommissioning Plan
Electrolyser	Disconnect from station and store. Potential to re-use at later future site or sell.
Buffer Storage	Complete abandonment in place following guidance in AS2885.3 Section 10.6. Disconnect from station piping and purge pipeline with nitrogen. Cut and remove above ground risers and cap pipeline below ground. Jemena may also perform testing on the removed riser sections to advance knowledge in hydrogen penetration and effect on carbon steel following abandonment activities.
Microturbine	Disconnect from station and store. Potential to re-use at later future site or sell.
Refueller	Disconnect from station and store. Potential to re-use at later future site or sell.
Piping / Tubing	Disconnect from station and purge. Remove sections for testing to determine hydrogen penetration and effect on steel.
Instruments	Remove and Jemena to add to business spares list.
Structural	Scrap.
Water System / Tank	Re-purpose for water storage for Jemena JGN or EGP.

If there is any modification of the plan included above, it will be submitted and discussed in line with any appropriate approvals and/or other Regulatory requirements prior to implementation.

3.6 Public utility adjustments

Feed water for the electrolyser will be obtained via the Sydney Water mains and/or RO quality recycled water. A new power connection will be installed for exclusive use of the P2G Plant, allowing for grid export and import power metering. This can be supplied by the existing electrical network infrastructure without need for addition or modification, beyond the installation of a utility switching station, underground cabling connection and on-site client owned HV Switchgear & Transformer. Provision for access to the power meter within the HV Switchgear will be made for the respective metering company (GPA Engineering 2019b).

4. Statutory and Planning Framework

Commonwealth and State legislation, as well as state planning instruments relevant to the proposal are outlined within Table 7 below.

Table 7: Relevant Commonwealth and State legislation and planning instruments

Name	Relevance to the Project
	COMMONWEALTH LEGISLATION
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	MNES include threatened species and ecological communities, migratory species (protected under international agreements), and National Heritage places (among others). Any actions that will or are likely to have a significant impact on the MNES require referral and approval from the Australian Government Environment Minister. Significant impacts are defined by the Commonwealth for MNES. No MNES have been identified as having potential to be impacted by the proposal (**Section 7.8**).
	STATE LEGISLATION
Biodiversity Conservation Act 2016 (BC Act)	The BC Act establishes a framework to avoid, minimise and offset impacts of proposed development and land use change on biodiversity. Clause 7.9(2) states that any application for development consent under Part 4 of the EP&A Act for SSD is to be: '*accompanied by a Biodiversity Development Assessment Report unless the Planning Agency Head and the Environment Agency Head determine that the proposed development is not likely to have any significant impact on biodiversity values*'. As the project does not propose to remove any native vegetation and the project site does not provide potential habitat for any threatened fauna species, Jemena submitted a Biodiversity Development Assessment Report (BDAR) Waiver (**Appendix B**) to the Planning Agency Head and the Environment Agency Head on 29 August 2019. The BDAR Waiver was accepted on 11 September 2019. Therefore, no further assessment of threatened species or ecological communities is required.
Biosecurity Act 2015 (Biosecurity Act)	The Biosecurity Act repealed the *Noxious Weeds Act 1993* and provides a framework for the prevention, elimination and minimisation of biosecurity risks posed by biosecurity matter, dealing with biosecurity matter, carriers and potential carriers, and other activities that involve biosecurity matter, carriers or potential carriers. Part 3 of the Biosecurity Act applies a general biosecurity duty for any person who deals with biosecurity matter or a carrier to prevent, eliminate or minimise any biosecurity risk they may pose. Under section 23 of the Act, a person who fails to discharge a biosecurity duty is guilty of an offence. Whilst the Act provides for all biosecurity risks, implementation of the Act for weeds is supported by Regional Strategic Weed Management Plans (RSWMP) developed for each region in NSW. Appendix 1 of each RSWMP identifies the priority weeds for control at a regional scale. However, landowners and managers must take appropriate actions to reduce the impact of problem weed species regardless of whether they are listed in Appendix 1 of the RSWMP or not as the general biosecurity duty applies to these species. Weed management is discussed in **Section 8**.
Environmental Planning and Assessment Act 1979 (EP&A Act)	The EP&A Act is the principal planning legislation for NSW. It provides a framework for the overall environmental planning and assessment of proposals. Part 4 of the EP&A Act provides for the assessment of development that requires consent. Part 4, Division

Name	Relevance to the Project
	4.7 of the EP&A Act establishes an approval regime for development that is declared to be SSD by either a SEPP or Ministerial Order. In accordance with Section 4.38 of the EP&A Act, the Minister for Planning is the consent authority for SSD. Pursuant to Clause 8 of Section 4.12 of the EP&A Act, an EIS is required to support an SSD. Section 1.3 (b) of the EP&A Act states that one of the objectives of the Act is to facilitate ESD by integrating relevant economic, environmental and social considerations in the decision-making process. An assessment of the proposal's merits under ecologically sustainable development provisions is provided in **Section 2.5**.
Fisheries Management Act 1994 (FM Act)	The FM Act governs the management of fish and their habitat in NSW. The objectives of the FM Act are to conserve fish stocks and key fish habitats (KFH), conserve threatened species, populations and ecological communities of fish and marine vegetation and to promote ecologically sustainable development. The FM Act also regulates activities involving dredging and / or reclamation of aquatic habitats, obstruction of fish passage, harming marine vegetation and use of explosives within a waterway. In accordance with Part 4, Division 1.7, Section 4.41 (b) of the EP&A Act, applications for separate permits under Sections 201, 205 or 219 of the FM Act are not required for SSD, but the offset policy still applies under the FM Act. Eastern Creek, approximately 100 m to the west is mapped as KFH. However, the proposal will not involve dredging and or reclamation of Eastern Creek or obstruction of key fish passage. Therefore, the offset policy does not apply.
Gas Supply Act 1996 (GS Act)	The GS Act aims to encourage the development of a competitive market in gas and deliver a safe and reliable supply of gas in compliance with the principles of ESD. Jemena currently hold a reticulator's authorisation to operate their network as required by the GS Act. The authorisation is subject to certain conditions, including that Jemena must develop, adopt and comply with a Network Code; maintain prudent insurances; and develop and maintain effective compliance management systems. Among other things, the GS Act requires that Jemena be a member of the energy ombudsman scheme and of Dial Before You Dig NSW/ACT Incorporated. The *Gas Supply (Safety and Network Management) Regulation 2013* requires that Jemena lodge, implement and periodically review a safety and operating plan to demonstrate sufficient management systems for safe operation of its gas distribution network.
Heritage Act 1977	The *Heritage Act 1977* provides protection of the environmental heritage of the State which includes places, buildings, works, relics, movable objects or precincts that are of State or local heritage significance. A key measure for the identification and conservation of State significant items is listing on the State Heritage Register (SHR) as provided in Part 3A of the *Heritage Act 1977*. There are no state listed items on the site.
National Parks and Wildlife Act 1974 (NPW Act)	The Act aims to conserve the natural and cultural heritage of NSW. Where works will disturb Aboriginal objects, an Aboriginal Heritage Impact Permit (AHIP) is required. An Aboriginal Due Diligence Assessment, in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW 2010) was undertaken by Biosis in 2014 and has been referred to in this EIS. An updated Aboriginal Heritage Information Management System (AHIMS) database search was undertaken on 09 September 2019. No Aboriginal objects or places have been identified as occurring within the proposal location and the potential of locating them during the proposed works is assessed as low.
Pipelines Act 1967 (Pipelines Act)	The Pipelines Act regulates the construction and operation of natural gas transmission pipelines in NSW. In accordance with Clause 11 of the Act, a person shall not construct,

<table>
<tr><th>Name</th><th>Relevance to the Project</th></tr>
<tr><td></td><td>alter reconstruct or operate a pipeline unless the operation is in pursuance of a license granted under the Act. The EGP is subject to Pipeline License No. 26. As no additional land is required for the proposal, no amendment to the Licence is required.</td></tr>
<tr><td>Protection of the Environment Operations Act 1997 (POEO Act)</td><td>The POEO Act is the key environmental protection and pollution statute. The POEO Act is administered NSW Department of Planning, Industry and Environment (DPIE) and establishes a licensing regime for waste, air, water and pollution. Relevant sections of the Act are listed below:
• Part 5.3 Water Pollution – addressed in Section 7.11
• Part 5.4 Air Pollution – addressed in Section 7.2
• Part 5.5 Noise Pollution – addressed in Section 7.5
• Part 5.6 Land Pollution and Waste – addressed in Section 7.4</td></tr>
<tr><td>Roads Act 1993 (Roads Act)</td><td>Section 138 of the Roads Act sets out the requirement for approval to carry out certain works within the vicinity of a road. Under section 138 a person must not, without consent of the appropriate roads authority:
• Erect a structure or carry out a work in, on or over a public road;
• Dig up or disturb the surface of a public road;
• Remove or interfere with a structure, work or tree on a public road;
• Pump water into a public road from any land adjoining the road; and/or
• Connect a road (whether public or private) to a classified road.
Given the access road to the WSGG Project site is an existing access road to the ECP facility, no new connect to a road is required. Furthermore, the Traffic and Transport assessment has concluded that the WSGG Project will not have significant traffic impacts (Section 7.7).</td></tr>
<tr><td>Water Management Act 2000 (WM Act)</td><td>The main objective of the WM Act is to manage NSW water in a sustainable and integrated manner that will benefit current generations without compromising future generations' ability to meet their needs. The WM Act is administered by Natural Resources Access Regulator (NRAR) and establishes an approval regime for activities within waterfront land, defined as the land 40 m from the highest bank of a river, lake or estuary.
Under the WM Act, activities and works proposed on waterfront land are regulated. These activities include:
• the construction of buildings or carrying out of works
• the removal of material or vegetation from land by excavation or any other means
• the deposition of material on land by landfill or otherwise
• any activity that affects the quantity or flow of water in a water source.
Eastern Creek is approximately 100 m to the west of the project site; therefore, the proposal is not within waterfront land.
In accordance with Part 4, Division 1.7, Section 4.41 (g) of the EP&A Act, a water use approval under Section 89, a water management work approval under Section 90 or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act is not required for SSD.</td></tr>
<tr><td>Western Sydney Parklands Act 2006 (WSP Act)</td><td>The WSP Act contains provisions relating to the management of Parklands defined under this Act by the WSPT. The principal function of the WSPT is to develop the Parklands into multi-use urban Parklands for the region of Western Sydney and to maintain and improve the Parklands on an ongoing basis.</td></tr>
</table>

Name	Relevance to the Project
	PLANNING INSTRUMENTS
State Environmental Planning Policy No. 33 – Hazardous and Offensive Development (Hazardous and Offensive Development SEPP)	The Hazardous and Offensive Development SEPP aims to provide a systematic approach to planning and assessing developments that are potentially hazardous or offensive. The proposal is likely to meet the definition of 'potentially hazardous industry', which is defined In Clause 3 of the SEPP as: *A development for the purposes of any industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:* *a. to human health, life or property, or* *b. to the biophysical environment,* *and includes a hazardous industry and a hazardous storage establishment.* If a development is classified as 'potentially hazardous industry', a PHA must be undertaken to determine the risk to the community, property and the environment. A PHA has been undertaken by GPA Engineering, which addressed the matters of considerations as outlined in Clause 12 of the SEPP (**Section 7.3**), which concluded that the calculated frequency of potentially fatal offsite individual risk for the WSGG Project is estimated to be approximately 8.4 x 10-6 per year. This value is below the tolerable risk target of 1 x 10-5 per year for 'active open space areas'.
State Environmental Planning Policy (Infrastructure) 2007 (Infrastructure SEPP)	The Infrastructure SEPP aims to: *assist in the effective delivery of public infrastructure across the State, by improving certainty and regulatory efficiency, through a consistent planning assessment and approvals regime for public infrastructure and services, and through the clear definition of environmental assessment and approval processes for public infrastructure and services facilities*. Clause 66A (1) of the Infrastructure SEPP states: Development for the purpose of a pipeline may be carried out by any person without consent on any land if the pipeline is subject to a licence under the Pipelines Act or a licence or authorisation under the GS Act.
State Environmental Planning Policy (State and Regional Development) 2011 (State and Regional Development SEPP)	The State and Regional Development SEPP aims to identify development that is State or regionally significant and requires approval by the Minister of Planning. In accordance with Part 2, Clause 8 of the State and Regional Development SEPP, development is declared to be State significant development for the purposes of the EP&A Act if: *a. the development on the land concerned is, by the operation of an environmental planning instrument, not permissible without development consent under Part 4 of the Act, and* *b. the development is specified in Schedule 1 or 2.* In accordance with Schedule 2(5) of the State and Regional Development SEPP, development is declared to be State significant development when: *Development that has a capital investment value of more than $10 million on land identified as being within the Western Parklands on the Western Sydney Parklands Map within the meaning of State Environmental Planning Policy (Western Sydney Parklands) 2009.* As the proposal will have a capital investment value of more than $10 million and is on land subject to the WSP SEPP, the proposed development is considered SSD. As such,

Name	Relevance to the Project
	the proposal is subject to assessment and determination under Part 4, Division 4.7 of the EP&A Act and, in accordance with Section 4.38 of the EP&A Act, approval from the Minister of Planning is required.
State Environmental Planning Policy (Western Sydney Parklands) 2009 (Western Sydney Parklands SEPP)	In accordance with the WSP SEPP, the land in which the proposal site is situated is unzoned. Clause 11 (1-3) of the WSP SEPP allows for the proposal to be carried out in the WSP only with consent. The proposal is not within land mapped as an Environmental Conservation Area, as defined within the WSP SEPP.
Western Sydney Parklands Plan of Management 2030	The Proposal location is within Precinct 9 (Horsley Park) as identified within the Western Sydney Parklands Plan of Management 2030. The desired future character of this precinct is to be a '*key WSPT Business Hub site as an extension of the Smithfield/Wetherill Park industrial area, surrounded by a sustainable urban farming precinct. The urban farming precinct will feature market gardening, community and research gardens, agri-tourism and education programs*'. This precinct identifies utilities infrastructure as a future land use opportunity.
LOCAL PLANNING INSTRUMENTS	
Fairfield Local Environmental Plan 2013 (FLEP)	The proposal is located within the FCC LGA, and as such a review of zoning maps within the FLEP was undertaken. The FLEP indicates that the location of the proposal is within an area covered by the Western Parklands SEPP, and therefore the land is not zoned within the FLEP. In accordance with clause 6 of the Western Sydney Parklands SEPP, the FLEP does not apply to the location of the proposal, however feedback from FCC on the SEARs and ongoing consultation has been addressed within this EIS.

5. Stakeholder and Community Consultation

Stakeholder and community consultation has been undertaken for the WSGG Project since 2018 in accordance with a Stakeholder Management Plan (SMP) developed specifically for the WSGG Project (**Appendix D**). The consultation has been undertaken in two ways:

- In a project specific way, discussing the key aspects of the project
- As part of business as usual engagement by Jemena, where Jemena discussed the WSGG Project with a range of other business issues.

Table 8 below outlines the key stakeholders and consultation undertaken for the WSGG Project during 2018 and 2019. In addition to the consultation undertaken, Jemena has a dedicated project website (https://jemena.com.au/about/innovation/power-to-gas-trial), ARENA has a dedicated webpage for the project (https://arena.gov.au/projects/jemena-power-to-gas-demonstration/), and Jemena utilises social media platforms to inform of updates, including YouTube, Twitter, Facebook and LinkedIn (**Appendix E**).

Table 8: Stakeholder and community engagement

Media	Organisation
Government (departmental)	• Federal Department of the Environment and Energy • Federal Department of Infrastructure, Regional Development and Cities • Federal Department of Treasury • NSW DPIE • Transport for NSW (including Roads and Maritime Services (RMS))
Government (political)	• Hon Angus Taylor MP, Minister for Energy and Emissions Reductions • Senator the Hon Matt Canavan MP, Minister for Resources and Northern Australia • Hon Mark Butler MP, Shadow Energy and Climate Change Minister • Pat Conroy, Shadow Assistant Minister for Climate Change and Energy • Hon Matt Kean MP, Minister for Energy and Environment • Hon Adam Searle MLC, Shadow Minister for Climate Change and Energy • Hon Chris Bowen MP, Member for McMahon • Tanya Davies MP, Member for Mulgoa • FCC Mayor Frank Carbone.
Residents	Chandos Road, Redmayne Rd and The Horsley Drive, Horsley Park, Austral Brickworks
Network users	Jemena Gas Networks Customer Council
Regulators	NSW DPIE (Natural Resources Regulator)
Aboriginal groups	Deerubbin Local Aboriginal Land Council (LALC)
Industry bodies	• Energy Consumers Australia; Energy Consumers Australia • Energy Networks Australia • Gas Energy Australia • Australian Pipelines & Gas Association (APGA) • Gas Appliance Manufacturers Association of Australia (GAMAA) • Property Council of Australia • Urban Development Industry of Australia • Australian Industry Group

Media	Organisation
Government agencies/organisations	• WSPT • Sydney Water • Sydney Catchment Authority • ARENA • CSIRO • Australian Energy Market Operator (AEMO) • Future Fuels CRC • Infrastructure Partnerships Australia • Australian Hydrogen Council • Green Building Council of Australia.
Community and other organisations	• Fairfield Chamber of Commerce • Fairfield Advance • Jemena Gas Network Customer Council
Emergency services	FCC Local Emergency Management Committee

5.1 Agency Consultation

The WSGG Project is classified as an SSD, and as such SEARs were issued by DPIE on 12 June 2019 (**Appendix A**). The SEARs are intended to guide the structure and content of this EIS and reflect the responsibilities and concerns of NSW government agencies in relation to the environmental assessment of the WSGG Project.

Table 9 below provides a summary of various agency comments and are cross referenced to where each agency's specific matters are addressed within this EIS.

Table 9: Agency comments on SEARs

Agency	Issue Summary	Addressed in EIS
Department of Industry - Water and Natural Resources Access Regulator	The SEARs should inlcude:	
	• The identification of an adequate and secure water supply for the life of the project. This includes confirmation that water can be sourced from an appropriately authorised and reliable supply. This is also to include an assessment of the current market depth where water entitlement is required to be purchased.	**Section 7.13**
	• A detailed and consolidated site water balance.	**Section 7.11.2**
	• Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	**Section 7.11.3**
	• Proposed surface and groundwater monitoring activities and methodologies.	**Section 8**
	• Consideration of relevant legislation, policies and guidelines, including the NSW Aquifer Interference Policy (2012), the Guidelines for Controlled Activities on Waterfront Land (2018) and the relevant Water Sharing Plans (available at https://www.industry.nsw.gov.au/water).	**Section 4**
DPIE – Hazards Team	Hazrads and Risks – the EIS must inlcude a preliminary hazard analysis (PHA) prepared in accordacne with the Department's *Hazardous Industry Planning Advisory Paper No.*	**Section 7.3 & Appendix C**

Agency	Issue Summary	Addressed in EIS
	6, *'Hazard Analysis'* and *Multi-level Risk Asssessment*. The PHA must inlcude and not be limited to:	
	• Verification that natural gas injected with a specified quantity of hydrogen can comply with *Australian Standard 4564: Specification for general purpose natural gas* and that this gas will not adversly impact pipeline integrity and saftey	**Section 7.3 & Appendix C**
	• Description of all plant and processes of the SSD and gas pieline, inlcuding flowrates, compositions and conditions, and the maximum project duration	**Section 3.3**
	• Hazard identification covering all plant and processes of the SSD and gas pipelines	**Section 7.3 & Appendix C**
	• description on proposed safeguards to be implemented for the SSD and gas pipelines.	**Section 8 & Appendix C**
	DPE – Hazards Team also recommend that the EIS report on the consultation outcomes between the Applicant and the teams administering the NSW *Pipelines Act 1967* and NSW *Gas Supply Act 1996*, ensuring that gas pipelines can continue to comply with the requirements of the Acts and the relevant Australian Standards during the maximum project duration, in view of the hazards and risks considerations above.	**Section 4**
DPIE - Division of Energy, Water and Portfolio Strategy	DPE Safety and Technical Regulation initial questions on Jemena's Hydrogen Generation Project Scoping Report:	**Section 7.2.2**
	• Will the hydrogen be odorised?	
	• What aspects will restrict condensation from entering the hydrogen pipework (is it 100% hydrogen only)?	**Section 7.3 & Appendix C**
	• Will the line have blow down facilities?	**Section 7.3 & Appendix C**
	• What will be the isolation process on the hydrogen components?	**Section 3.5**
	• How will the injection into the network be controlled?	**Section 3.5**
	• Will the waste process be part of the Safety and Operating Plan?	**Section 8**
	• What safety devices will be installed to maintain the Maximum Allowable Operating Pressure?	**Section 7.3 & Appendix C**
Fairfield City Council	**Strategic Land Use Planning Comments**	**Section 4**
	Legislative Context	
	Due to the nature of the project and land constraints noted below it is requested that any future EIS address the proposals comply with the following legislation:	
	• Biodiversity Conservation Act 2016 (BC Act) • Western Sydney Parklands Act 2006 (WSP Act) • Protection of the Environment Operations Act (POEO Act) • SEPP (infrastructure 2007 (Infrastructure SEPP) • SEPP (Western Sydney Parklands (WSP SEPP) • SEPP (State and Regional Development) 2011 (SRD SEPP) • SEPP 33 Hazardous and Offensive Development (SEPP 33, and • Fairfield Local Environmental Plan 2013	
	Flooding	**Section 7.11**

Agency	Issue Summary	Addressed in EIS
	The development area is subject to low risk main stream flooding across the existing facility, the north west of the facility is affected by mainstream medium flood risk. It is suggested that the applicant apply for a section 10.7 (2) and (5) planning certificate prior to preparation of the EIS.	
	Proximity to Bushfire Prone Land Fairfield Council's Bushfire Prone Land Maps identify that the site is located 45 metres east of category 1 bushfire prone land at 672 Chandos Road, Horsley Park. The adjacent western site known as 216 – 226 Horsley Drive is classed as category 3 bushfire prone land. The subject site is affected by the bushfire vegetation buffer. Council officers request that an EIS address the developments proximity to this land affectation.	**No. Bushfire management will be in accordance with existing management practices.**
	Ecologically Endangered Communities The applicant will request a Biodiversity Assessment Report (BDAR) waiver to waive the BDAR assessment requirements within the Biodiversity Conservation Act 2016 (NSW), Council officer's object to the waiving of these requirements as no impact on local fauna including wild life was conducted as part of the previous biodiversity assessment undertaken for the adjacent gas metering facility. Council officers note that a Biodiversity Assessment was prepared for the Horsley Park Mater Station located behind the H2GO site in 2014. The applicant should note that the site adjoins Shale Plains Woodland Vegetation which is identified within Council's biodiversity strategy as vegetation of high significance.	**Section 7.8**
	Sewer The site has no sewer. The proposal will produce approximately 500 litres a day of wastewater to be stored onsite. The wastewater will be pumped out and trucked away every 2 weeks. The EIS should address risk and safety hazard procedures including mechanisms to prevent a spill and procedures in the event of wastewater contamination onsite.	**Section 8**
	Environmental Management Comments The project is identified as State Significant Development (SSD) therefore the NSW Environmental Protection Agency (NSW EPA) is the appropriate regulatory authority (ARA). As the proposed project is identified as SSD, EMS will defer comment to the NSW EPA.	**N/A**
	Council officers request all relevant EPA comments to be inserted as SEARs requirements.	**N/A**
	Development Engineering Comments Onsite, Jemena representatives stated that the access way for bus refuelling would have gravel turning circle. Council's development engineers raised concerns over this arrangement, stating that the buses as they turn would wear down the surface and that a concrete pad or sealed bitumen would be more adequate. Council officers request that the SEARs enforce this requirement.	**Section 7.7.1.2**
	The site is identified in low flood risk precinct as a result of mainstream flooding. In this regard, a flood risk management report shall be prepared by a qualified consultant and submit to Council to demonstrate that the proposal fully complies with Chapter 11 of Council's Fairfield Citywide DCP 2013. Relevant flood information can be obtained from Council.	**Section 7.11**
	A storm water plan shall be prepared by a qualified engineer in accordance with Council's storm water Management Policy (September 2017) and submit to council. An	**Section 7.11**

Agency	Issue Summary	Addressed in EIS
	onsite detention (OSD) system shall be incorporated into the storm water design. All proposed hardstand areas shall be drained in the OSD.	
	All parking spaces, driveways and manoeuvring area shall be designed in accordance with AS2890. 1:2004 and AS2890.2:2002 and clearly illustrated on the architectural plans. All parking spaces, driveways and manoeuvring areas shall be suitably sealed and drained	**Appendix J**
	Swept path diagram if the largest vehicle type that will service the site shall be submitted to demonstrate that the vehicle can enter, manoeuvre and exit from the site safely.	**Appendix J**
	A concept earthworks plan shall be prepared detailing proposed cut and fill of the site. Adequate cross sections and existing and proposed surface levels shall be included in the plan.	**N/A**
	The project is identified as SSD, therefore under the BC Act, proponents of Part 4 activities must apply the test of significance (5-part test) pursuant to section 7.3 of the Environmental Planning and Assessment Act 1979 (EP&A Act) to determine whether the proposed activity is likely to significantly affect threatened species or ecological communities, or their habitats. The report is to take into account the Noise Impact Survey – 2014 (appendix 3) and potential impact on Fauna based on multiple night surveys for birdlife and Microbats on the Western Sydney Parkland Site.	**Appendix B**
	Traffic Engineering Comments A construction traffic management plan is to be submitted to Council for assessment. The construction traffic management plan shall include information such as construction vehicle routes, the type and the number of trucks, hours of operation, access arrangements and traffic control to be implemented at/near the site.	**Appendix J**
	A roadway/footpath occupation permit is required to be obtained from Council's City Assets Branch and all roadway/footpath applications require a traffic control plan (prepared by a suitably qualified personnel) to be submitted. In addition to Council's ROL, the applicant is required to apply for a temporary speed zone approval from Roads and Maritime Service (RMS) to alter any speed limits on local roads within the Fairfield Local Government Area. Temporary speed zoning and speed limit selection must comply with the requirements of RMS.	**Appendix J**
	A dilapidation report is to be submitted to Council's City Assets Brand for assessment prior to the commencement of work.	**Appendix J**
	Adequate area is to be provided on-site for the manoeuvring of vehicles particularly where the site requires access by large rigid and articulated vehicles. Further information shall be provided to Council regarding the largest size of vehicle using the site during the construction stage. A swept path diagram showing the vehicle manoeuvring into, within and out of the site shall be submitted for assessment.	**Appendix J**
	The number of heavy vehicles using Chandos Road shall be kept to a minimum as Chandos road is a street that is signposted with 5-tonne load limit restrictions.	**Appendix J**
Office of Environment and Heritage (now Biodiversity Conservation	BCD recommends the SEARs include: • The development incorporates green walls, green roof and/or cool roof into the design (see comments on Built Form and Urban Design)	**No. Green infrastructure not practical at this scale.**
	• The climate change projections developed for the Sydney Metropolitan area are used to inform the building design and asset life of the project	**No. No proposed buildings.**

Agency	Issue Summary	Addressed in EIS
Division (BCD) within DPIE)	**Aboriginal cultural heritage**	**Section 5**
	• Identify and describe the Aboriginal cultural heritage values that exist across the whole area that would be affected by the development and document there in an Aboriginal Cultural Heritage Assessment Report (ACHAR). This may include the need for surface survey and test excavation. The identification of cultural heritage values must be conducted in accordance with the Code of Practice for Archaeological Investigations of Aboriginal Objects in NSW (OEH 2010), and guided by the Guide to investigating, assessing and reporting on Aboriginal Cultural Heritage in NSW (DECCW, 2011)	
	• Consultation with Aboriginal people must be undertaken and documented in accordance with the Aboriginal cultural heritage consultation requirements for proponents (2010 DECCW). The significance of cultural heritage values for Aboriginal people who have a cultural association with the land must be documented in the ACHAR.	**Section 5.2**
	• Impacts on Aboriginal Cultural heritage values are to be assessed and documented in the ACHAR. The ACHAR must demonstrate attempts to avoid impact upon cultural heritage values and identify any conservation outcomes. Where impacts are unavoidable, the ACHAR must outline measures proposed to mitigate impacts. Any objects recorded as part of the assessment must be documented and notified to BCD. Note that due diligence is not an appropriate assessment, an ACHAR is required.	**Section 5**
	Biodiversity	**Section 7.8**
	• Biodiversity impacts related to the proposed development are to be assessed in accordance with Section 7.9 of the Biodiversity Conservation Act 2017 the Biodiversity Assessment Method and documented in a Biodiversity Development Assessment Report (BDAR). The BDAR must include information in the form detailed in the Biodiversity Conservation Act 2016 (s6.12), Biodiversity Conservation Regulation 2017 (s6.8) and Biodiversity Assessment Method, including an assessment of the impacts of the proposal (including an assessment of impacts prescribed by the regulations).	
	• The BDAR must document the application of the avoid, minimise and offset framework including assessing all direct, indirect and prescribed impacts in accordance with the Biodiversity Assessment Method	**Section 7.8**
	• The BDAR must include details of the measures proposed to address the offset obligation as follows ○ The total number and classes of biodiversity credits required to be retired for the development/ project; ○ The number of classes of like-for-like biodiversity credits proposed to be retired in accordance with the variation rules; ○ Any proposal to fund a biodiversity conservation action; ○ Any proposal to conduct ecological rehabilitation (if a mining project) ○ Any proposal to make a payment to the Biodiversity Conservation Fund If seeking approval to use the variation rule, the BDAR must contain details of the reasonable steps that have been taken to obtain requisite like-for-like biodiversity credits.	**Section 7.8**
	• The BDAR must be submitted with all spatial data associated with the survey and assessment as per Appendix 11 of the BAM	**Section 7.8**

Agency	Issue Summary	Addressed in EIS
	• The BDAR must be prepared by a person accredited in accordance with the Accreditation Scheme for the Application of the Biodiversity Assessment Method Order 2017 under s6.10 of the Biodiversity Conservation Act 2016.	**Section 7.8**
	Water and Soils	**Section 7.11**
	• The EIS must map the following features relevant to water and soils including: ○ Acid sulphate soils (Class 1,2,3 or 4 on the Acid Sulphate soil planning map). ○ Rivers, streams, wetlands, estuaries (as described in s4.2 of the Biodiversity Assessment Method). ○ Wetlands are described in s4.2 of the Biodiversity Assessment method ○ Groundwater ○ Groundwater dependent ecosystems ○ Proposed intake and discharge locations	
	• The EIS must describe background conditions for any water resource likely to be affected by the development, including: ○ Existing surface and groundwater ○ Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations. ○ Water Quality Objectives (as endorsed by the NSW Government http://www.environment.nsw.gov.au/ieo/index.htm) including groundwater as appropriate that represent the community's uses and values for the receiving waters ○ Indicators and trigger values/criteria for the environmental values identified at © in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government. ○ Risk Based Framework for considering Waterway health outcomes In strategic land-use planning decisions http://www.environment.nsw.gov.au/research-and-publications/publications-search/risk-based-framework-for-considering-waterway-health-outcomes-in-strategic-land-use-planning.	**Section 7.11**
	• The EIS must assess the impacts of the development on water quality, including: ○ The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality objectives over time where they are currently not being achieved. This should include assessment of the mitigating effect of proposed stormwater and wastewater management during and after construction. ○ Identification of proposed monitoring of water quality ○ Consistency with any relevant certified Coastal Management Program (or Coastal Zone Management Plan)	**Section 7.11**
	• The EIS must assess the impact of the development on hydrology, including: ○ Water balance including quantity, quality and source ○ Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas ○ Effects to downstream water-dependant flora and fauna including groundwater dependent ecosystems	**Section 7.11**

Agency	Issue Summary	Addressed in EIS
	○ Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge e.g. river benches) ○ Changes to environmental water availability, both regulated/licenced and unregulated/rules-based sources of such water. ○ Mitigating effects of the proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options ○ Identification of proposed monitoring of hydrological attributes	
	• The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: ○ Flood prone land ○ Flood planning area, the area below the flood planning level ○ Hydraulic categorisation (flood ways and flood storage areas) ○ Flood hazard	**Section 7.11**
	• The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for event, including a minimum of the 5% Annual Exceedance Probability (AEP), 1% AED, flood levels and the probable maximum flood, or an equivalent extreme event.	**Section 7.11**
	• The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: ○ Current flood behaviour for a range of design events as identified in 14 above. This includes the 0.5% and 0.2% AEP year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	**Section 7.11**
	• Modelling in the EIS must consider and document: ○ Existing council flood studies in the area and examine consistency to the flood behaviour documented in these studies ○ The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood, or an equivalent extreme flood. ○ Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazard categories and hydraulic categories ○ Relevant provisions of the NSW Floodplain development manual 2005.	**Section 7.11**
	• The EIS must assess the impacts on the proposed development on flood behaviour, including: ○ Whether there will be detrimental increases in the potential flood affection of other properties, assets and infrastructure ○ Consistency with council floodplain management plans. ○ Consistency with any rural floodplain management plans ○ Compatibility with the flood hazard of the land. ○ Compatibility with the hydraulic functions of flow conveyance in flood ways and storage in flood storage areas of the land ○ Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site.	**Section 7.11**

Agency	Issue Summary	Addressed in EIS
	○ Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses. ○ Any impacts of the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the NSW SES and council. ○ Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the NSW SES and council. ○ Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probably maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and NSW SES. ○ Any impacts the development may have on the social and economic costs to the community as consequences of flooding.	
RMS	Roads and Maritime would require the following issues to be included in the transport and traffic impact assessment of the proposed development: • Daily and peak traffic movements likely to be generated by the proposed development including the impact on nearby intersections and the need/associated funding for upgrading or road improvement works (if required).	**Appendix J**
	• Details of the proposed accesses and the parking provisions associated with the proposed development including compliance with the requirements of the relevant Australian Standards (i.e.; turn paths, sight distance requirements, aisle widths, etc.).	**Appendix J**
	• Proposed number of car parking spaces and compliance with the appropriate parking codes.	**Appendix J**
	• Details of service vehicle movements (including vehicle type and likely arrival and departure times).	**Appendix J**
	• Roads and Maritime requires an assessment of the likely toxicity levels of loads transported on arterial and local roads to / from the site and, consequently, the preparation of an incident management strategy for crashes involving such loads, if relevant.	**Appendix J**
	• Roads and Maritime will require in due course the provision of a traffic management plan for all demolition/construction activities, detailing vehicle routes, number of trucks, hours of operation, access arrangements and traffic control measures.	**Appendix J**
WSPT	**Bus Refuelling Facility** Trust notes that the safe operation of the facility is of utmost importance and that any hazards and risks associated with hydrogen bus refuelling facility are managed by Jemena.	**Section 7.3**
	Land Tenure and Access The Trust notes that the following report section under 4.3.1 correctly summarises discussions to date on the project. "Preliminary discussions with WSPT have identified the need for WSPT approval to utilise WSP land for the location of the turning circle adjacent to the facility. Requirements for access to this land will be further defined with WSPT and will likely be	**Section 3.4**

Agency	Issue Summary	Addressed in EIS
	established under a temporary tenure agreement between Jemena and WSPT for the duration of the project. WSPT have identified an area of land suitable for the proposed turning circle and raised a number of queries in relation to the utilisation, maintenance and access to the land proposed to be utilised for the turning circle, which Jemena are working with WSPT to address. Jemena will continue to work with WSPT regarding use of land adjacent to the Horsley Park Facility and will continue to engage with WSPT to ensure that the project aligns with the development guidelines outlined in the WSP Plan of Management". • Appendix 1 – Site Layout and Concept Plan • The preliminary "Overall Site Layout Plan" illustrates the bus-turning facility on Trust land in concept line work only. The Trust requests an updated site layout plan that overlays the bus turnaround and slip-lane onto cadastral survey plans with land boundaries clearly shown to provide an accurate impact of the project onto Trust's owned land. • Trust recommends that the "Overall Site Layout Plan" illustrates the bus turning swept paths to confirm the need by Jemena of locating the bus turnaround onto Trust's owned land. • A review of the alignment of the existing gravel road at the bus turnaround may also ascertain if the turning circle facility can be entirely located onto land owned by Jemena. • Trust recommends that the existing gravel road and bus turnaround be an all weathered sealed surface to ensure that dust and erosion runoff does not impact the adjacent urban farming land-use lots. • Trust recommends that for the life of this pilot project that boundary fencing will be required to ensure adequate safety of adjacent land-users.	

Additional consultation has been undertaken with a number of agencies to clarify some of the issues raised in the SEARs or seek further advice prior to EIS lodgement. Further consultation has been undertaken with the following local and State government authorities:

- DPIE
- DPIE Energy Networks (Regulator)
- FCC
- Sydney Water
- WSPT

Consultation with DPIE, DPIE Energy Networks (Regulator), FCC and WSPT has been undertaken throughout the project, beginning at the scoping phase of the WSGG Project, which included detailed pre-approvals meetings to outline the project and seeking feedback on and endorsement of the project proposal and the intended approvals pathway. Whilst development approval via FCC has since been determined not applicable to the project, consultation with FCC provided useful insight into areas of potential concern to FCC, for consideration during project development and to be addressed in the EIS. This early consultation with the above listed stakeholders included:

- DPIE – the purpose of the meeting was to outline the project, discuss options and likely project approval pathway and to seek feedback from DPIE. The meeting was attended by representatives from DPIE, Jemena and GPA Engineering on 6 February 2019.
- DPIE Energy Networks (Regulator) – the purpose of the meeting was to provide an update on the potential approvals pathway, discuss the role of Independent Pricing and Regulatory Tribunal (IPART) and Department of Trade & Investment Regional Infrastructure and Services (DTIRIS) during the approvals process, discuss potential project implications in more detail, and to agree on a way forward in resolving regulatory and approval requirements. The meeting was attended by representatives from DPIE, DPIE Energy Networks (Regulator), Jemena and GPA Engineering on 19 February 2019.
- FCC – the purpose of the meeting was to outline the project, discuss the likely project approval pathway and to seek feedback from FCC. The meeting was attended by representatives from FCC, Jemena and GPA Engineering on 5 February 2019.
- WSPT – the purpose of the meeting was to outline the project, discuss the potential for use of WSPT adjacent land, outline the proposed approvals pathway, and to seek feedback from WSPT. The meeting was attended by representatives from WSPT, Jemena and GPA Engineering on 5 February 2019.

A progress meeting was held with DPIE on 16 October 2019 to discuss the progress of the WSGG Project. The meeting was attended by representatives of DPIE, Jemena, GPA Engineering and ELA. Discussion with DPIE included a general update on the progress of the EIS, clarification of the EIS lodgement date and public exhibition period, and pathways for amendments to the EIS if solar panels are to be investigated during the operation of the WSGG Project within the Jemena Horsley Park Facility.

A progress meeting was held with DPIE Energy Networks (Regulator) on 16 October 2019 to discuss the progress of the WSGG Project. The meeting was attended by representatives of DPIE Energy Networks (Regulator), Jemena and GPA Engineering. Discussion with DPIE Energy Networks (Regulator) included a general update on the progress of the EIS, and for clarification relating to the separation of the regulation of gas and downstream impacts from the EIS.

A progress meeting was held with FCC on 16 October 2019 to discuss the progress of the WSGG Project, with specific discussion around transport and traffic, and engagement of local and state emergency services. The meeting was attended by representatives of FCC, Jemena, GPA Engineering and ELA. Outcomes from this meeting with FCC have informed parts of this EIS in relation to the traffic and transport assessment (**Section 7.6.1**), including:

- Outlining the safest route to and from the WSGG Project site for buses to utilise the HRS.
- A Construction Traffic Management Plan will be developed due to the current load limits of 5 tonne along Chandos Road **Section 8**.
- A dilapidation report will be prepared prior to any buses utilising Chandos Road for hydrogen refuelling, as outlined within the mitigation measures in **Section 8.**

Sydney Water have been contacted as part of the consultation process to discuss the usage of mains water for the WSGG Project. Initial feedback from Sydney Water has been positive, with a request from Sydney Water to include provisions within the design of the P2G Plant to trial recycled water as part of the WSGG Project. As such, the design of the P2G Plant will include a delivery point for recycled water to run the electrolyser, as per Sydney Water's request. Further consultation will occur with Sydney Water during the approval process.

Several discussions were held with WSPT over the course of the project development phase, and a progress meeting was held with the WSPT on 18 October 2019 to discuss the progress of the WSGG Project, including design and EIS progress. The meeting was attended by representatives of the WSPT, GPA Engineering and ELA. Discussion with WSPT included a general update on the progress of the EIS, the potential for irrigation availability, and potential inclusion of solar panels within the Jemena facility for future operations.

The feedback from WSPT was positive, with WSPT asking about encroachment upon WSPT land during construction activities (discussed in more detail in **Section 3.4**), and details regarding a boundary fence between Jemena and WSPT lands (discussed in more detail in **Section 3.4.5**). WSPT was also open to discussing the use of wastewater from the P2G Plant and were generally supportive of potential solar panels within the Jemena facility for future operations. An additional phone meeting was held with WSPT on 30 October 2019 to discuss the outcomes of the previous progress meeting and additional design reforms that were required as a result of the outcomes of the PHA. Feedback during the meeting was positive, with consultation to be ongoing during the EIS approval process and beyond.

Ongoing consultation will continue to be undertaken, as outlined within the SMP, with agencies during the approval process for the WSGG Project. Consultation will continue to be undertaken with DPIE, DPIE Energy Networks (Regulator), FCC (including a presentation to the Local Emergency Management Council meeting, which typically has attendees from FCC, NSW Police, Regional Emergency Management Coordinators, Fire & Rescue NSW, Rural Fire Service, State Emergency Services (and others), Sydney Water, Endeavour Energy, and WSPT.

5.2 Aboriginal Community Consultation

The Deerubbin LALC were contacted by Jemena in October 2019 to discuss the WSGG Project. The Deerubbin LALC advised Jemena that they did not require a site visit and correspondence via email was sufficient for any future engagement with the Deerubbin LALC for the WSGG Project. Jemena therefore provided an email with a fact sheet describing the WSGG Project (**Appendix F**).

5.3 Community Consultation

The SEARs require consultation to be undertaken at an appropriate and justified level with the public, including any relevant community groups and adjoining and affected landowners. Initial community consultation involved broad scale media, including a dedicated project website, media releases, and public presentations.

Targeted consultation with adjoining and potentially affected landowners within a 500 m radius of the WSGG Project site was undertaken during early October 2019. Initially, Jemena distributed a flyer to 12 adjoining and potentially affected landowners to inform them of the direct consultation process for the WSGG Project and landowners were invited to call in order set up a face to face meeting time. Nine adjoining and potentially affected landowners responded, and face to face meetings were undertaken with six adjoining and potentially affected landowners between the 1 and 3 October 2019. Face to face meetings were attended by representatives of Jemena and ELA, and topics discussed included:

- Introduction of the proposed WSGG Project (**Appendix F**)
- General overview of the P2G process
- EIS progress and process
- Consultation process moving forward by Jemena

As part of the face to face meetings with the adjoining and potentially affected landowners, questions and/or concerns regarding the project were invited, and either answered within the meeting or addressed within this EIS. Common questions and/or concerns expressed by the adjoining and potentially affected landowners included:

- What is hydrogen?
- How noisy will it be?
- Is it safe?
- What is the construction timeframe?
- Where will it be built within the current site?
- Are Jemena buying new land?
- What will be the impact to land value?
- Will it be detrimental to our health?

The questions and/or concerns expressed by the adjoining and potentially affected landowners have been addressed within this EIS and are summarised in Table 10.

Table 10: Community questions and/or concerns addressed within this EIS

Community Question and/or Concern	Addressed in EIS
What is hydrogen?	Hydrogen and the process involved in extracting hydrogen through an electrolyser is described in **Section 3**.
How noisy will it be?	Noise analysis undertaken for the WSGG Project is provided in **Section 7.5**.
Is it safe?	A hazard and risk assessment was completed for the WSGG Project and is provided in **Section 7.3**.
What is the construction timeframe?	The construction timeframe is provided in **Section 3.4**.
Where will it be built within the current site?	The site layout is provided in Figure 5.
Are Jemena buying new land?	The WSGG Project will occur within the current Jemena Horsley Park Facility within Lot 1 DP 499001 and Lot 3 DP 1002746. No additional land will be bought by Jemena for the WSGG Project.
What will be the impact to land value?	Impacts to land values are not anticipated and is provided in **Section 7.12.2.2**.
Will it be detrimental to our health?	Impacts relating to health are provided in **Section 7.12.**

Austral Bricks were consulted, as they are an adjoining landholder to the WSGG Project site. A meeting was held with the Austral Bricks on 4 October 2019 to introduce the WSGG Project, provide some technical detail of the project, and to provide Austral Bricks an opportunity to ask questions or provide comments on the project. The meeting was attended by representative of Austral Bricks, Jemena and ELA. Austral Bricks were generally supportive of the WSGG Project and expressed no concerns.

Ongoing community consultation will be undertaken, as outlined within the SMP, during the approval process for the WSGG Project. Consultation that will be undertaken includes:

- Community information session and barbeque to be held offsite at the Horsley Park Hall during early December 2019. This information session will provide the local community an avenue to find out more about the WSGG Project, meet the team and to ask questions about the project.
- Jemena will contact adjoining and potentially affected landowners to inform them when the EIS has been submitted to the DPIE and where the EIS will be on public exhibition. This will be undertaken via email or flyer.
- Jemena will contact adjoining and potentially affected landowners once the outcomes of the EIS have been received from the DPIE and will provide a project schedule for the WSGG Project. This will be undertaken via email or flyer.
- Jemena will contact adjoining and potentially affected landowners prior to construction to inform of dates and times.
- Jemena will provide adjoining and potentially affected landowners an open day prior to commissioning, to view the WSGG Project.

6. Environmental Risk Assessment

The Australian New Zealand Risk Management Standard (AS/NZS ISO 31000:2009) defines risk management as the "coordinated activities to direct and control an organisation with regard to risk" (Standards Australia 2009). Risk arises in all aspects of the project life cycle and offers both opportunity and threat and must therefore be managed appropriately. Risk management involves establishing an appropriate risk management culture and applying logical and systematic risk management processes to all stages in the life cycle of any activity, function or operation.

This EIS adopts an environmental impact assessment methodology aligned to the AS/NZS ISO 31000:2009 standard:

- Potential risks (environmental impacts) have been identified through the Environmental Assessment (**Section 7**)
- Strategies and actions are identified to mitigate the impact of the risk (**Section 8**)
- An assessment is made of the likelihood of the risk occurring and the consequence if the risk were to occur:
    - the likelihood of the risk occurring is described as very unlikely, unlikely, possible, likely, or almost certain to occur
    - the consequences or potential impact if the risk event occurred are described as minor, major, severe, critical or catastrophic.

The risk matrix below (Table 11) determines a risk rating of low, medium, high or extreme.

Table 11: Environmental Risk Assessment rating matrix

Risk Assessment Matrix		**Consequence**				
Likelihood		Minor	Major	Severe	Critical	Catastrophic
		A	B	C	D	E
Very Unlikely	1	Low	Low	Medium	Medium	Medium
Unlikely	2	Low	Low	Medium	Medium	High
Possible	3	Low	Medium	High	High	High
Likely	4	Medium	Medium	High	High	Extreme
Almost Certain	5	Medium	High	High	Extreme	Extreme

An environmental risk analysis has been undertaken for all potential environmental impacts that have been considered within this EIS. The results of this risk analysis are provided in Table 12. The unmitigated risk rating is the risk rating prior to detailed assessment, or any mitigation being applied and is therefore precautionary and worst case.

Table 12: Environmental Risk analysis of adverse environmental issues

Factor	Receptor	Potential Impact	Likelihood	Consequence	Unmitigated Risk
Air Quality	WSGG Project Site and Nearby residences	Emissions	4	A	Medium[2]
		Dust Deposition	2	B	Low
		Odour	2	B	Low
	Adjoining Environment	Significant Greenhouse Gas Emissions	5	A	Medium
Hazard and Risks	WSGG Site and Nearby residences	Hydrogen	1	D	Medium
		Natural Gas	1	D	Medium
		Oxygen	1	B	Low
		Bushfire and Electrical Fire	2	B	Low
Waste management	WSGG Project site and adjoining areas	Contamination of land and water	1	A	Low
		Resource wastage	2	A	Low
		Human and environmental health	1	B	Low
Noise and Vibration	Nearby residences	Nuisance noise levels during construction	3	A	Low
		Nuisance noise levels during operation	4	A	Medium
Visual	Nearby residences	Reduction in visual amenity	2	A	Low
	Adjoining landscape	Reduction in visual amenity	2	A	Low
Traffic and transport	Existing road network	Increase in traffic volumes	4	A	Medium
		Increased traffic risks and/or reduced safety	3	D	High
Biodiversity	Flora species, plant communities and/or habitat	Disturbance/loss	1	A	Low
	Fauna species	Injury and mortality	1	A	Low
	Terrestrial and aquatic ecosystems	Introduction/spread of weeds	2	A	Low
		Introduction/spread of pests	2	A	Low
		Sedimentation and erosion	2	A	Low
		Soil and water pollution	2	A	Low

[2] Although emissions are likely to occur, impacts are predicted to be negligible. This gives an overall consequence of medium. See Section 7.2.2 for further information.

Factor	Receptor	Potential Impact	Likelihood	Consequence	Unmitigated Risk
		Indirect impacts of proposal e.g. light, noise, dust	2	A	Low
Heritage	Aboriginal heritage	Impacts on known artefacts/values	1	A	Low
		Impacts on unknown artefacts/values	2	B	Low
	Historic heritage	Impacts on known artefacts/values	1	A	Low
		Impacts on unknown artefacts/values	1	A	Low
Water and Land resources	Surface water	Degradation of water quality	2	A	Low
	WSGG Project Site	Disturbance and erosion of soils and productive topsoil	3	A	Low
		Soil compaction leading to concentrated runoff and erosion	3	A	Low
		Soil contamination due to spills	2	A	Low
		Introduction/spread of weeds	3	A	Low
	Nearby properties	Reduced agricultural viability	1	A	Low
		Dust deposition	2	A	Low
		Reduction in water quantity	1	A	Low
		Flooding	1	A	Low
	Groundwater	Degradation of water quality	1	A	Low
		Reduction in water quantity	1	A	Low
	Aquatic Ecosystems	Direct Impacts	1	A	Low
		Indirect Impacts	2	A	Low
Social and Economic	Social	Carbon Emissions	5	A	Medium
		Safety	1	D	Medium
		Health	1	A	Low
		Water Consumption	5	A	Medium
	Economic	Decreased Land Value	1	B	Low

In summary, the following environmental risks were considered to be key issues for detailed assessment (**Section 7**) and consideration of mitigation strategies (**Section 8**) within this EIS:

- Air Quality and Odour
- Hazards and Risks
- Noise and Vibration

- Traffic and Transport

Air Quality and Odour, Hazards and Risks, Noise and Vibration, Traffic and Transport impacts were investigated by specialists. Summaries of these reports are included in **Section 7** of this EIS. The full reports are attached as Appendices (**Appendix C**, **Appendix G**, **Appendix I**, and **Appendix J**). Lower risk issues are addressed in **Section 7**.

7. Environmental Assessment

7.1 Assessment methodology

The **Environmental Assessment** has been undertaken to assess the potential environmental impacts for a range of specific issues (Table 13) identified within the SEARs and through site investigations.

Table 13: Potential environmental impacts

Issues	Section
Air Quality and Odour	7.2
Hazards and Risk	7.3
Waste	7.4
Noise and Vibration	7.5
Visual	7.6
Traffic and Transport	7.7
Biodiversity	7.8
Aboriginal Heritage	7.9
Historic Heritage	7.10
Water and Land	7.11
Social and Economic	7.12
Infrastructure	7.13
Cumulative Impacts	7.13.1

A description of the ***existing environment*** is provided for each issue, considering existing levels of development, as well as antecedent conditions as relevant. This provides an opportunity to consider both environmental state and function in the absence of the proposed WSGG Project.

In accordance with the requirements of the SEARs, all ***potential impacts*** associated with the proposed WSGG Project are considered across the entire lifespan of the development, considering construction, operational and decommissioning phases. Potential impacts are considered in addition to the existing environmental conditions, representing potential cumulative impacts. Furthermore, where known future development is proposed, consideration is given to potential cumulative impacts as relevant.

Mitigation measures are proposed to effectively manage all potential environmental impacts. These may include design considerations, monitoring strategies, construction safeguards, consultation, training and awareness programs, modified work practices, management plans or other relevant management strategies. A full list of mitigation and environmental management strategies and commitments is provided in **Environmental Management** (**Section 8**).

The **Project Justification** (**Section 2**) provides triple-bottom-line (environmental/social/economic) evaluation of the proposed WSGG Project in order to fully describe potential benefits and impacts to the environment and the local, regional and NSW community.

Potential **residual environmental risks** following mitigation are investigated using likelihood/consequence analysis to describe the potential magnitude of residual impacts. Where the mitigated impact remains high or extreme, further justification is provided to contextualise project risks going forward.

Justification against high level social and economic expectations is then considered against the principles of **ESD**, and more specifically, considering the particular ***socio-economic*** attributes associated with the proposed WSGG Project.

Finally, **potential alternatives** are considered to ensure that approval of the proposed WSGG Project is not detrimental when assessed against potential alternative land uses or development.

The **Conclusion** (**Section 9**) integrates the relevant **Statutory and Planning Framework** (**Section 4**) and commitments made through the **Stakeholder and Community Consultation** process (**Section 5**) with the findings of the **Environmental Assessment** to provide a concise statement regarding the suitability of the proposed WSGG Project and outlines any key points for consideration as part of the development approval process.

7.2 Air Quality

An Air Quality Impact Assessment was undertaken by Benbow Environmental (2019) to determine the likely air quality and Greenhouse Gas (GHG) impacts of the proposal (**Appendix G**). The assessment was undertaken in accordance with the following guidelines:

- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (EPA 2016)
- AS ISO 14064.1: 2018– "Greenhouse gases" – "Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals"
- Department of Climate Change and Energy Efficiency, August 2019. *Australian National Greenhouse Accounts – National Greenhouse Accounts Factors*
- Department of Climate Change and Energy Efficiency, October 2017. *National Greenhouse and Energy Reporting System Measurement – Technical Guidelines*
- Department of Climate Change and Energy Efficiency, 2019. *Australian National Greenhouse Accounts, Quarterly Update of Australia's National Greenhouse Gas Inventory*, March Quarter 2019
- Greenhouse Gas Protocol, revised edition 2015. *Corporate Accounting and Reporting Standard.*

7.2.1 Existing Environment

7.2.1.1 Climate

The monthly and annual climate statistics between the years 1997-2019 for the Horsley Park Equestrian Centre AWS 067119 monitoring station (approximately 2.2 km south of the proposal site) is outlined in Table 14.

Table 14: Climate data from the Horsley Park Equestrian Centre AWS (Benbow Environmental 2019)

Month	Mean Maximum Temperature (^{0}C)	Mean Minimum Temperature (^{0}C)	Daily Wind Run (km)	Mean Rainfall (mm)	Mean Number of Days of Rain ≥ 1 mm
January	30.1	17.9	212	75.6	7.6
February	28.9	17.8	204	103.6	7.1
March	26.9	16.2	177	83.3	8.0
April	23.9	13.0	174	70.3	6.8
May	20.6	9.0	157	41.9	5.0
June	17.6	7.2	174	74.7	6.3
July	17.4	5.8	177	35.2	5.0
August	19.0	6.4	198	36.8	4.0
September	22.4	9.3	211	35.1	4.9
October	24.7	11.8	202	58.8	5.8
November	26.4	14.4	215	78.6	7.0
December	28.4	16.3	211	66.4	7.1
Annual	**23.9**	**12.1**	**193**	**757.3**	**74.6**

7.2.1.2 Seasonal Wind Trends

Between the years 2014-2018, winds mostly arrive at the proposal site from the south west (16-20% of the time). Winds arrive at the proposal site from other directions less than 12% of the time, with wind blowing from the east and north east less than 8% of the time. The average wind speed between 2014 and 2018 was 2.07 m/s and the calms frequency was 19% (Benbow Environmental 2019).

7.2.1.3 Terrain and Structural Effect on Dispersion

Although there are small ridges to the west and east of the proposal site, katabatic flow is unlikely to affect emissions as there is sufficient distance and northerly directions of the site are relatively flat (Benbow Environmental 2019).

7.2.1.4 Local Air Quality

Ambient air quality data for NO_x, PM_{10} and $PM_{2.5}$ from the nearest air quality monitoring station, located in William Lawson Park, Myrtle Street (approximately 6 km south of the proposal site) obtained for 2007-2018 are is outlined in **Table 15**.

Table 15: Summary of ambient air quality from Prospect Air Quality Monitoring Station (Benbow Environmental 2019)

Year	NO Average (mg/m^3)	No2 Average (ppb)	PM_{10} Average (mg/m^3)	$PM_{2.5}$ Average (mg/m^3)
2007	N/A	N/A	0.018	N/A
2008	N/A	N/A	0.018	N/A
2009	N/A	20.70	0.026	N/A
2010	N/A	22.58	0.015	N/A
2011	N/A	18.82	0.016	N/A
2012	N/A	18.82	0.017	N/A
2013	N/A	20.70	0.019	N/A
2014	N/A	18.82	0.018	N/A
2015	N/A	20.70	0.018	0.0082
2016	9.82	18.82	0.019	0.0087
2017	9.82	18.82	0.019	0.0077
2018	8.59	16.93	0.022	0.0085
2007-2018	**9.45**	**19.57**	**0.019**	**0.0083**

7.2.2 Potential Air Quality Impacts

The proposal will have three sources of emissions to air, including the gas generator (microturbine), electrolyser and a buffer store blowdown vent. Future sources may also include an additional electrolyser and a hydrogen refuelling and dispensing station.

The generator has the potential to emit nitrogen oxides from the consumption of natural gas. The manufacturer specifications of the generator state a maximum of 19 mg/m^3 of NO_x emissions at 15% O_2 (Benbow Environmental 2019). However, this emission concentration is at the source and is therefore expected to have minimal impacts to nearby receptors. The generator will initially be operated on 100%

natural gas, with the intention to be converted to operate on 100% hydrogen after one year of operation.

The electrolysis process produces both hydrogen and oxygen. The hydrogen will be pumped into the buffer store and the oxygen will be emitted to open air and is therefore, not considered to be a significant risk to the surrounding receptors and environment (Benbow Environmental 2019).

The buffer store blowdown vent will be required occasionally to vent hydrogen within the facility and is therefore not considered a significant source of emissions (Benbow Environmental 2019).

The overall sources of emissions and potential impacts are summarised in Table 16. As the generator is only intended to be operated on natural gas for the first six months of operation, impacts regarding emissions such as nitrogen oxides and fugitive natural gas where predicted to be negligible. Therefore, modelling was not warranted. Once the generator is operated on hydrogen, the only emissions from the P2G plant will be oxygen, water and fugitive hydrogen.

Table 16: Sources of emissions to air (Benbow Environmental 2019)

Source	Scope	Emissions	Predicted Impacts
Generator (on Natural Gas Operation)	Current	Nitrogen Oxides, Fugitive Natural Gas and Odour	Low
Electrolyser (1)	Current	Oxygen and Fugitive Hydrogen	Very Low
Buffer Store Blowdown Vent	Current	Fugitive Hydrogen	Very Low
Electrolyser (2)	Future	Oxygen and Fugitive Hydrogen	Very Low
Hydrogen Refuelling and Dispensing Station	Future	Fugitive Hydrogen	Very Low
Generator (After Conversion to Hydrogen Fuel Gas Operation)	Future	Fugitive Hydrogen and Water	Very Low

7.2.2.1 Odour

As natural gas generally has no odour, odorant is used within the existing gas facility in order to detect accidental leaks. No new sources of odour have been identified for the proposal.

7.2.2.2 Dust and Particulates

No sources of dust or particulates have been identified during the operational phase of the proposal. Minor dust emissions may occur during the construction phase of the WSGG Project facility; however, these will be minimised through air quality mitigation measures outlined in **Section 8**.

In summary, the air quality impacts from the proposal are expected to be very low and will not cause a negative impact on the health and environment of the surrounding area (Benbow Environmental 2019).

7.2.3 Potential Greenhouse Gas Impacts

GHG emissions can be both direct and indirect and are categorised into three broad scopes:

- **Scope One:** All direct GHG emissions
- **Scope Two:** Indirect emissions from consumption of purchased electricity, heat or steam

- **Scope Three:** Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope Two, outsourced activities, waste disposal, etc.

The operation of electrolysers, generators and refuelling stations has the potential to generate the following GHG emissions (Benbow Environmental 2019):

- Direct GHG emissions from the consumption of natural gas in the microturbine generator for production of electricity (Scope One)
- Indirect GHG emissions from the consumption of generated electricity by the electrolyser (Scope Two)
- Indirect GHG emissions from the production of natural gas and electricity such as activities related to the extraction and processing of raw materials (Scope Three).

Benbow Environmental (2019) assessed one scenario to predict GHG emissions.

- 1 x Microturbine Generator with 100% consumption of natural gas for six months; and
- 1 x 500 kW electrolyser (using purchased green power).

It is noted that this scenario assumes that the generator will be operated using 100% natural gas for the first six months of operation (maximum of 180 days) and will be converted to the consumption of 100% hydrogen within six months of operation. After this conversion, the only remaining GHG emissions associated with the WSGG Project will be Scope Three GHG emissions.

The National Greenhouse Accounts (NGA) Factors, August 2019 was used to estimate the Scope One GHG emissions produced as a result of gas consumption within the generator. Calculations of the Scope One emissions were based on the assumption that the generator consumes 291.6 GJ of natural gas per annum (Benbow Environmental 2019). The Scope One GHG emissions are presented in Table 17. Converting consumption of 100% hydrogen gas by the generator will reduce the Scope One GHG emissions to zero.

Table 17: Estimated Scope One GHG emissions for Scenario One (Benbow Environmental 2019)

Activity	Annual Consumption (GJ/year)	Emissions Factor (kg CO_{2-e}/GJ			Annual GHG Emissions (tonnes CO_{2-e})
		CO_2	CH_4	N_20	
Consumption of natural gas by generator	291.6	51.4	0.1	0.03	15
Total annual Scope One GHG emissions for Scenario One					**15**

The NGA Factors, August 2019 was used to estimate the Scope Two GHG emissions associated with the consumption of purchased electricity due to the use of fuels such as coal upstream within power generation plants. All electricity used for the WSGG Project will be green power from an appropriate provider. Purchased green power energy has no net GHG emissions. As such there are considered to be no Scope 2 emissions (Benbow Environmental, 2019).

The NGA Factors, August 2019 was used to estimate the Scope Three GHG emissions associated with the exploration, production, transmission and distribution of natural gas as well as the extraction, processing and transportation of fuels to electricity power plants. Calculations of the Scope Three emissions were based on an emissions factor of 12.8 Co_{2-e}/GJ for natural gas, as provided within the NGA Factors (2019). The Scope Three GHG emissions are presented in Table 18.

Table 18: Estimated Scope Three GHG emissions for Scenario One (Benbow Environmental 2019)

Energy Source	Annual Consumption	Emission Factor (kg CO_{2-e}/GJ)	Annual GHG Emissions (Tonnes CO_{2-e})
Natural Gas	291.6 GJ	12.8 CO_{2-e}/GJ	4
		Total annual Scope Three GHG Emissions for Scenario One	**4**

Table 19 outlines the estimated total annual GHG emissions for the WSGG Project.

Table 19: Estimated total annual GHG emissions for the proposal (Benbow Environmental 2019)

Emission Type	Annual GHG Emissions (tonnes Co2-e)
Scope One: Natural gas consumption of generator	15
Scope Two: Electricity consumption	0
Scope Three: Natural gas and electricity Scope Three emissions	4
TOTAL	**19**

Australia's total emissions in 2017 were estimated to be 534.7 Mt CO_{2-e} (Benbow Environmental 2019). The estimated annual greenhouse emission for the proposal is 0.000019 Mt CO_{2-e}. Therefore, the annual contribution of greenhouse emissions from the current proposal in comparison to the Australian greenhouse emissions in 2017 is approximately 0.000000004% (Benbow Environmental 2019).

7.3 Hazards and Risk

In order to quantitatively determine the risk of a major incident at the WSGG Project facility affecting offsite land users, GPA Engineering (2019c) undertook a Level Two PHA (**Appendix C**). The PHA was prepared in accordance with the following requirements:

- Hazardous Industry Planning Advisory Paper (HIPAP) 6: Guidelines for Hazard Analysis (DP&E 2011)
- The risk criteria outlined in HIPAP 4: Risk Criteria for Land Use Planning (DP&E 2011).

The objective of this analysis was to determine the risk of a major incident at the WSGG Project facility affecting offsite land users and to compare this with tolerable risk criteria. The scope of the PHA included:

- Systematic identification of hazard
- Determination of the consequences of identified hazard
- Determination of the likelihood of loss of containments hazards using published data
- Determination of the acceptability of the risk by comparison to the risk criteria specified in HIPAP 4: Risk Criteria for Land Use Planning (DP&E 2011).

The PHA has been based upon the methodology outlined within Hazardous Industry Planning Advisory Paper (HIPAP) 6: Guidelines for Hazard Analysis (DP&E 2011) and the risk criteria outlined in HIPAP 4: Risk Criteria for Land Use Planning (DP&E 2011) for major “potentially hazardous” development. There are five stages in risk assessment, including:

1. Hazard Identification – Review of possible accidents and impacts that may occur based on previous experience, industry research and judgements.
2. Consequences and Impact Analysis – Define the characteristics of the identified possible accidents and the facility thresholds for each consequence type e.g. jet fire, flash fire, vapour cloud explosion.
3. Frequency Analysis – Define the probability of the identified possible consequences
4. Risk Analysis – Define the acceptable risk levels and compare against the determined location specific individual tolerable risk targets.
5. Review Mitigation Options – Review options for mitigation or management where tolerable limits have been exceeded (GPA Engineering 2019c).

7.3.1 Hazardous Materials

7.3.1.1 Hydrogen

Hydrogen is flammable over a very wide range of concentrations in air (4 – 75%) and is explosive over a wide range of concentrations (15 – 59%) at standard pressure and temperature. The storage quantity of hydrogen on site will be approximately 280 kg including the buffer storage and high-pressure hydrogen storage (GPA Engineering 2019c).

7.3.1.2 Natural Gas

The natural gas to be present in the facility is composed predominantly of methane gas (>92 mole %) with the residual mainly ethane (approx. 4 mole %) and carbon dioxide (<2 mole %). There is no storage of natural gas on site beyond the inventory in the Jemena Horsley Park Facility piping and buried EGP transmission pipeline and distribution pipelines (GPA Engineering 2019c).

7.3.1.3 Oxygen

There is no storage of oxygen on site. Oxygen will only be present in the electrolyser building where it is contained and vented to a safe location above the height of the electrolyser package (GPA Engineering 2019c).

7.3.2 Hazard Identification

Hazard identification and analysis was undertaken in the form of Hazard Identification (HAZID) and Hazard and Operability (HAZOP) workshops. These studies identified hazards along with existing and proposed safeguards which were to be incorporated into the design. Scenarios were then developed for consequence modelling, and consequence modelling was undertaken at specific operating conditions and leak types/sizes for each case (GPA Engineering 2019c).

The PHA identified the following scenarios as having the greatest potential for offsite consequence, as they may act as a catalyst for hydrogen fuelled flash fires or jet fires with potentially fatal radiation effects that extend beyond the Jemena boundary fence:

- Hydrogen high pressure storage equipment flange leak (10 mm)
- Hydrogen high pressure storage equipment full bore leak (15 mm)
- Refueller equipment flange leak (10 mm)
- Refueller – refuelling hose failure (15 mm) (GPA Engineering 2019c).

7.3.3 Scenarios for Consequence Modelling

A set of representative incident scenarios were determined based on the current design of the WSGG Project. In general, these events were divided into the following categories:

- Moderate releases (punctures) caused by overpressure resulting in a leak from a flange / valve, corrosion (internal or external), flexible hose failure, vibration small fitting failure, etc., characterised by a hole of 10 mm equivalent diameter
- External impact, characterised by a hole with a diameter equal to the pipe diameter or, for vessels and certain process equipment, a hole with a diameter equal to the diameter of the largest attached pipe
- Third party strike to the buried hydrogen storage pipeline, characterised by a hole of 50 mm equivalent diameter
- Gasket failure due to overpressure, poor installation, etc. For the 500 nominal bore buffer storage risers, leaks have been characterised by a hole of 20 mm equivalent diameter for a gasket segment and a hole of 78 mm equivalent diameter for full gasket failure (GPA Engineering 2019c).

7.3.4 Consequence Modelling

Due to the properties of natural gas and hydrogen being lighter than air, the most probable consequences were determined to consist of:

- Jet Fires
  - A jet fire occurs when a flammable liquid or gas, under some degree of pressure, is ignited after release, resulting in the formation of a long, stable flame.
- Flash Fires

    - A flash fire occurs when a cloud of flammable gas mixed with air is ignited.
- Explosions
    - Explosions can occur through a variety of mechanisms, but in each case damage or injury is caused by a pressure wave which is created by rapid expansion of gases. Explosions may also occur as a result of catastrophic rupture of a pressurised vessel, ignition of dust clouds, thermal decompositions, runaway reactions and detonation of high explosives such as TNT. Both blast waves and projectile fragments may result (GPA Engineering 2019c).

Consequence analysis was undertaken using the DNV GL process hazard analysis software program Phast (version 8.1) (GPA Engineering 2019c).

The results of these analyses determined that the scenarios with the highest potential consequence were those which have the potential for offsite consequence - being in this case flash fires or jet fires with radiation effects at sufficient level to cause a fatality that extended beyond the Jemena boundary fence. For the modelled continuous release rate, these scenarios were:

- 5b – Hydrogen high pressure storage equipment full bore leak (15 mm)
- 6a – Refueller equipment flange leak (10 mm)
- 6b – Refueller – refuelling hose failure (15 mm) (GPA Engineering 2019c).

There were two scenarios that had jet fires with potential radiation effects at the levels sufficient to cause an injury that extended beyond the Jemena boundary fence. For the continuous release rates modelled these scenarios were:

- 3d – Full gasket failure of a 500 mm NB flange
- 6b - Refueller – refuelling hose failure (15 mm) (GPA Engineering 2019c).

A frequency analysis for these scenarios with consequences of a jet fire with fatal radiation levels or a flash fire was conducted to be compared with defined tolerable risk targets. For each of the areas capable of causing a potentially fatal offsite impact, event trees were created, and resultant frequencies were calculated. The results of these calculations are summarised in Table 20 below (GPA Engineering 2019c).

Table 20 Likelihood of potential fatal offsite effects with a continuous release rate (GPA Engineering 2019c)

Scenario	Frequency Per Year
High Pressure Hydrogen Storage – Leak 100%	7.9×10^{-5}
Refueller dispenser – Hose Leak 10%	4.3×10^{-6}
Refueller dispenser – Hose Full Bore	2×10^{-6}
Refueller dispenser - Hose Full Bore (1050 uses per year)	1.6×10^{-7}
Total	$\mathbf{8.8 \times 10^{-5}}$

The results of the partial quantification have shown that the aggregate frequency of all events which could have significant offsite consequences is approximately $\mathbf{8.8 \times 10^{-5}}$ per year. An outcome of this preliminary assessment was for the final design to include a firewall on the east side of the High-Pressure

Hydrogen Storage facility. The firewall will be designed to achieve a Fire Resistance Level (FRL) of 240/240/240 in accordance with AS 1596 ‘The Storage and Handling of LP Gas’ and the American Standard NFPA 2 ‘Hydrogen Technology Code’. This will eliminate the consequence of potentially fatal radiation crossing the site boundary. This leaves only leaks from the refueller/dispenser with potentially fatal offsite consequences. The leak frequencies for the refueller dispenser failures are provided in Table 21 (GPA Engineering 2019c).

Table 21 Likelihood of potential fatal offsite effects with a continuous release rate - refueller dispenser failures (GPA Engineering 2019c)

Scenario	Frequency Per Year
Refueller dispenser – Hose Leak 10%	4.3×10^{-6}
Refueller dispenser – Hose Full Bore	2×10^{-6}
Refueller dispenser – Hose Full Bore (1050 uses per year)	1.6 x 10-7
Total	**8.4×10^{-6}**

The calculated frequency of potentially fatal offsite individual risk for the WSGG Project is estimated to be approximately 8.4×10^{-6} per year. This value is below the tolerable risk target of 1×10^{-5} per year for ‘active open space areas’. This value will be achieved through the design of a firewall to be installed to prevent any unintended releases from the hydrogen high pressure storage facility having potentially fatal offsite consequences (GPA Engineering 2019c).

There were two scenarios that had jet fires with potential radiation effects at the levels sufficient to cause an injury that extended beyond the Jemena boundary fence. For the continuous release rates modelled these are provided in Table 22 (GPA Engineering 2019c).

Table 22 Likelihood of potential Injuries offsite effects with a continuous release rate (GPA Engineering 2019c)

Scenario	Frequency Per Year
Failure of 500 mm NB Gaskets (full)	7.6×10^{-10}
Refueller dispenser – Hose Full Bore	2.8×10^{-7}
Refueller dispenser – Hose Full Bore (per use failures)	2.2×10^{-8}
Total	**3.1×10^{-7}**

The probability of these events occurring is 3.1×10^{-7} and is the below risk target of 50×10^{-6} listed in HIPAP 4 (GPA Engineering 2019c).

It was noted that none of the modelled consequence contours indicated that the residential dwellings on the opposite side of Chandos Road will be impacted by potential consequences (GPA Engineering 2019c).

7.3.5 Downstream Impact Assessment

A Downstream Impact Assessment (**Appendix H**) was prepared by GPA Engineering (2019d) to identify the potential impacts from the WSGG Project to the distribution network downstream of the injection point at the Jemena Horsley Park Facility Trunk Receiving Station. The assessment included the Sydney

Secondary Mains distribution network, including the downstream medium and low-pressure mains and the downstream industrial commercial and domestic users when:

- Hydrogen of up to 2% (by volume), the target injection percentage, is added to the natural gas mixture
- Hydrogen of up to 10% (by volume) is temporarily released into the network. This scenario was only possible during failure of the hydrogen injection flow control valve and coincident low flow of natural into the Secondary Mains. A shutdown has been included in the design to isolate hydrogen injection from the network, during a low natural gas flow event. This has been calculated to a specific set point to ensure mixing ratio does not reach 10% vol (GPA Engineering 2019d).

The assessment included an analysis of the impacts of a hydrogen blend on the following:

- Network materials; including the carbon steel Secondary Mains and downstream polyethylene, nylon, cast iron, and carbon steel low pressure and medium pressure mains.
- Gas composition & quality; including assessment against the requirements and limits of AS4564-2011 and analysis of the change in properties introduced by the blend.
- Safety; including impact on gas build-up in buildings, radiation distance and odorisation (GPA Engineering 2019d).

This assessment also addresses the SEAR to "*provide verification that natural gas injected with a specified quantity of hydrogen can comply with Australian Standard 4564: Specification for general purpose natural gas and that this gas will not adversely impact pipeline integrity and safety*".

The downstream impact assessment found that all natural gas and hydrogen blends are compliant with the Australian Standard AS 4564-2011. At the target blending percentage of 2% and the shutdown limit of 10%, the limits stipulated in AS 4564-2011 are within the allowable range for the expected range of natural gas compositions.

7.4 Waste

7.4.1 Existing Environment

The existing waste streams within the facility include:

- Bulk liquid separator, which removes liquid hydrocarbons from the natural gas supply
- Gas filters, which remove solid debris (pipeline dust) present within the natural gas. The filters consist of banks of plastic and fabric filter cartridges.

The filter cartridges are removed and replaced annually and are placed into HAZMAT drums, along with any cleaning materials. Maintenance of the facility may require the removal and replacement of seals, lubricants, gauges and measurement devices, which are then disposed of. The existing facility also contains an office, which occasionally produces office wastes.

7.4.2 Potential Impacts

7.4.2.1 Construction Waste

The majority of waste generation during construction is likely in the form of excess spoil and plant packaging. Additional waste may be generated from general waste from staff and contractors.

Potential impacts from construction waste generation include:

- Minor spills from hazardous fuel and chemical use can be an environmental issue. However, in the context of the materials and equipment utilised on this project, are typically small in scale and localised only. On site spill kits will be utilised to contain and remove any contaminated materials. Used spill kits shall be disposed of at a licenced waste facility.
- Minor pollution of the environment from other general wastes (e.g. packaging). Waste of this type will be collected and disposed of or recycled in appropriate on-site bins.
- Wastewater generated from the purification process. This will comprise of slightly elevated levels of minerals typically found in mains water only, without addition of any other substances.

Offsite disposal at a waste facility is the preferred option for managing the plant packaging, which may include wooden pallets, plastic and other wrapping materials, pipe offcuts and general refuse. Any excess spoil from earthworks is proposed to be classified in accordance with Waste Classification Guidelines (EPA 2014) and disposed of at an appropriately licenced waste facility. No waste is to be imported into the site.

Removal and appropriate disposal of general waste generated by the contractors during the proposed works shall comply with Jemena and Regulatory requirements.

7.4.2.2 Construction Resource Usage

The main resources required for the construction of the new facility include steel for the associated pipework, quarry products for the new hardstand surfaces, concrete, plinths for the connecting pipework and polymer and resin coatings for new pipework. The volumes of such resources are not considered significant and will therefore not limit resource availability for other purposes.

7.4.2.3 Operational Wastewater

The electrolyser will require 2,135 L of mains water per day, approximately 1,600 L litres of which will be converted into purified water for electrolyser use. This will generate approximately 535L of wastewater. Mains water has a salinity of around 57 ppm, with the wastewater having salinity of 500 ppm. Sydney Water allow disposal of wastewater with salinity of 500 ppm for Industrial Trade Waste (Total Dissolved Solids).

Jemena is still assessing the options for wastewater removal, however the following measures, either individually or in combination, are being considered:

- Truck the wastewater offsite to a licenced facility for disposal.
- Reuse the wastewater for irrigation, pending regulatory approval.
- Treat and reuse part of the wastewater within the facility. This may include options such as further concentrating the wastewater for disposal and reusing the treated portion of the water for on-site washing or septic systems.

7.5 Noise and Vibration

A noise and vibration assessment was undertaken by Marshall Day Acoustics Pty Ltd (2019) to investigate potential noise impacts due to the construction and operation of the WSGG Project (**Appendix I**). The assessment of operational noise has been undertaken in accordance with the requirements of the NSW EPA's *Noise Policy for Industry* (NPfI).

The assessment of construction noise and vibration assessment was undertaken in accordance with the requirements of the EPA *Interim Construction Noise Guidelines* and EPA's *Assessing Vibration: A technical Guideline*.

The operational noise assessment was based on:

- Operational noise limits determined in accordance with the NPfI, accounting for existing background noise levels at neighbouring sensitive locations
- Predicted noise levels for the WSGG project based on the proposed site layout and noisy equipment
- A comparison of the predicted noise levels with the criteria derived in accordance with the NPfI.

7.5.1 Existing Environment

The nearest residential receivers and their distance to the nearest site boundary has been provided in **Table 23** below.

Table 23: Nearest residential receivers considered in assessment (Marshall Day Acoustics 2019)

Receiver reference	Address	Distance to nearest site boundary (m)
R1	187 – 201 Chandos Road	≈ 90
R3	203 – 209 Chandos Road	≈ 130
R6	168 – 174 Chandos Road	≈ 160

An attended noise survey was carried out near the site on 11 September 2019, between the hours of 2 – 3 pm. This survey was undertaken in order to make observations of the noise environment at each of the noise logger locations and carry out spot measurements for noise logger validation purposes.

Ambient and background noise levels at site were measured using two noise loggers, one near the southern site boundary (Logger One), and one on the southern side of Chandos Road opposite the site at a location considered to have a noise environment that was representative of the nearest residential receiver (Logger Two) (Figure 14). Both noise loggers measured 24-hour noise levels at 15-minute intervals between 12 September 2019 – 25 September 2019. The measured NPfl background noise levels are summarised in Table 24.

Table 24: NPfI time periods and measured background noise levels summary (Marshall Day Acoustics, 2019)

Period	Time of Day	RBL, $L_{A90,15min}$ (dB)	$L_{Aeq,15min}$ (dB)
Day	7 am – 6 pm	41	54
Evening	6 pm – 10 pm	43	52
Night	10 pm – 7 am	41	52

Review of logger data shows noise levels patterns consistent with a city fringe semi-rural setting. During weekday periods, noise levels typically increased and decreased with regard to expected traffic, rising during the early morning, dropping in the middle of the day and steadily rising in the early evening and into the night. In general, background levels were relatively consistent during weekday periods, with levels being noticeably lower on weekends.

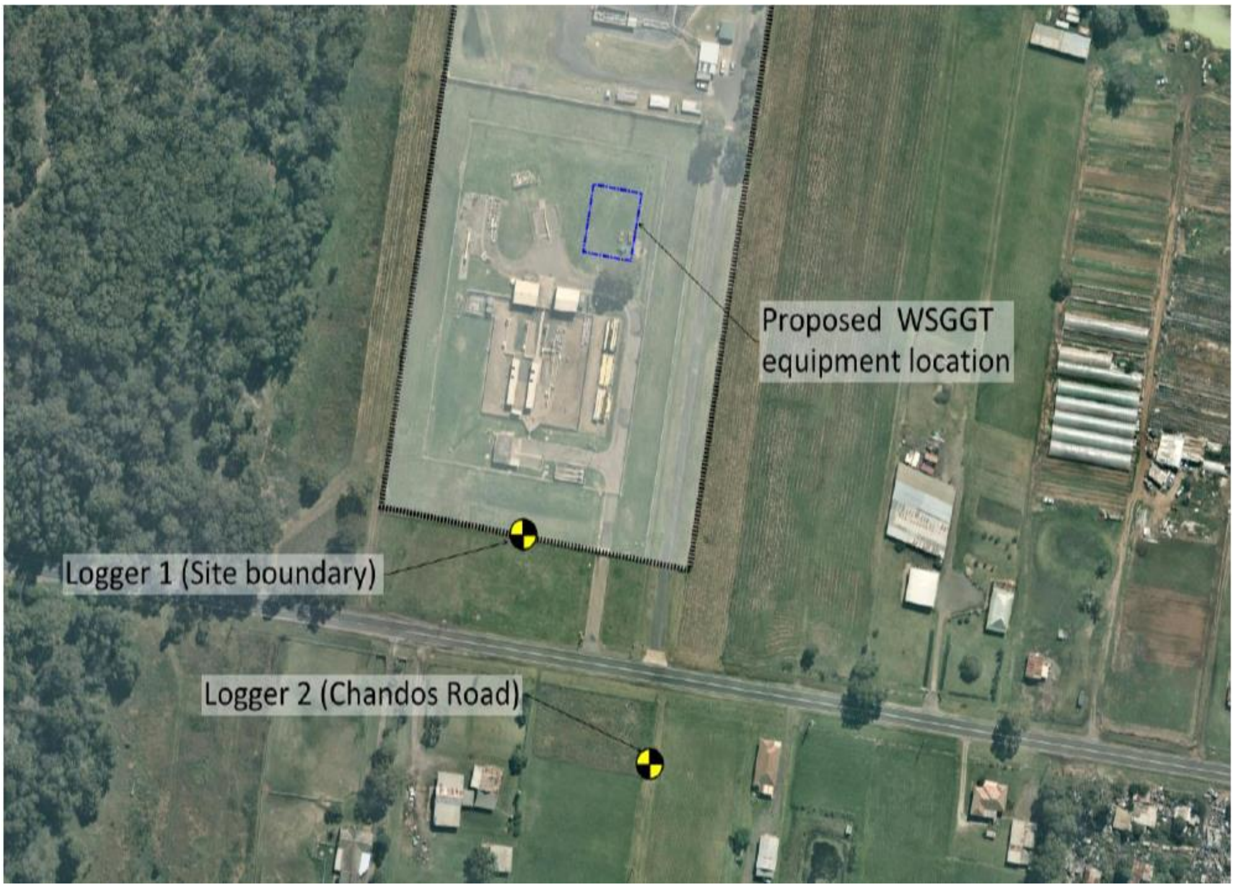

Figure 14: Location of noise loggers (Marshall Day Acoustics, 2019)

7.5.2 Potential Impacts

A noise model was prepared to determine the noise levels at the nearest noise sensitive receivers. The following factors were considered:

- The amount of noise being generated at the site during operational times
- The distance between the sources and receivers
- The presence of obstacles such site buildings that obstruct the noise path
- The hardness of ground between the source and receiver.

A 3-dimensional digital model of the site and surrounding environment was created using SoundPLAN proprietary modelling software (version 8.1).

7.5.2.1 Construction Noise

For construction noise modelling, a conservative assumption was made that plant items will be operating for 100% of the time over a 15-minute period except for deliveries.

The predicted L_{Aeq} levels from the proposed construction steps and nominated equipment indicate that noise from construction will exceed the ''noise affected'' goals from the EPA criteria at some residential receivers by up to 4 dB. Predicted noise levels are within the "highly affected" noise goals for all steps, however this is based on the conservative assumption that all equipment will be operating simultaneously.

On-site noise measurements indicated an average daytime noise level of L_{Aeq} 15 min 54 dB, as such, predicted exceedances are unlikely to be intrusive when considering existing noise on site. Additionally, since all construction work will be restricted to take place only during the daytime, there will be no construction noise impacts to sensitive receivers at night.

Where the "noise affected" management level is predicted to be exceeded, the *Interim Construction Noise Guidelines* require that all feasible and reasonable work practices be employed. Where it is predicted that the "highly noise affected" management level will be exceeded, respite periods will be considered.

7.5.2.2 Operational Noise

Two operational noise model scenarios were considered within the assessment: operational noise from equipment that typically operates in a constant or continuous manner; and, operational noise from equipment that operates intermittently and is associated with maximum noise level events.

The operational noise model for continuous noise sources has been prepared for assessment against NPfI Trigger Levels criteria, and assumes all equipment operating simultaneously at full capacity, except for buses accessing the site.

The operational noise model for single noisy events has been prepared for assessment against the NPfI maximum noise level criteria. It should be noted that venting events from the sources listed for the maximum event noise scenario are only likely to occur very occasionally and will not be considered a regular occurrence.

Preliminary modelling found that the noise contribution from operation of the microturbine may give rise to noise levels exceeding the NPfI Project trigger levels during operation at night (Table 25). The mitigation measures assessed as part of the assessment included either installation of a noise screen to the south side of the microturbine, or relocation of the microturbine to enable screening from the process gas container, or limitation of operation during day and evening. The project has determined to limit operation of the microturbine to only operate between 7am and 10pm as the noise levels are within the trigger levels during these hours (Table 25).

Table 25: Predicted noise levels both base case and with reduced operating times at night (Marshall Day Acoustics, 2019)

Receiver	Predicted Noise Level, L_{Aeq}, DB (Base Case)	Predicted Noise Level, L_{Aeq}, dB Day and Eve (Night) (Reduced Operating Times)	Project Trigger Levels (L_{Aeq})		
			Day	Evening	Night
R1	38	38 (35)	46	43	38
R3	32	32 (30)	46	43	38
R6	34	34 (32)	46	43	38

The predicted maximum noise levels for single events (gas venting) are shown in Table 26. It should be noted that the predicted levels are external levels and internal levels inside dwellings are likely to be at least 10-15dB lower (Marshall Day Acoustics, 2019).

As venting events are only likely to occur very occasionally (less than once per week), they will not be considered a regular occurrence. The NSW *Road Noise Policy* states that 'one or two noise events per night, with maximum internal noise levels of 65 – 70 dB (A) are not likely to affect health and wellbeing significantly.

In consideration of this, and the frequency of vent noise events expected, it is not considered necessary to apply noise control measures to these noise sources (Marshall Day Acoustics, 2019).

Table 26: Predicted operational noise levels for single gas venting events (Marshall Day Acoustics, 2019)

Receiver	Predicted Noise Level, L_{AFmax} dB
R1	67
R3	63
R6	61

7.5.2.3 Vibration Assessment

Given the separation distances to residential receivers and the types of construction activities, the risk of vibration impacts is considered to be insignificant and therefore vibration has not been assessed in detail. Notwithstanding this, vibration generating activity will be minimised where possible through the construction methodologies and selection of appropriate construction equipment.

7.6 Visual

7.6.1 Existing Environment

The site is located in a predominantly flat landscape, with elevation ranging from between 60 – 70 m above sea level Australian Height Datum (AHD), gently sloping from the south-east to north–west (Figure 15). The landscape is typical of the rural landscape of Western Sydney. Land within and surrounding the site has been historically cleared for grazing and agricultural uses and the existing gas facility. Patches of native vegetation in the surrounding area have been retained, particularly around Prospect Reservoir, and to the west of the proposed development.

Prospect Reservoir is located approximately 1.2 km north east of the proposed project, however, the vegetation surrounding the publicly accessible areas of Prospect Reservoir limit the views of the proposed WSGGP from the Reservoir.

Chandos Road immediately adjoins the existing Horsley Park Facility and is subject to low volumes of local traffic.

Figure 15: View of proposed location of WSGGP, looking north from the existing access road

7.6.2 Potential Impacts

As part of the WSGG Project, a 6.5 m tall blowdown pipe will be required to be constructed. A desktop spatial assessment was therefore undertaken to determine potential sensitive receivers in proximity to the facility, which may have a direct line of sight of the blowdown pipe.

A radial topographic analysis was undertaken which, based on the topography alone, identified 12 sensitive viewing locations (Figure 16). This assessment was undertaken using Light Detection and Ranging (LIDAR) with a Desktop Elevation Model (DEM) of 1 m therefore, assuming a 'bare-earth' model. However, views from these residential receivers are highly likely to be obstructed or completely screened by vegetation and will be from a long distance therefore reducing impacts upon visual amenity at these locations.

To refine this assessment, a line of site assessment was then undertaken using a LiDAR derived 2 m Digital Surface Model (DSM). The line of site assessment plotted the 12 points associated with the previously identified sensitive viewing locations. These points were chosen as they are indicative of the typical line of sight from these properties when looking towards the WSGG Project site. The assessment was undertaken utilising the assumption that the receiver's view is taken from 1.5 m above the DEM elevation and will view the proposed WSGG Project at 6.5 m above the DEM, which is the highest visible point of the proposed WSGG Project infrastructure (blowdown pipe). To determine the degree of visual impact from the identified sensitive receivers, the following factors were also considered:

- **Landscape Character:** All aspects of a tract of land between the WSGG Project facility and the sensitive receiver (i.e. built or natural), which may obstruct the line of site.
- **Magnitude of Impact:** The distance between the sensitive receiver and the WSGG Project facility.
- **Sensitivity:** The sensitivity of the receiver and its capacity to absorb change (i.e. residential receivers are assumed to have high sensitivity whereas industrial receivers are assumed to have low sensitivity).

The visual impact rating was then determined by cross-referencing the magnitude of the impact with the sensitivity of the receiver. The visual impact rating was classified as per the below:

- **High:** The visual impact on these viewers is significant and would typically require improvement.
- **Moderate:** The visual impact on these viewers is at a localised scale and can be mitigated or already has some existing screening or an existing setback which minimises visual impact.
- **Low:** The visual impact on these viewers is considered low and no or very little improvement is required.
- **Negligible:** The visual impact on these viewers is considered very low or non-existent and no improvement is required.

The line of site assessment identified 3 sensitive viewing locations that will have a moderate impact rating and have a clear line of site of the blowdown vent (Table 27 and Figure 17). It was concluded that these impacts are already mitigated through the existing distance between the sensitive receivers and WSGG Project facility. Therefore, no further mitigation measures are recommended.

Table 27: Visual impact assessment factors

Sensitive Receiver	Address	Sensitivity	Landscape Character	Magnitude of Impact (Distance)	Visual Impact Rating
A	259-273 Chandos Road, Horsley Park (Lot 120 DP 13905)	Dwelling (high)	Vegetation	556 m	Negligible
B	211-217 Chandos Road, Horsley Park (Lot 58B DP 17288)	Dwelling (high)	No Obstruction	208 m	Moderate
C	203-209 Chandos Road, Horsley Park (Lot 58A DP 17288)	Dwelling (high)	No Obstruction	204 m	Moderate
D	187-201 Chandos Road, Horsley Park (Lot 57 DP 13961)	Dwelling (high)	Vegetation	215 m	Negligible
E	168-174 Chandos Road, Horsley Park (Lot 93 DP 752041)	Dwelling (high)	Buildings	215 m	Negligible
F	171-185 Chandos Road, Horsley Park (Lot 56 DP 13961)	Dwelling (high)	No Obstruction	266 m	Moderate
G	150-154 Chandos Road, Horsley Park (Lot 3 DP 30290)	Dwelling (high)	Topography	327 m	Negligible
H	137-153 Chandos Road, Horsley Park (Lot B DP 361393)	Dwelling (high)	Buildings	435 m	Negligible
I	126-130 Chandos Road, Horsley Park (Lot 7 DP 30290)	Dwelling (high)	Buildings	509 m	Negligible
J	121-135 Chandos Road, Horsley Park (Lot 54 DP 13961)	Dwelling (high)	Vegetation	529 m	Negligible
K	105-119 Chandos Road, Horsley Park (Lot 53 DP 13961)	Dwelling (high)	Vegetation	573 m	Negligible
L	105-119 Chandos Road, Horsley Park (Lot 53 DP 13961)	Dwelling (high)	Vegetation	639 m	Negligible

The proposed development will not increase the level of light pollution within the surrounding area, as the only operational light impacts will exist in the form of simple lighting to enable emergency night-time access to the control hut. As the WSGG Project facility will predominantly not be operated outside of standard daytime hours, this impact is anticipated to be negligible and infrequent.

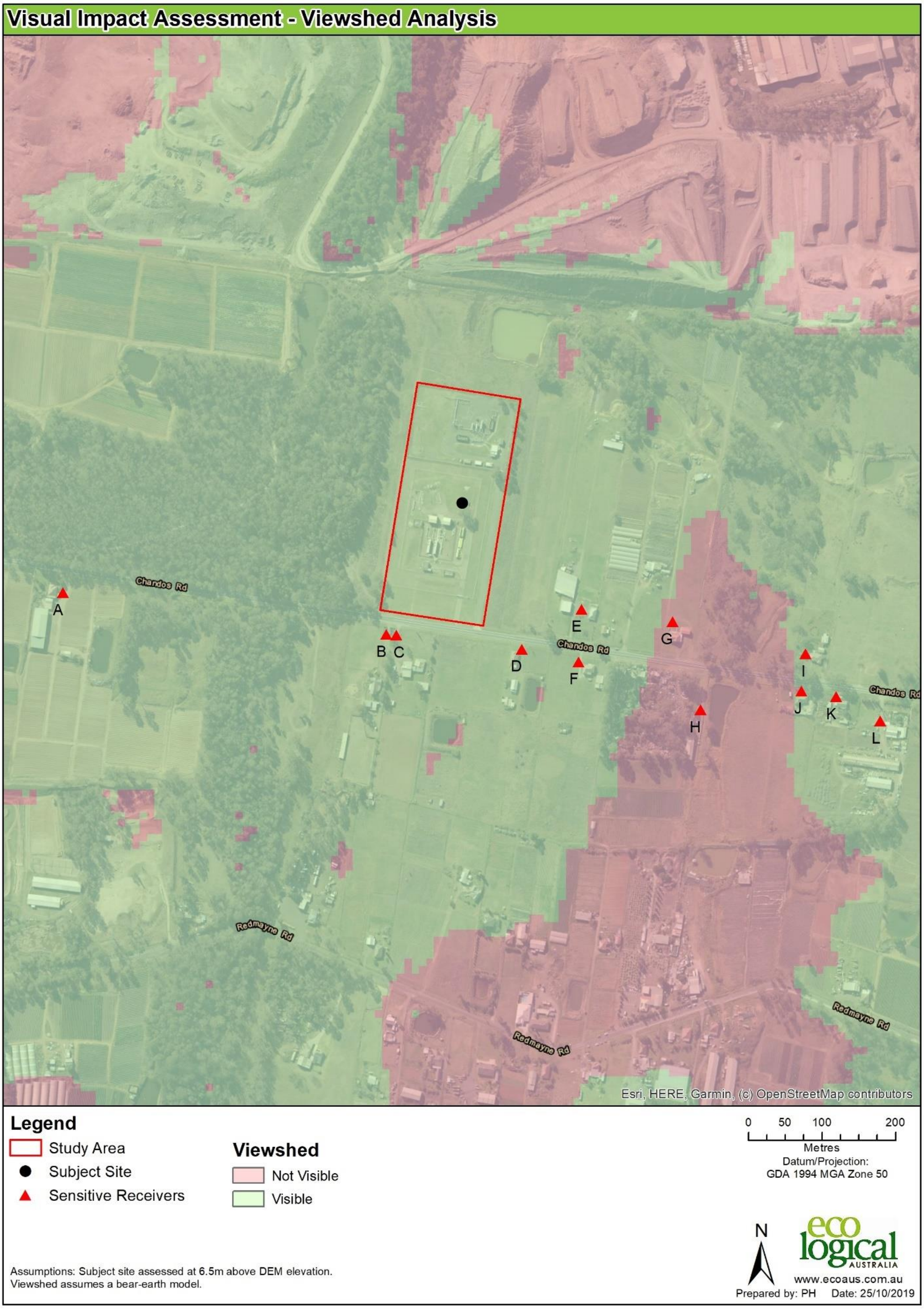

Figure 16: Viewshed analysis indicating sensitive viewing locations (based on elevation and assumes not buildings or trees)

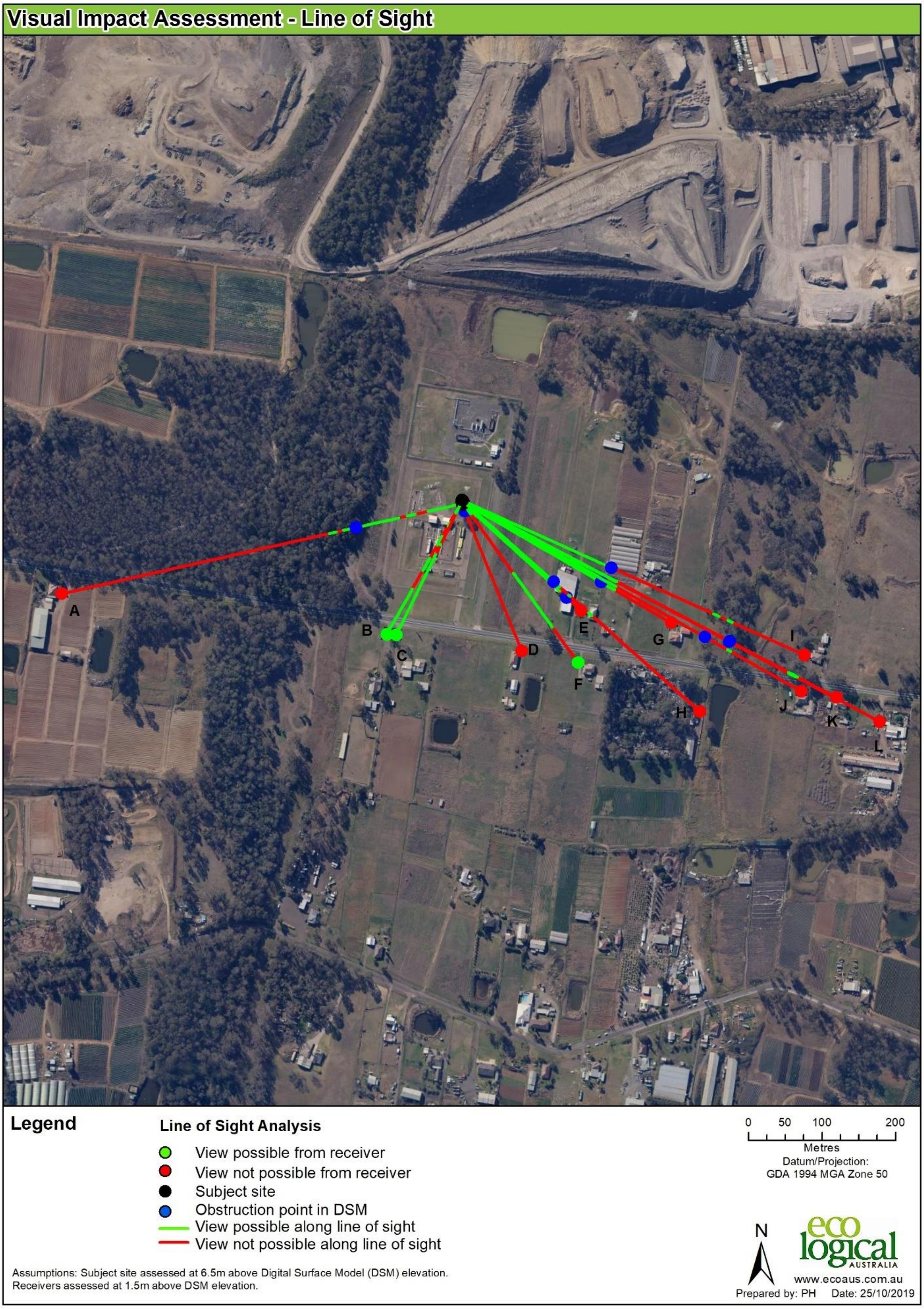

Figure 17: Line of site visual assessment

7.7 Traffic and Transport

A traffic impact assessment was prepared by TTM (2019) which investigated the traffic aspects associated with the proposed development (**Appendix J**). The scope of this assessment included:

- Review of concept design plans
- Assessment of the proposed development layout of the site with respect to Council, Traffic, Access, Parking and Servicing requirement
- Swept path analysis for proposed design
- Determination of the likely traffic generation for the proposed development and identification of potential traffic impacts on the local road network.

The development plans were assessed against the following guides and standards:

- Fairfield City Wide DCP 2013
- Australian Standards (AS 2890)
- RTA (RMS) Guide to Traffic Generating Developments.

7.7.1 Existing Environment

7.7.1.1 Existing Transport Infrastructure

The existing site is accessed from Chandos Road, which provides an east-west link between Wallgrove and Ferrers Road. Chandos Road is a local road administered by FCC, whereas Wallgrove Road is under the authority of RMS.

Chandos Road is a 2-lane undivided street with a carriageway of approximately 8 metres. The road provides access to various residential, commercial and industrial property lots on either side.

Wallgrove Road is a 2-lane undivided street with a carriageway of approximately 12 metres including shoulders on either side. Wallgrove Road carries significantly higher volume of vehicles as compared to Chandos Road.

Chandos Road and Wallgrove Road intersect to form a four-legged stop-controlled with Chandos Road being a minor road. Access from Wallgrove Road to Chandos Road is restricted for vehicles having Gross Vehicle Mass of 5 tonnes and over.

No dedicated parking spaces exist on site for use by the construction project.

7.7.1.2 Internal Road Layout

The internal road connecting Chandos road to site is approximately 5 metres in width. The existing internal road is an unsealed road with loose gravel occupying the length of the road. The new bus turnaround will be a sealed bituminised road at the end of the internal road, contained within Jemena's property boundary. The characteristics of the internal road with respect to FCC and AS 2890 requirements is provided in Table 28.

Table 28: Driveway design requirements and provision (TTM 2019)

Design Aspect	Council / AS 2890 Requirements	Existing / Proposed Provision	Compliance
Access Driveway Width			
Private Vehicle	6.0 m to 9. 0 m	9.0 m	Compliant
Commercial Vehicle (MRV)	9.0 m		
Access Driveway Grade	First 6 m from the property boundary shall be a maximum of 1:20 (5%)	First 6 m from the property boundary has a maximum of 1:20 (5%)	Compliant
One-Way Road Width	3.0 m (min) between kerbs	4.5 m	Compliant

During refuelling activities, the site is expected to have three buses per day from a single bus company. The proposed turning circle to be constructed will be designed to accommodate up to 3 buses at a time, with the third bus being refuelled. It is unlikely that more than one bus will be present on site at a time, though if this occurs, there will be sufficient unsealed space on both sides of the road for vehicles to pass.

7.7.2 Potential Impacts

As per discussion with FCC, the need for refuelling buses to access the site through the safest route was identified. Two access routes were discussed:

- The shortest access route assuming arrival of buses from the M7 is to access Wallgrove Road, travel northbound, turning right on to Chandos Road and turn left into the site access road.

An alternative route was identified due to FCC's safety concerns regarding buses making right turns towards Chandos Road considering the heavy traffic on Wallgrove Road. The alternate route involves exiting on to Horsley Drive from the M7 motorway, travelling eastbound, turning left towards Ferrers Road, travelling northbound on Ferrers Road, turning left on to Chandos Road and from there, turning right into the site access road.

In order to mitigate the safety concerns associated with turning right across a high traffic volume road, Jemena proposes that buses will adopt the second route of travel for refuelling operations. It should be noted that this plan cannot be formalised until agreement with the third-party bus provider is completed. The project hydrogen storage volume supports three buses, for a maximum of 2 visits each per day resulting in a minor increase in traffic in the area.

The proposed facility will normally be unmanned and require vehicular access during daily hours of operation. The maximum vehicular activity will take place during construction, which will potentially require up to 10 light vehicles and 8 heavy vehicles per day, resulting in a trip generation of up to 36 trips per day. This amount of traffic generation is considered relatively minor and not of a level normally associated with unacceptable traffic implications in terms of road network capacity, efficiency or traffic related environmental effect (TTM 2019).

Both light and heavy vehicles accessing the site will either perform a left or right turn for access to the internal road towards the site. The access point off Chandos Road has adequate sight distances for vehicles turning in and out of the internal road.

During construction, safety measures such as traffic controllers, truck crossing or entering signs etc. will be included as part of a construction traffic management plan.

In addition to the pre and post construction dilapidation reports, if the refueller is installed after the completion of the main project scope, a further dilapidation report will be submitted to FCC prior to the beginning of bus refuelling operations.

7.8 Biodiversity

Section 7.9 (2) of the BC Act states that a SSD Application must be accompanied by a BDAR unless the Planning Agency Head and the Environment Agency Head determine that the proposed development is not likely to have any significant impact on biodiversity values.

ELA carried out a site visit, which determined that no significant impact on biodiversity value will occur as a result of the proposed development. ELA then prepared a BDAR waiver request on behalf of Jemena (**Appendix B**). The BDAR waiver request was submitted to the DPIE on 29 August 2019. On 11 September 2019 DPIE confirmed that a waiver was granted. Therefore, submission of a Biodiversity Development Assessment Report is not required.

7.8.1 Existing Environment

7.8.1.1 Vegetation Mapping

A review of the available vegetation mapping (OEH 2013) indicated that no vegetation communities were present within the proposal site (Figure 18). Table 29 outlines the vegetation communities that occur within proximity of the study area, including the equivalent Plant Community Types (PCTs) and conservation status in accordance with both the State BC Act and Commonwealth EPBC Act.

Table 29: Vegetation communities previously mapped in proximity to the proposal site (OEH 2013)

Vegetation Community	PCT ID and Name	BC Status	EPBC Status
River-flat Eucalypt Forest	**835:** Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	E	-
Cumberland Plain Woodland	**849:** Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	CE	CE
Cumberland Plain Woodland	**850:** Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Basin Bioregion	CE	CE

E = Endangered; CE = Critically Endangered

7.8.1.2 Bionet Records

The NSW Atlas of NSW Wildlife database search determined that no threatened flora and fauna species had previously been recorded within the study area (Figure 19 and Figure 20).

Under the environmental provisions of the EPBC Act, no Commonwealth listed threatened species, ecological communities or migratory species exist within or have habitat within the site. As such, no MNES will be impacted as a result of the proposed works and a referral to the Commonwealth due to impacts on such species is not recommended.

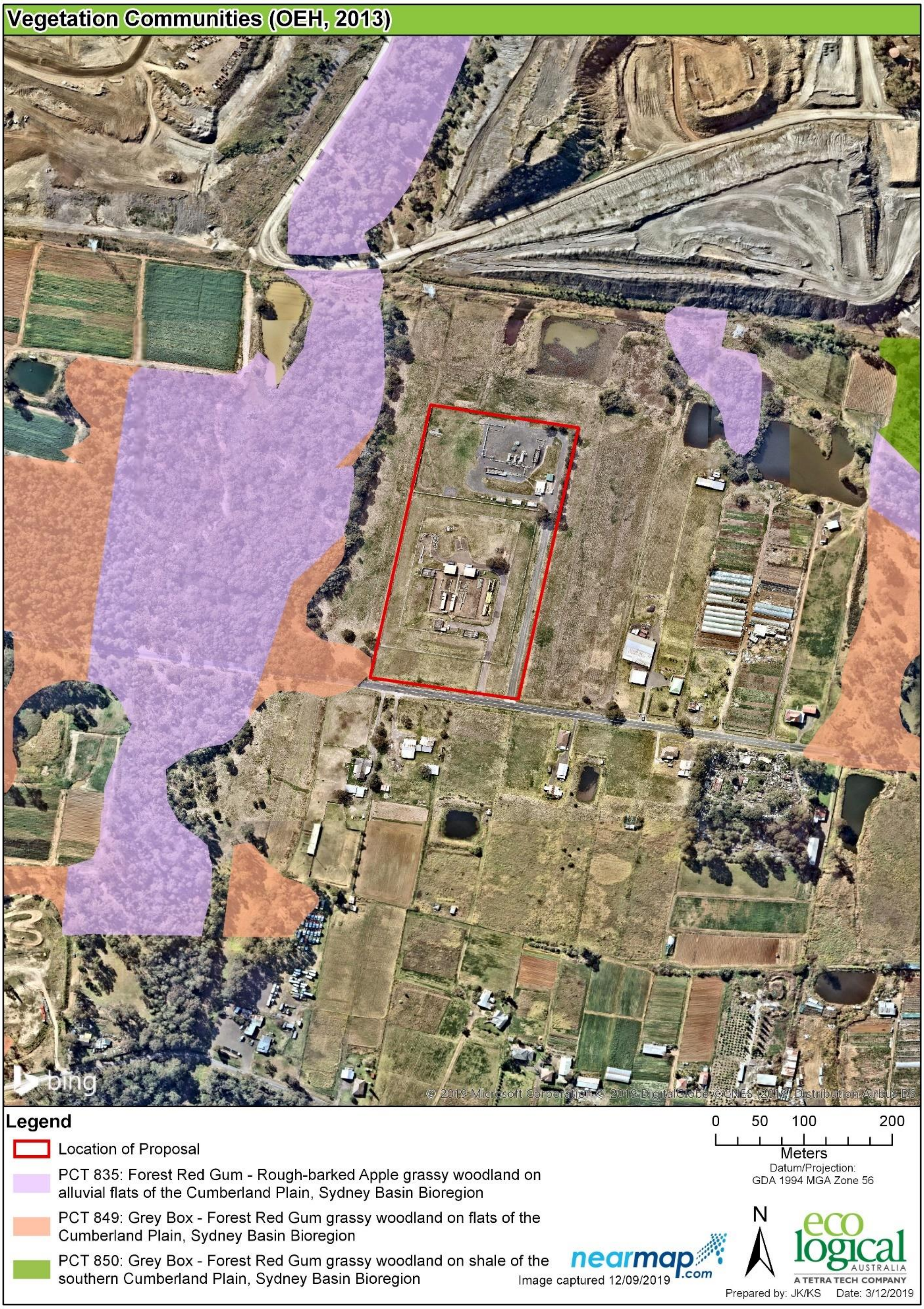

Figure 18: Mapped vegetation communities in relation to the study area (OEH 2013)

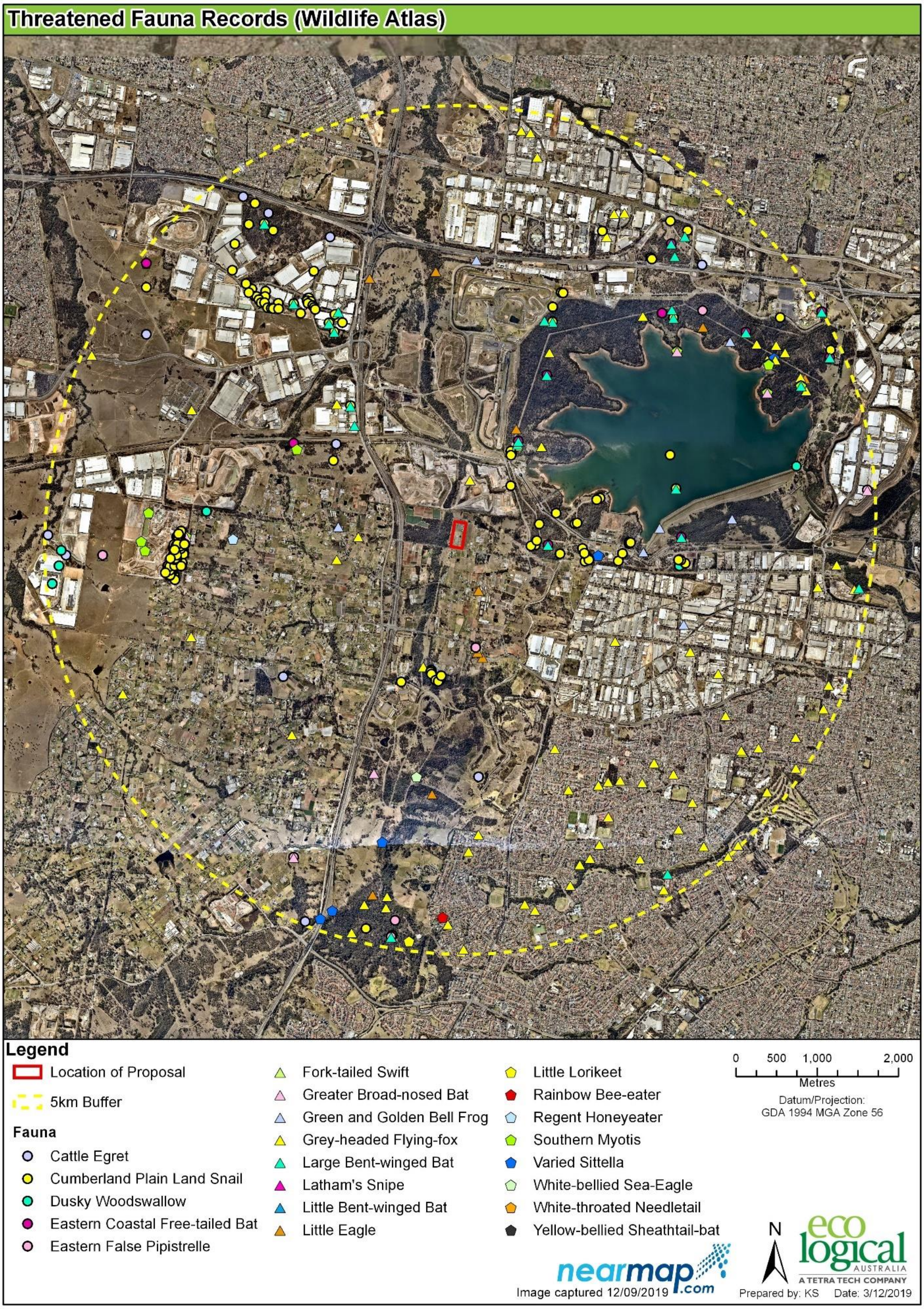

Figure 19 Threatened fauna species records in relation to the study area (5km Buffer)

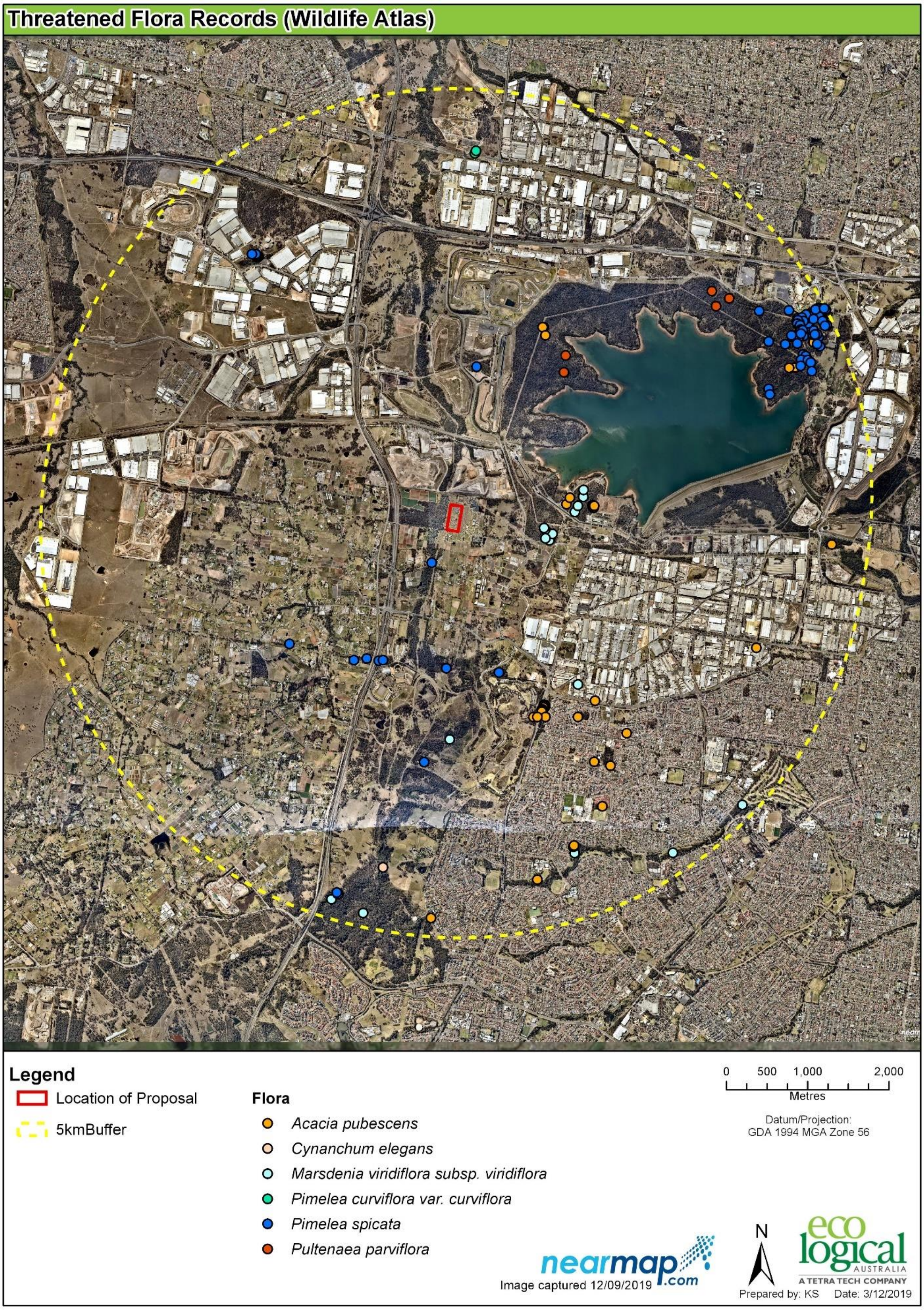

Figure 20 Threatened flora species records in relation to the study area (5km buffer)

7.8.2 Potential Impacts

7.8.2.1 Direct Impacts

Due to previous land management practices, the study area has largely been cleared for the existing gas facility. The small amount of vegetation present is not consistent with any listed PCT. This is primarily due to the lack of connectivity and small number of individuals present. Currently, vegetation on site consists of two individual *Eucalyptus tereticornis* (Forest Red Gum) with an exotic dominated groundcover consisting primarily of *Pennisetum clandestinum* (Kikuyu) and *Trifolium spp*.

No habitat is available for threatened flora species due to the high level of modification and ongoing maintenance of vegetation and soils within the site. Minimal foraging habitat is available for fauna species and there are no sufficient foraging resources to sustain threatened fauna. No fauna was observed during the site inspection.

The two trees which are located within the subject site will be retained as part of the development. Vegetation within the site is comprised of predominantly exotic grasses and herbs, with sparse *Themeda triandra* (Kangaroo Grass) located to the east of the subject site.

Due to the lack of native vegetation connectivity, lack of identifiable PCTs or vegetation communities within the study area and lack of threatened species habitat or foraging habitat, the proposed development will have no direct impacts on biodiversity values within the area.

7.8.2.2 Indirect Impacts

The site contains very limited vegetation, which has been previously cleared for the current gas facility. Movement across the site for less mobile threatened fauna species is already highly limited. Additionally, no facilities which may inhibit flight over the development site are proposed.

The human made structures within the development site are modern and do not consist of potential roosting habitat for threatened microbat species such as open roof crevices, culverts, bridges, railway tunnels or stormwater tunnels. The development will not compromise habitat suitability for threatened species.

The nearest mapped watercourse in relation to the development site is located approximately 100 m east, and due to this distance, the proposed development will not impact on hydrological processes.

No significant indirect impacts are anticipated as a result of the proposed development.

7.9 Aboriginal Heritage

7.9.1 Existing Environment

The AHIMS is a database maintained by DPIE and regulated under Section 90Q of the NPW Act. AHIMS holds information and records regarding the registered Aboriginal archaeological sites (Aboriginal objects, as defined under the Act) and declared Aboriginal places that exist in NSW.

An extensive search of the AHIMS database was conducted on 9 September 2019 to identify if any registered Aboriginal sites were present within, or adjacent to, the study area.

The AHIMS database search was conducted within the following lot/coordinates:

- **Lat, Long From:** -33.8484, 150.8364
- **Lat, Long To:** -33.8124, 150.8936
- **Buffer:** 200m

The AHIMS search identified 61 Aboriginal sites recorded in or near the proposal site and no Aboriginal places.

An Aboriginal Due Diligence was undertaken by Biosis Pty Ltd in 2014 in accordance with the requirements of the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW 2010) for the same study area, although for different proposed works. As the previous report covered impacts to the entire lot, the conclusions and recommendations presented within it are relevant to the current study. The report stated that the study area was generally located within an area of high archaeological potential for Aboriginal sites, as it is within 100 m of Eastern Creek. The level of potential for intact archaeological deposits was downgraded to low due to the high-level ground disturbance from the installation of the existing gas meter station and associated infrastructure.

There is a recorded AHIMS site (45-5-2567) located approximately 20-30 m to the west of the western boundary of the proposal site (Figure 21). The site was recorded in 1999 as part of the survey of the proposed EGP route. The recorded site consists of two silcrete (one flake and one core) located within a market garden within a vehicle track. It was determined as part of the assessment that there was low potential for other archaeological material due to the high levels of disturbance resulting from the twentieth century market gardening. The site card states that a Consent to Destroy (Section 90) permit had been applied for, but the status of the site on the AHIMS register is ‘valid’.

Figure 21: Registered AHIMS Sites in relation to the study area

7.9.2 Potential Impacts

The proposed works will not impact upon AHIMS site 45-5-2567, as it is recorded outside of the study area. There are no potential impacts to unrecorded archaeological deposits because the potential for intact deposits of Aboriginal objects were assessed to be low.

7.10 Historic Heritage

7.10.1 Existing Environment

Searches were made of the following heritage databases on 9 September 2019 in order to determine if any places of historical significance are located within or in proximity to the study area. Databases searched included:

- World Heritage List
- National Heritage List
- Commonwealth Heritage List
- NSW SHR
- NSW State Heritage Inventory
- Section 170 Registers
- FLEP (2013).

The results of the searches indicated that there are no known items of historical heritage significance located within or in proximity to the study area (Figure 22). There is no archaeological potential for relics within the proposed study area as soils within the area have been heavily disturbed by subsequent agricultural and construction activities.

7.10.2 Potential Impacts

The proposed works will not impact on any known historical sites or objects. The proposed works can therefore proceed with caution without the need for further historical archaeological assessment.

Figure 22: Historic heritage items in relation to the study area

7.11 Water and Land

7.11.1 Existing Environment

The topography within and surrounding the proposed WSGG Project site is gently undulating, declining gradually towards the northwest of the site. The average slope across the Jemena Horsley Park Facility is around 3-4%. The surface of the existing facility features local variations due to excavations that have occurred to create a level bench on which the existing facility is constructed. The general topography of the proposed WSGG Project site is shown in Figure 23.

Observations from site indicate that the site drains to the north and east of the facility, as shown in Figure 23, across the existing Jemena Horsley Park Facility area and thence to Eastern Creek. The landforms in this location have been significantly altered from the original contours, through past agricultural practices, construction of the electricity transmission lines and the establishment of the quarry and tile manufacturing activities that occur to the north. Water ponds to the north-east of the site, which connects to a swampy area orientated east to west under the transmission lines. The swampy area drains overland to the west and into Eastern Creek when water levels are sufficiently high.

The ground surfaces both inside and outside the existing facility upslope and downslope from the proposed work location and feature continuous and dense grass cover. The site driveway, internal access road and the hardstand area around the existing pipework and apparatus feature are constructed from blue metal rock.

Figure 23: Site topography

As the facility is on raised ground relative to Eastern Creek and located near the top of the catchment, it is unlikely that it will be subject to significant flood levels affecting the whole site. This is corroborated in the Rural Area Flood Study (BMT WBM, 2013) which demonstrated that only in peak maximum flood (PMF) conditions will the western edge of the site possibly be slightly inundated (Figure 24). The site is just east (i.e. outside) of the designated Low Flood Risk Precinct as determined in the Fairfield Flood Planning Map, 2014.

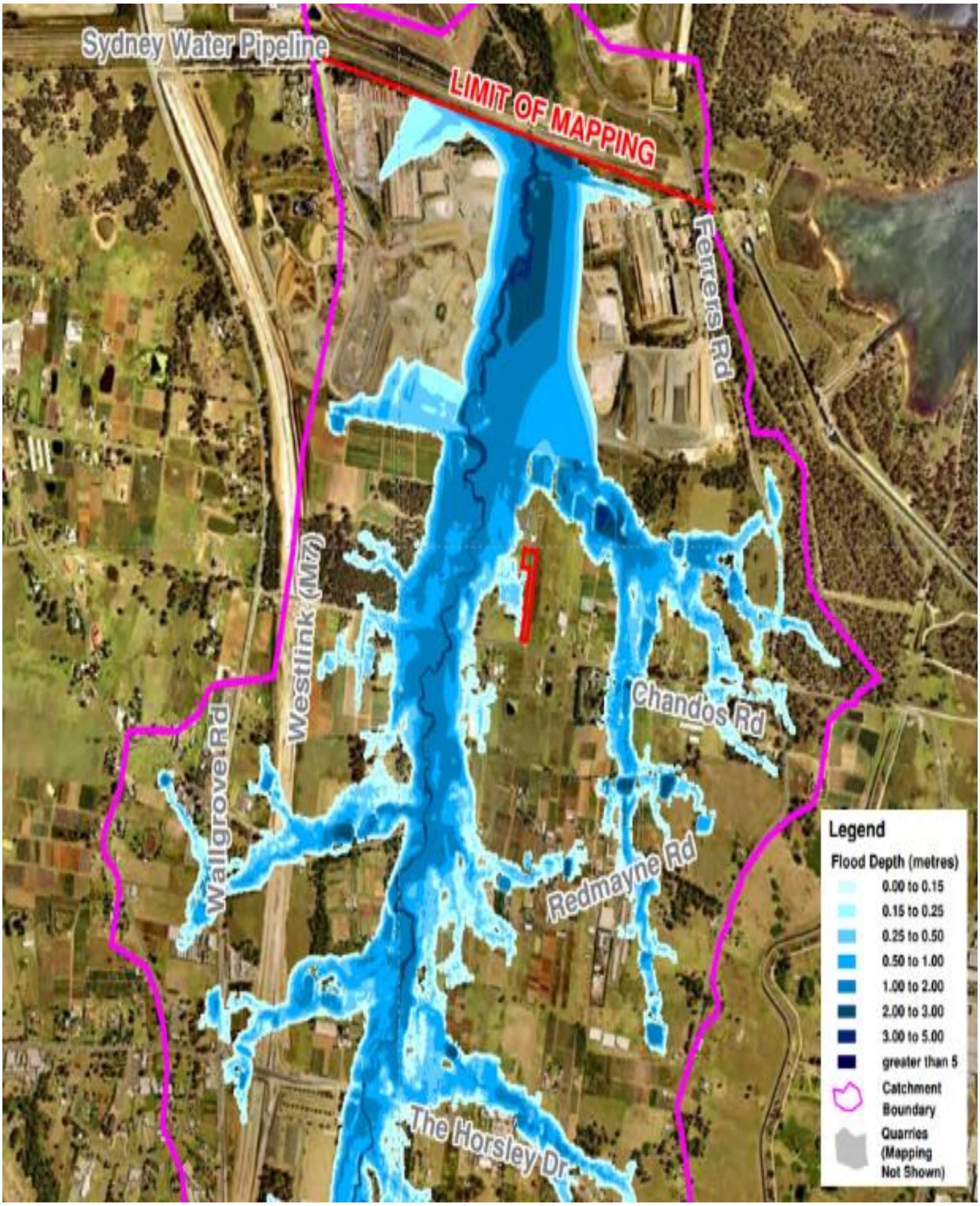

Figure 24: Northern area of Eastern Creek – Peak Maximum Flood (PMF) extent (BMT WBM, 2013)

A Waste Classification Assessment was undertaken by Alliance Geotechnical (2018a) which determined the material classification of in-situ material located at the existing Horsley Park Facility. A total of seven soil samples were collected, three from a previous stockpile and four from alternate test pit locations. The soil sampling and soil stratigraphy observed within the test pits is provided in Table 30.

Table 30: Soil test pit result (Alliance Geotechnical 2018a)

Depth (m)	Material Observation	Additional Comments
0.0 – 0.7	FILL: Silty SAND, brown, fine grained medium dense, dry.	Grass and rootlets at surface
0.7 – 1.2	FILL: CLAY, dark brown, firm, medium – high plasticity, moist.	Nil
1.2 – 1.6	FILL: CLAY, grey-red, very stiff, high plasticity wet.	Nil
	End of Pits – 1.6 m	

No visible signs of contamination such as asbestos containing material, hydrocarbon odours or staining were observed on site. The laboratory analysis tested for the following parameters:

- Arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc (metals)
- Total Recoverable Hydrocarbons
- Polycyclic Aromatic Hydrocarbons
- Benzene, Toluene, Ethylbenzene, total Xylene
- Asbestos ID
- pH and electrical conductivity
- Foreign materials (Alliance Geotechnical 2018a).

The analytical results indicated that within the two alternate test pits, values were below the General Solid Waste CT1 criteria as outlined in the NSW EPA Waste Classification Guidelines (2014). Sample collections within the stockpile indicated that in-situ material was classified as General Solid Waste CT1 (non-putrescible). The risk of encountering contaminated soils is very low (Alliance Geotechnical 2018a).

Drilling of five boreholes to a maximum depth of 5.4 m was undertaken as part of a Geotechnical Investigation (Alliance Geotechnical 2018b). The inferred subsurface soil and rock conditions are summarised in **Table 31** below.

Table 31: Subsurface Soil Profile (Alliance Geotechnical 2019b)

Borehole (No.)	Depth Below Existing Ground Surface				Termination Depth (m)
	Topsoil silty clay/clay	**Alluvium** stiff to very stiff clay	**Residual Soil** Very stiff to hard clay	**Bedrock** EW to HW, VL to L St. Shale	
BH!	0.0 – 0.1	0.1 – 1.0	1.0 – 2.0	-	2.0
BH2	0.0 – 0.1	0.1 – 1.2	1.2 – 2.8	2.8 -5.4	5.4
BH3	0.0 -0.15	0.15 – 0.5	0.5 – 2.4	2.4 -5.1	5.1
BH4	0.0 – 0.15	0.15 – 0.8	0.8 – 1.9	1.9 – 2.5	2.5
BH5	0.0 – 0.15	0.15 – 0.9	0.9 – 2.3	2.3 – 2.5	2.5

Legend:

VL St.: Very Low Strength

L. St.: Low Strength

M St.: Medium Strength

H St.: High Strength

EW: Extremely weathered

HW: Highly weathered

MW: Moderately weathered

SW: Slightly weathered

Groundwater seepage was not observed during the drilling of any boreholes. However, it should be noted that groundwater seepage level is subject to seasonal and climatic conditions and may vary across the site. Groundwater may also occur at the interface of bedrock and residual soils.

7.11.2 Site water balance

The PEM electrolysers use about 2L feed water per m^3 of hydrogen produced. The facility is to be designed to produce about 100 m^3 per hour and hence will require up to 1,600 L/day or 0.58 ML/a of purified water delivered to the electrolyser inlets. Purification will be via ultra-filtration or RO, producing a permeate stream for electrolyser inlet and a wastewater stream of approximately four times the feed concentration; a feed yield of about 75%. This process will therefore require 2,135 L/day of mains water and generate approximately 535 L/day of wastewater. The wastewater stream is to be blended back to levels suitable for irrigation on local plots.

The hydrochemistry of indicative mains water is provided in Table 32. A four times concentrate will have a salinity of about 500 ppm and hence may not require blending to be suitable for irrigation of pasture crops, though some blending will be required for market garden crops if grown (DEC 2004). The volume of water applied (up to 0.19ML/a) at that salinity was calculated to require an irrigation area of approximately 0.05 ha if applied to pasture, e.g. Kikuyu grass (which is already present on site), to ensure no additional water runoff (above natural conditions) occurs from the site (ANZECC & ARMCANZ, 2000; 2018).

Contaminant levels in the concentrate will still be below the ANZECC and ARMCANZ guidelines for irrigation waters (ANZECC & ARMCANZ, 2000; 2018) and the sodium adsorption level (SAR) ratio will remain low at about 1.

Table 32: Indicative mains water supply composition.

Component	Units	Composition
Physical characteristics		
True colour	TCU or HU	<2 - 4
Turbidity	NTU	0.1 - 0.2
Total dissolved solids	mg/L	100 - 136
pH	pH units	7.9 - 8.2
Conductivity	mS/m	180 - 220
Total hardness	mg $CaCO_3$ / L	47 - 63
Calcium hardness	mg $CaCO_3$ / L	31 - 42
Magnesium hardness	mg $CaCO_3$ / L	19 - 23
Alkalinity	mg $CaCO_3$ / L	31 - 42
Temperature	°C	14 - 23
Dissolved oxygen	% saturation	97 - 126
Disinfectants		
Free chlorine	mg/L	<0.04 – 0.04
Monochloramine	mg/L	0.72 – 1.48
Disinfection by-products		
Trihalomethanes	mg/L	0.041 – 0.121
Inorganic chemicals		
Aluminium	mg/L	0.010 – 0.020
Ammonia (as NH_3)	mg/L	<0.001 – 0.40
Arsenic	mg/L	<0.001
Cadmium	mg/L	<0.001
Calcium	mg/L	12.6 - 17.0
Chloride	mg/L	25.5 – 30.6
Chromium (Cr as VI)	mg/L	<0.0004
Copper	mg/L	0.005 – 0.034
Cyanide	mg/L	<0.005
Fluoride	mg/L	0.97 - 1.10
Iron	mg/L	0.010 – 0.022
Lead	mg/L	<0.001
Nickel	mg/L	<0.001
Magnesium	mg/L	4.3 - 5.3
Manganese	mg/L	<0.001 – 0.002
Mercury	mg/L	<0.0001
Nitrate (as NO_3)	mg/L	0.61 – 1.10

Component	Units	Composition
Nitrite (as NO_2)	mg/L	<0.001 – 0.023
Phosphorous	mg/L	0.007 – 0.009
Potassium	mg/L	1.9 – 2.3
Reactive Silica (as SiO_2)	mg/L	2.5 – 4.9
Selenium	mg/L	<0.003
Silver	mg/L	<0.003
Sodium	mg/L	12.3 – 15.2
Sulfate	mg/L	7.4 – 8.8
Zinc	mg/L	<0.005
Organic compounds		
Chlorinated, polynuclear aromatic, aromatic hydrocarbons		nd
Chlorophenols		nd
Pesticides		nd

7.11.3 Potential impacts

The proposed bulk earthworks of the facility and pipeline areas will include topsoil stripping to a minimum of 150 mm (to be confirmed following detailed geotechnical investigation) and spoiling in suitable areas (GPA Engineering 2019b). A platform will be developed for the placement of the plant equipment, piping and machinery. Underground pipelines will be placed at a top-cover depth of 900 mm.

These activities will impose no more than pre-existing impact to the site, with erosion control devices and sediment traps designed and installed based on industry best management practice to minimise the potential of sediment leaving the site. Where topsoil is to be stored in stockpiles, the material shall be placed in a series of low dumps not exceeding 3 m high to retain soil structure for short term and 10 m high for long term, with batters at 6H:1V slopes. The external slopes of the stockpile shall be revegetated as soon as possible to resist erosion.

Permanent works shall be designed to mitigate and minimise erosion of the constructed pad surfaces, including at the tie-in locations and beyond into the surrounding land. The site is not located on flood-prone land and no excavations will penetrate to impact on local groundwaters. Water application to the land from electrolyser outputs will not pose any rise to soils or impose additional water stress to the environment. The risk to surface and groundwater's is considered very low.

No groundwater seepage was encountered during the geotechnical investigation (Alliance Geotechnical 2019b). However, as groundwater seepage levels are subject to seasonal and climatic conditions, and inflow may occur within the interface of bedrock and residual soils, there still remains a possibility that groundwater seepage may be encountered during excavation or pile boring. The proposed development will not involve the installation of piles or excavation at a depth exceeding 2 m, and therefore the risk of encountering groundwater is very low. In the unlikely event that groundwater is encountered during construction, sump and pump methods are recommended (Alliance Geotechnical 2019b).

Flooding within the site is regarded as a low risk scenario from a land use planning point of view. The facility hardstands have been designed with a cross slope of 1:50 and side batters of 1:4 to ensure water runoff during rain events and prevent pooling on site. The contours of the land surrounding the hydrogen production facility fall towards the north west. Based on flood mapping available of the area the location of the production facility and the bus turnaround and refuelling infrastructure and is adjacent an area listed as a low risk flood precinct, and well clear of the medium and high risk flood precincts of the nearby Eastern Creek based on review of flood risk mapping for the area. The low risk flood precinct is described on the flood risk map as lands within the extent of the Probable Maximum Flood (PMF) but above the peak water level of the 1 in 100-year average recurrence interval (ARI) design flood. The flood risk to the proposed development site is therefore minimal.

7.12 Social and Economic

7.12.1 Social

To identify the social benefits or impacts of the proposal, the outcomes of the community consultation strategy as well as the findings presented in the COAG Energy Council's issues papers, prepared for the National Hydrogen Strategy, were assessed.

The findings presented in the COAG Energy Council's issues papers identified key issues and impacts that are perceived by the community regarding an emerging hydrogen industry. It was concluded that Australia's acceptance for large-scale hydrogen production depends on a better understanding and mitigation of the following impacts (COAG Energy Council 2019c):

- **Carbon Emissions:** The generation of hydrogen with electrolysis may lead to short-term increases in GHG emissions, if the electricity used is not completely renewable.
- **Safety:** Hydrogen is a volatile and flammable gas by nature and the perceived safety risks regarding accidents, collisions, fires and explosions are elevated due to low levels of public awareness.
- **Water Consumption:** Production of hydrogen using electrolysis requires large amounts of water, which may potentially increase both the demand and price for what is already a scarce commodity.

As detailed in **Section 5**, two main concerns were identified among relevant community members during the community consultation strategy:

- **Safety/health:** As concluded within the COAG Energy Council's issues papers, perceived safety risks are high due to the low levels of public awareness.
- **Noise:** It was perceived that the additional blowdown vent required may increase operational noise levels.

7.12.1.1 Carbon Emissions

Although the generator will initially run on natural gas, it is envisioned that it will be switched over to run only on hydrogen after six months of operation. Furthermore, Jemena are investigating the construction of onsite solar as an alternative to purchasing green electricity (subject to a separate assessment). The proposal will allow the community to benefit from renewable energy such as solar and wind. Future storage solutions are being developed however, they require both investment and time. Jemena is uniquely placed to utilise the Jemena Gas Network for the storage of renewable energy through the P2G process. Hydrogen can be safely stored within Jemena's pipelines, turning the network into a giant battery. The proposal will therefore enhance Australia's renewable energy capability and ensure a low carbon future for industry and community by the following means:

- Bring clean, green and renewable energy to Australian homes and businesses
- Accelerate Australia's hydrogen vehicle industry
- Use existing infrastructure to make renewable technology cheaper, faster and more reliable.

The proposal therefore aims to prove the technology used within the WSGG Project, so that future development of large-scale green hydrogen production is further enabled.

7.12.1.2 Safety

The WSGG Project is being developed in accordance with a range of international and Australian regulations, standards and best practice guidelines that will assist to ensure that the design, construction and operation of the facility is safe.

The intention of the proposal is to utilise P2G trial as a tool to help demonstrate the environmental and safety aspects associated with the production, distribution and use of hydrogen. This will allow a better understanding of how hydrogen can be effectively managed through existing regulations, codes and standards as well as provide industry experience into how such regulations and standards can be improved.

7.12.1.3 Water Consumption

As discussed in **Section 7.11**, the PEM electrolysers use about 2L feed water per m^3 of hydrogen produced. The facility is to be designed to produce about 100 m^3 per hour and hence will require up to 1,601.25 L/day or 0.58 ML/a of purified water delivered to the electrolyser inlets. The required water will be sourced from the mains water supply. Sydney Water have been contacted as part of the consultation process to discuss the usage of mains water for the WSGG Project. Initial feedback from Sydney Water has been positive, with a request from Sydney Water to include provisions within the design of the P2G Plant to trial recycled water as part of the WSGG Project to further reduce the amount of mains water used. As such, the design of the P2G Plant will include a delivery point for recycled water to run the electrolyser, as per Sydney Water's request.

7.12.1.4 Noise

As outlined in **Section 7.5**, preliminary modelling found that the noise contribution from operation of the microturbine may give rise to noise levels exceeding the NPfI Project trigger levels during operation at night. The mitigation measures assessed as part of the assessment included either installation of a noise screen to the south side of the microturbine, or relocation of the microturbine to enable screening from the process gas container, or limitation of operation to day and evening only. The project has determined to limit operation of the microturbine to only operate between 7am and 10pm as the noise levels are within the trigger levels during these hours.

Venting events are only likely to occur very occasionally (less than once per week) and will not be considered a regular occurrence. The NSW *Road Noise Policy* states that 'one or two noise events per night, with maximum internal noise levels of 65 – 70 dB (A) are not likely to affect health and wellbeing significantly.

The predicted L_{Aeq} levels from the proposed construction steps and nominated equipment indicate that noise from construction will exceed the ''noise affected'' goals from the EPA criteria at some residential receivers by up to 4 dB. Predicted noise levels are within the "highly affected" noise goals for all steps, however this is based on the conservative assumption that all equipment will be operating simultaneously.

On-site noise measurements indicated an average daytime noise level of L_{Aeq} 15 min 54 dB, as such, predicted exceedances are unlikely to be intrusive when considering existing noise on site. Additionally, since all construction work is restricted to take place only during the daytime, and the microturbine is intended to operate during day and evening hours only, there will be no construction or operational noise impacts to sensitive receivers at night.

7.12.2 Economic

To identify the economic benefits or impacts of the proposal, this assessment has been based upon the outcomes of the community consultation strategy as well as the findings presented in the COAG Energy Council's issues papers, prepared for the National Hydrogen Strategy.

It was concluded that Australia's acceptance for large-scale hydrogen production depends on a better understanding and mitigation of the following impact (COAG Energy Council, 2019c):

- **Increased Consumer Cost:** It is anticipated that the consumers will have to bear the costs related to the production of hydrogen.

The main economic issue raised by the community within the COAG Energy Council's issue papers was the assumed increase in consumer cost (COAG Energy Council 2019c). Hydrogen production costs are currently high but do have the potential for reduction in the near future. The community has raised concerns in regard to costs associated with refitting of distribution networks to take hydrogen, the capacity to produce low-cost hydrogen and the uncertainty of additional costs hydrogen may add to current gas supply and whether such costs would be applied more generally even to non-gas users.

As detailed in **Section 5**, one main concern was identified among relevant community members during the community consultation strategy:

- **Decrease in Land Value:** Concern was raised over the land value of neighbouring properties and whether the additional infrastructure may decrease value over time.

7.12.2.1 Increased Consumer Costs

The Australian Gas Infrastructure Group (AGIG) has suggested that costs for hydrogen production (if initially existing infrastructure will have capacity to transport this production) may potentially reach price parity with domestic natural gas markets that are exposed to global markets by 2030 (Figure 25).

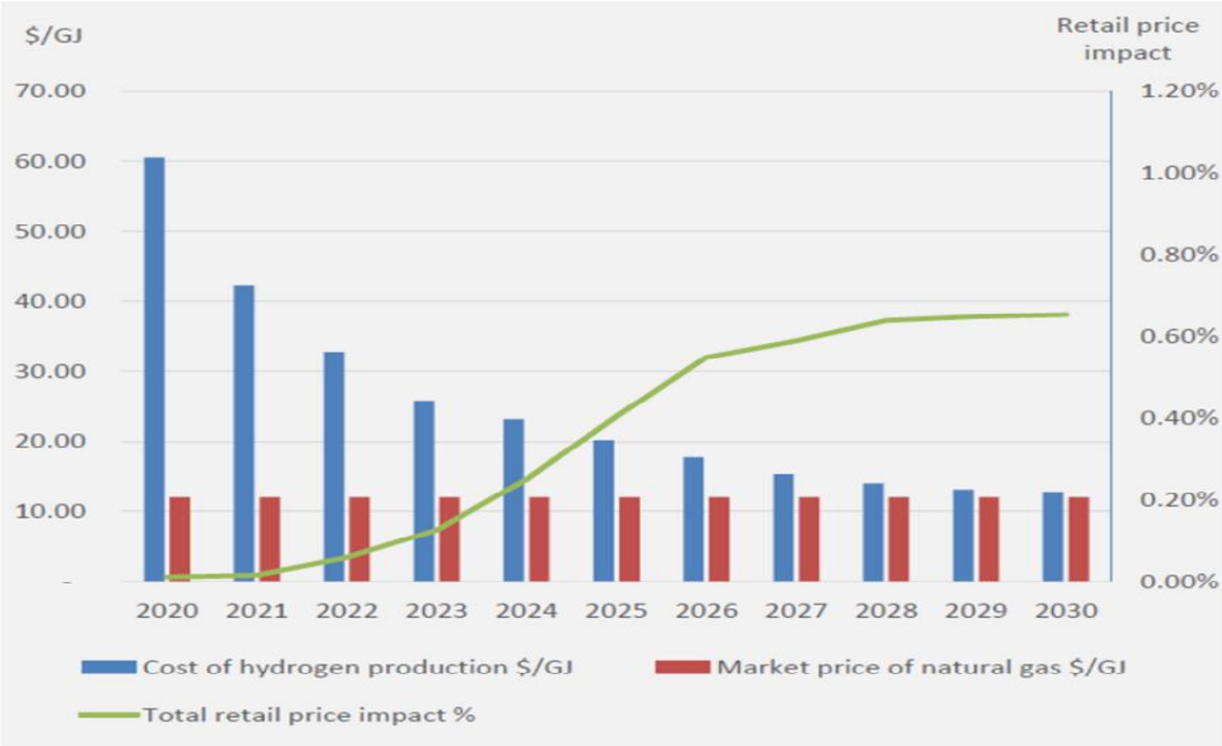

Figure 25: AGIG estimate of hydrogen and natural gas costs and retail price effects for a 10% renewable gas (COAG Energy Council 2019d)

Building both skills and experience within the domestic hydrogen industry will help decrease costs, allowing Australia to develop a competitive hydrogen export industry (COAG Energy Council 2019d). The WSGG Project will also enable Australia to build the knowledge and the handling and technical expertise required for an export industry to operate safely and effectively (COAG Energy Council 2019d).

Hydrogen may prove to be a better substitute form of energy than electrification in the aim to decarbonise the country as it may strengthen the security and reliability of renewable electricity systems as well as diversify fuel supply options for transport (COAG Energy Council 2019d).

Additionally, costs associated with the WSGG Project will not be passed on to consumers.

7.12.2.2 Decrease in Land Value

As the WSGG Project is proposed to be constructed and operated wholly within the existing facility boundary, it is not anticipated that the value of lands surrounding the facility will decrease as a result of the proposal going ahead.

7.13 Infrastructure

7.13.1 Existing Environment

The main utility infrastructure associated with the WSGG Project is that which is in place for the existing Jemena Horsley Park Meter Station Facility. A similar natural gas facility, which is also operated by Jemena, is located to the south of the facility.

The existing Jemena Horsley Park Facility transfers gas into the Jemena Gas Distribution Network, and transfers around 18PJ of gas per year at a typical flow rate of 56,000 m^3/hr. Peak flow rates through the facility equate to just over 160,000m^3/hr. Gas pressures on site currently range from 1MPa to a maximum of 7MPa (GPA 2019a).

The Jemena Horsley Park Facility is connected to two major pipelines which supply the gas network. These pipelines are:

- The Jemena Central Trunk Pipeline – this pipeline is located underground and passes under the southwestern corner of the facility. The facility's outlet is connected to the pipeline underground
- The Jemena Eastern Gas Pipeline – runs underground along the north-south alignment of the facility's western extent. The pipeline enters the facility from its north-western corner

The Jemena Horsley Park Facility is connected to the local electricity and telecommunications networks on Chandos Road via services that run along the access road for the facility. To the north of the existing facility is an easement which contains high voltage electricity transmission lines. These transmission lines supply electricity from the TransGrid Sydney West Substation on Wallgrove Road, Eastern Creek.

Overhead telecommunications and power lines run along Chandos Road to the south of the facility. Underground water supply is located along Chandos Road to the south of the site.

7.13.2 Impact Assessment

The existing infrastructure will remain un-impacted by the WSGG Project. The proposal will marginally increase the amount of high-pressure gas within the facility; however, it will not exceed the designed pressures of the existing facility. Furthermore, studies have concluded that at low blending concentrations, there is little or no change to natural gas infrastructure and that blending at relatively low hydrogen concentrations (up to 10% in volume) may not require major investment or modification to infrastructure (COAG Energy Council 2019d). As the proposed blending concentration will be significantly less than 10%, modifications to the existing infrastructure are not anticipated.

Construction of the proposed WSGG Project will occur while the existing facility is operational. Construction activities will be monitored closely to ensure that the existing pipeline infrastructure is not damaged or compromised. If this occurs, it may necessitate temporary partial or complete facility shut down.

A hydrogen buffer store will be constructed as part of the proposed development in order to store hydrogen and allow for controlled injection into the gas network at an appropriate rate. This will assist to ensure that the hydrogen injection rate can be varied in response to changes in the natural gas demand via a fail-safe injection control panel. The operation of the facility will be monitored and controlled from both the constructed and previously in place control rooms. Existing inspection, testing and maintenance schedules will be updated to include the proposed development and minimise the potential for impacts on gas supply. No negative impacts to gas supply are anticipated.

Water which will be fed through the electrolyser and converted into hydrogen gas will be supplied from the existing water main which fronts the facility and/or RO quality recycled water. The WSGG Project will require up to 2,135L/day of water. This water demand is not expected to significantly increase the load on the existing systems. Meetings between Sydney Water and Jemena have indicated that in order to minimise the amount of mains water utilisation, there exists a potential opportunity to utilise recycled water for delivery into the electrolyser. In order for this to occur, allowances have been made within the design of the WSGG Project to enable infrastructure to be constructed at a later date which may facilitate this opportunity.

The conversion of water into hydrogen gas will utilise purchased green electricity as an energy source. In order for the proposal to meet its proposed production of 52,600 kg/yr of hydrogen, an estimated 6GWh is required. This can be supplied by the existing electrical network infrastructure without need for addition or modification, beyond the installation of a utility switching station, underground cabling connection and on-site client owned HV Switchgear & Transformer. No significant impacts on power infrastructure are anticipated.

A feasibility study is being conducted, which considers the use of a 550kW (DC) solar installation to be utilised as an alternative 'green' energy source for powering the proposed development. If feasible, this will be assessed in the future as a modification or separate project approval to the works outlined within this EIS.

7.14 Cumulative Impacts

7.14.1 Existing Environment

The proposal site is wholly within Jemena's Horsley Park Facility and is therefore currently used as a gas network facility. The proposal site is surrounded by WSP to the west, rural land to the east, Austral Bricks plant to the north and Chandos Road to the south. Land use surrounding the proposal site is predominantly rural-residential, as well as pastoral lands.

Austral Brick Co Pty Ltd are proposing to upgrade the existing Plant Two at 780 Wallgrove Road, Horsley Park, which is directly north of the WSGG Project. The proposal includes an upgrade of the existing brick kiln as it currently operates inefficiently by losing heat, requiring large amounts of gas to run and the construction of a new production building. As no other significant development is known to be currently proposed within the near vicinity of the proposal site at this time, the cumulative impact assessment has been based on the proposed cumulative impacts of both the WSGG project and the Austral Bricks Plant Two upgrade proposal.

7.14.2 Potential Impacts

7.14.2.1 Hazards and Risk

As concluded by GPA Engineering (2019c) in **Section 7.3**, the scenarios with the greatest consequences for the site are hydrogen fuelled flash fires or jet fires with radiation effects at levels sufficient to cause a fatality that extend beyond the Jemena boundary fence. For the WSGG Project, the cumulative frequency of a potentially fatal offsite impact is estimated to be approximately 1.7×10^{-4} in a million per year. This value is above the tolerable risk target of 1×10^{-5} in a million per year for 'active open space areas'. However, this has been mitigated through redesigning the facility so that the high-pressure hydrogen storage equipment is moved further within the site boundary as well as the installation of a firewall.

Following the implementation of the above, the residual potentially fatal offsite individual risk for the WSGG Project is estimated to be approximately 5.9×10^{-6} in a million per year (from dispenser failure), which is below the tolerable risk target of 1×10^{-5} in a million per year for 'active open space areas'.

It should be noted that none of the consequence contours modelled are expected to impact the residential dwellings on the other side of Chandos Road approximately 250 m away from the new facility.

RiskCon Engineering (2018) undertook an assessment to determine the relevance of the Hazardous and Offensive Development SEPP for the Austral Brick Plant Two upgrade proposal. It was concluded that the materials proposed to be stored as part of the expansion indicated no additional dangerous goods will be stored or handled in relation to the expansion. Therefore, as there is no increase in dangerous goods, there is no increase in assessable quantities under the Hazardous and Offensive Development SEPP. Therefore, as the facility is not classified as potentially hazardous, it was not necessary to prepare a PHA for the Austral Brick Plant Two upgrade proposal.

It is therefore concluded that the Austral Brick Plant Two expansion proposal will not increase any potential hazard and risks identified within the PHA for the WSGG Project.

7.14.2.2 Cumulative Air Quality Impacts

Airlabs Environmental (2019) assessed the air quality impacts of the Austral Brick Plant Two upgrade proposal and concluded that all the assessed pollutants will comply with the relevant assessment criteria at all the identified sensitive receptors at all times.

The total estimated annual operational GHG emissions from the Plant Two facility are expected to be approximately 0.023 Mt $CO_{2\text{-}e}$, which contributes to approximately 0.004% of the 2017 national GHG emissions (Airlabs Environmental, 2019). As concluded in **Section 7.2**, the estimated annual greenhouse emission for the WSGG project is 0.000019 Mt $CO_{2\text{-}e}$ and the annual contribution of greenhouse emissions from the WSGG Project in comparison to the Australian greenhouse emissions in 2017 is approximately 0.000000004% (Benbow Environmental 2019). Therefore, together both the WSGG Project and the Austral Brick Plant Two upgrade proposal will contribute to approximately 0.004%.

7.14.2.3 Cumulative Noise and Vibration Impacts

A Noise Impact Assessment was prepared by Benbow Environmental (2019) for the Austral Brick Plant Two upgrade proposal. It was concluded the noise generating scenarios are predicted to comply with the project specific noise levels at all receivers during all time periods and considered weather conditions. The operational noise levels also complied with the existing environmental protection licence noise limits. The Operational Noise Assessment undertaken by Marshall Day Acoustics (2019) for this proposal concluded that the noise contribution from operation of the microturbine may give rise to noise levels exceeding the NPfI Project trigger levels during operation at night. The mitigation measures assessed as part of the assessment included either installation of a noise screen to the south side of the microturbine, or relocation of the microturbine to enable screening from the process gas container, or limitation of operation during day and evening. The project has determined to limit operation of the microturbine to only operate between 7am and 10pm as the noise levels are within the trigger levels during these hours.

Noise predications of construction activities were found to exceed the ICNG 'noise affected' levels at some locations, based on the conservative assumption that all plant will operate simultaneously. There is therefore the potential for both projects to exceed the ICNG 'noise affected' levels if construction was to occur concurrently. However, given the distance between both proposal sites (approximately 675 m), this is considered unlikely. Furthermore, there is a large overburden mound between the two proposal sites, which is likely to act as a noise buffer for both projects.

7.14.2.4 Cumulative Traffic Impacts

A Transport Assessment report was prepared by Ason Group (2019) for the Austral Brick Plant Two upgrade proposal. It was concluded that as the proposal does not provide for any increases in staff of heavy vehicle movements outside of construction works, or generate any additional trips over and above the approved level of traffic generation at the intersection of Access Road and Ferrers Road, the proposal is unlikely to cause significant traffic impacts. The Traffic Impact Assessment undertaken by TTM (2019) for this proposal concluded that the amount of traffic generation is considered relatively minor and not of a level normally associated with unacceptable traffic implications in terms of road network capacity, efficiency or traffic related environmental effect. Therefore, no cumulative traffic impacts are anticipated.

7.14.2.5 Cumulative Soil and Water Impacts

No cumulative soil or water impacts are anticipated. Although the WSGG Project may require additional water from the Sydney Water mains, the Austral Brick Plant Two upgrade proposal does not require any additional water intake.

It is noted that the Austral Brick Plant Two upgrade proposal will increase the overall hardstand area within the property, therefore increasing surface runoff within the Eastern Creek catchment. However, as the WSGG Project is not proposing to increase overall hardstand area as well, no cumulative impacts to stormwater runoff are anticipated.

8. Environmental Management

The following mitigation measures have either been identified through the assessment undertaken through this EIS, supporting assessments or are standard best practice environmental management controls. They will be incorporated into the detailed design phase of the proposal and during operation of the proposal, should it proceed. These mitigation measures will minimise any potential adverse environmental impacts arising from the proposal. The controls measures are summarised in Table 33.

Table 33: Summary of mitigation measures

Impacts To	Reasons	Mitigation Measures	Code
Soil Erosion and Sedimentation	During earthworks and site establishment	The area of disturbance associated with the proposal will be limited to the greatest extent practicable to minimise the potential for erosion from site.	SES01
		An Erosion and Sediment Control Plan (ESCP) will be prepared for the proposal in accordance with the requirements of Managing Urban Stormwater: Soils and Construction (Landcom, 2004) (the 'Blue Book').	SES02
		All site stormwater control features will be identified prior to construction and appropriate controls and protection measures developed, documented in the ESCP and implemented during all works.	SES03
		Onsite stockpiling of excavated material will be minimised.	SES04
		All stockpiles of loose and erodible materials will be provided with suitable controls, for example sediment fencing or filter socks, to prevent erosion.	SES05
		Inspect erosion controls regularly (daily during workdays) and after rainfall. Fix damaged controls immediately.	SES06
		Schedule the work outside of predicted heavy rain periods.	SES07
		All surfaces disturbed as part of the proposal will be rehabilitated at the completion of construction to reinstate ground surface stability and reduce the potential for ongoing erosion from site.	SES08
		The effectiveness of site restoration and rehabilitation activities will be monitored during routine facility visits by operational personnel. Corrective actions will be carried out as required to address any ground instability and erosion issues as required.	SES09
		Sump and Pump methods for management of groundwater will be required if groundwater seepage is encountered during excavation or piling. Alternatively, tremie concrete placement method may be adopted for concrete placement, if required (Alliance Geotechnical, 2019b).	SES10
Soil Contamination	Incidental discovery of soil contamination	If contaminated soils are uncovered during the works, all works within the vicinity of the find must cease immediately and Jemena's Project Manager and Environmental Representative be notified immediately.	SC01

Impacts To	Reasons	Mitigation Measures	Code
	Pollution of soil from chemical spills (e.g. fuel or oil from machinery)	For any excess spoil where potentially, contaminating activities have been identified on site this material will be tested and classified prior to leaving site. For any excess spoil material classified as contaminated, disposal of this material will be at an appropriately licensed landfill in accordance with the EPA (2014) Waste Classification Guidelines.	SC02
		Store all chemicals (e.g. fuel, oil) in appropriate bunding/storage systems within the approved storage facility.	SC03
		Store and handle any hydrocarbons and other chemicals required to carry out the proposal in accordance with the relevant Safety Data Sheet (SDS) and product label to reduce the potential for spillage and potential spill volumes.	SC04
		Refuel construction plant and equipment offsite at a suitable location wherever practicable to avoid the potential for soil contamination in work location and associated contamination of runoff water from site.	SC05
		Use appropriate task-specific equipment during any onsite refuelling to minimise the potential for spillage and potential spill volumes.	SC06
		Clean up any spills immediately, isolate and contain any potential contaminated material and dispose of at an appropriately licensed waste facility.	SC07
		If any visual or olfactory evidence of potentially contaminated soils or other materials is uncovered all excavation work at that location will cease until the nature and extent of any potential issues were quantified and appropriate management and mitigations measures developed and implemented to protect the environmental and personnel health safety in accordance with relevant legislation and guidelines.	SC08
		Ensure appropriate spill kits are carried with the equipment.	SC09
Water Quality	Excess sediment input into local waterways Pollution of waterways (ground water or surface water) from chemical spills (e.g. fuel or oil)	Implement sediment and silt control measures prior to commencement of construction works in accordance with: • NSW Office of Environment & Heritage, Erosion and sediment control on unsealed tracks • Managing Urban Stormwater: Soils and Construction - Volume 1, 4th Edition (The Blue Book) • DECC, 2008, Managing Urban Stormwater, Soils and construction, Volume 2A Installation of services, Department of Environment and Climate Change (NSW).	WQ01
		Weather forecasts will be checked daily to ensure that work is not carried out before or during high rainfall.	WQ02

Impacts To	Reasons	Mitigation Measures	Code
		Store all chemicals (e.g. fuel, oil) offsite and if required to be stored onsite, chemicals should be stored in appropriate bunding/storage systems and only for short periods.	WQ03
		Ensure appropriate spill kits, are present onsite.	WQ04
		Ensure all equipment is in good working order.	WQ05
		Carry associated Material Safety Data Sheets (MSDS) for all chemicals.	WQ06
Biodiversity	Damage to vegetation that is not proposed for removal Injured or orphaned wildlife Spread of priority weeds	Works must be stopped if any previously undiscovered threatened species or communities are discovered during works. An assessment of the impact and any required approvals must be obtained. Works must not recommence until DPIE has provided written approval to do so.	BD01
		The site-specific CEMP must include instructions for dealing with orphaned or injured native animals and include the contact details for the NSW Wildlife Information, Rescue and Education Service Inc (WIRES).	BD02
		Wash down equipment and vehicles prior to and after use, to manage the introduction and spread of weed propagules.	BD03
Aboriginal Heritage	Discovery of unsuspected Aboriginal objects Discovery of human remains	All contractors undertaking earthworks on site should be briefed on the protection of Aboriginal heritage objects under the NPW Act, and the penalties for damage to these items.	AH01
		Should an unexpected Aboriginal object be identified during construction, work in the immediate vicinity of the find is to stop and the area must be fenced off with suitable markers (star pickets, flagging or barrier mesh). The Jemena Project Manager and Environment Representative are to be notified. Engage an archaeologist to determine the significance of the find, and if required, determine the notification, consultation, and approval requirements. Works must not recommence until Jemena has provided written approval to do so.	AH02
		If human remains are discovered, works should immediately cease, and the NSW Police should be contacted. If the remains are suspected to be Aboriginal, the BCD may also be contacted at this time to assist in determining appropriate management.	AH03
Historic Heritage	Impacts to heritage items	In accordance with Section 146 of the *Heritage Act 1977*, if an archaeological relic (such as a deposit or artefact) is uncovered during works, work must cease in the affected area and a qualified archaeologist contacted to assess the find. Further advice and clarification may be sought from the Heritage Council of NSW, or the Heritage Division under delegation regarding assessment and approvals	HH01
Air Quality		Works must be minimised during high wind periods.	AQ01

Impacts To	Reasons	Mitigation Measures	Code
	Dust generation from ground disturbing works	Dust suppression should be applied as required to limit excessive dust generation.	AQ02
	Fumes generation from machinery	Plant and equipment must be regularly inspected to ascertain that fitted emission controls are operating efficiently.	AQ03
	Cumulative impacts of GHG emissions	Plant and equipment must be maintained in accordance with manufacturer's specifications to ensure that it is in a proper and efficient condition.	AQ04
		Do not have machinery running while not in use.	AQ05
		Minimise use of machinery for required activity only.	AQ06
		Vehicles to maintain recommended speed.	AQ07
		Look for excessive dust generation and slow down if needed.	AQ08
		Reduce facility blow downs (frequency and volumes released) during maintenance to the greatest extent practicable.	AQ09
		Stockpiles of earth should be covered or sprayed down with water (Benbow 2019)	AQ10
		Movement of soil or dusty material should be ceased during high wind (Benbow 2019)	AQ11
Noise and Vibration		Avoid simultaneous operation of noisy plant within discernible range of a sensitive receiver.	NV01
		Construction works will only occur during the following times: • Monday to Friday 7:00 am to 5:00 pm, • Saturday 8:00 am to 1:00 pm.	NV02
		Maximise the distance between noisy plant items and nearby residential receivers and potential fauna habitat.	NV03
		Orient equipment such as offensive noise carriers away from residential receivers and potential fauna habitat.	NV04
		Plants used intermittently are to be throttled or shut down when not required.	NV05
		Operation of the microturbine will only be between 7 am and 10 pm.	NV06
Visual	Visual impacts on the community	Notify community or neighbours where light impacts are anticipated.	VS01
		Position lighting in residential areas to direct light away from houses wherever possible.	VS02
Traffic and Transport	Disruption to traffic flows	Vehicles, materials and equipment must be positioned to minimise impacts to public access and parking.	TR01
		Heavy vehicles, if required, will be restricted to specified routes.	TR02

Impacts To	Reasons	Mitigation Measures	Code
		Develop a Construction Traffic Management Plan prior to construction activities to be approved by FCC.	TR03
		A temporary designated parking area will be allocated as part of construction planning within Jemena's Horsley Park Facility and will be detailed within the Construction Traffic Management Plan.	TR04
	Road Dilapidation	Prior to the commencement of construction (and again after construction), a dilapidation report is to be prepared and submitted to FCC for Chandos Rd. The report is to consider the use of 3 buses per day to utilise the HRS for refuelling.	TR05
Waste	Construction waste and excess spoil Litter left on site by staff/contractors	Resource management options for the project must be considered against a hierarchy of the following order embodied in the *Waste Avoidance and Resource Recovery Act 2001*. • Avoid unnecessary resource consumption. • Recover resources (including reuse, reprocessing, recycling and energy recovery). • Dispose (as a last resort).	WS01
		All wastes must be classified in accordance to the Waste Classification Guidelines (DECC, 2009) prior to disposal and transported to a licensed waste disposal facility.	WS02
		Ensure appropriate sorting and segregation of construction waste to ensure the efficient recycling of wastes.	WS03
		Reduce packaging waste where possible, by returning packaging to suppliers, purchasing in bulk, requesting cardboard or metal drums rather than plastic and using returnable packaging such as pallets and reels.	WS04
		All waste must be removed from the site on completion of the works.	WS03
		Upon completion of waste disposal, all original weighbridge / disposal receipts issued by the receiving waste facility must be retained in a waste register as evidence of proper disposal.	WS04
		An adequate number of bins must be placed at the site for workers and all litter will be placed in these bins. Work areas of the project site will be kept clean and free of litter, including cigarette butts, at all times.	WS05

8.1 Residual Environmental Risk Assessment

A residual environmental risk analysis has been undertaken for all potential environmental impacts that have been considered within this EIS and considers the mitigation measures outlined in Table 33. The analysis utilises the risk matrix provided in Table 11. The results of this residual risk analysis are provided in Table 34.

Table 34: Residual Environmental Risk analysis of adverse environmental issues

Factor	Receptor	Potential Impact	Likelihood	Consequence	Risk
Air Quality	WSGG Project Site and Nearby residences	Emissions	5	A	Medium
		Dust Deposition	2	A	Low
		Odour	2	A	Low
	Adjoining Environment	Significant Greenhouse Gas Emissions	5	A	Medium
Hazard and Risks	WSGG Site and Nearby residences	Hydrogen	1	B	Low
		Natural Gas	1	B	Low
		Oxygen	1	B	Low
		Bushfire and Electrical Fire	2	B	Low
Waste management	WSGG Project site and adjoining areas	Contamination of land and water	1	A	Low
		Resource wastage	2	A	Low
		Human and environmental health	1	B	Low
Noise and Vibration	Nearby residences	Nuisance noise levels during construction	3	A	Low
		Nuisance noise levels during operation	4	A	Low
Visual	Nearby residences	Reduction in visual amenity	2	A	Low
	Adjoining landscape	Reduction in visual amenity	2	A	Low
Traffic and transport	Existing road network	Increase in traffic volumes	4	A	Medium
		Increased traffic risks and/or reduced safety	3	D	High
Biodiversity	Flora species, plant communities and/or habitat	Disturbance/loss	1	A	Low
	Fauna species	Injury and mortality	1	A	Low
	Terrestrial and aquatic ecosystems	Introduction/spread of weeds	2	A	Low
		Introduction/spread of pests	2	A	Low
		Sedimentation and erosion	2	A	Low
		Soil and water pollution	2	A	Low

Factor	Receptor	Potential Impact	Likelihood	Consequence	Risk
		Indirect impacts of proposal e.g. light, noise, dust	2	A	Low
Heritage	Aboriginal heritage	Impacts on known artefacts/values	1	A	Low
		Impacts on unknown artefacts/values	2	B	Low
	Historic heritage	Impacts on known artefacts/values	1	A	Low
		Impacts on unknown artefacts/values	1	A	Low
Water and Land resources	Surface water	Degradation of water quality	2	A	Low
	WSGG Project Site	Disturbance and erosion of soils and productive topsoil	3	A	Low
		Soil compaction leading to concentrated runoff and erosion	3	A	Low
		Soil contamination due to spills	2	A	Low
		Introduction/spread of weeds	3	A	Low
	Nearby properties	Reduced agricultural viability	1	A	Low
		Dust deposition	2	A	Low
		Reduction in water quantity	1	A	Low
		Flooding	1	A	Low
	Groundwater	Degradation of water quality	1	A	Low
		Reduction in water quantity	1	A	Low
	Aquatic Ecosystems	Direct Impacts	1	A	Low
		Indirect Impacts	2	A	Low
Social and Economic	Social	Carbon Emissions	5	A	Medium
		Safety	1	B	Low
		Health	1	A	Low
		Water Consumption	5	A	Medium
	Economic	Decreased Land Value	1	B	Low

9. Conclusion

9.1 Strategic Need and Benefits

The WSGG Project proposes a power to gas (P2G) facility to transform renewable electrical energy into a combustible gas, hydrogen, which is either injected at up to 2% by volume into the Sydney secondary gas distribution network, supplied to a microturbine to generate electricity for export back to the grid, or potentially supplied to an adjacent hydrogen refuelling station (HRS) for bus refuelling. The objective of the WSGG Project is to test and demonstrate P2G technology in the gas distribution network to aid in the transition to a low or zero carbon gas network and facilitate the development of commercially viable systems. Australia's acceptance for large-scale hydrogen production depends on a better understanding of P2G.

Commercially this technology is currently considered non-viable, as typical natural gas prices per unit of energy are an order of magnitude lower than power prices.

However, building both skills and experience within the domestic hydrogen industry will help decrease costs, allowing Australia to develop a competitive hydrogen export industry (COAG Energy Council 2019d). The WSGG Project is a sound option to build these skills and experience. The WSGG Project will also enable Australia to build the knowledge and the handling and technical expertise required for an export industry to operate safely and effectively (COAG Energy Council 2019d).

Hydrogen may prove to be a better substitute form of energy than electrification in the aim to decarbonise the country as it may strengthen the security and reliability of renewable electricity systems as well as diversify fuel supply options for transport (COAG Energy Council 2019d).

9.2 Environmental Assessment and Mitigation of Impacts

The key environmental risks have been investigated through detailed specialist investigations. These included:

- **Air Quality –** The air quality assessment undertaken by Benbow Environmental (2019) estimated that the annual contribution of greenhouse gas emissions from the current proposal in comparison to the Australian greenhouse emissions in 2017 is approximately 0.000000004%. No significant sources of emissions were determined, and no significant impacts to air quality are anticipated to occur (Benbow Environmental 2019).
- **Hazards and Risk –** The PHA undertaken by GPA Engineering (2019b) determined that the aggregate frequency of all events is below the tolerable risk target of 1×10^{-5} per year for 'active open space areas'. All natural gas and hydrogen blends are compliant with the national standard AS 4564-2011. At the target blending percentage of 2% and the shutdown limit of 10% the limits stipulated in AS 4564-2011 are within the allowable range for the expected range of natural gas compositions (GPA Engineering 2019d).
- **Waste –** The majority of waste generation during construction is likely in the form of excess spoil and plant packaging. Wastewater during operation will be removed in three ways, specifically:
  - Truck the wastewater offsite to a licenced facility
  - Reuse the wastewater for irrigation

  - Treat and reuse the part of the wastewater within the facility and dispose of a higher concentrated wastewater to a licenced facility.
- **Noise and Vibration –** In order to ensure that operational noise levels are kept within trigger levels, operation of the microturbine will be limited to between 7am and 10pm. Where "noise affected" management levels are predicted to be exceeded during construction, respite periods will be considered.
- **Visual** – the assessment identified 3 sensitive viewing locations which will have a moderate impact rating and have a clear line of site of the blowdown pipe. However, it was concluded that these impacts are already mitigated through the existing distance between these sites and the WSGG facility.
- **Traffic and Transport –** The amount of traffic generation is considered relatively minor and not of a level normally associated with unacceptable traffic implications in terms of road network capacity, efficiency or traffic related environmental effect (TTM 2019).
- **Biodiversity** – The BDAR waiver report determined that no significant impacts to biodiversity values will occur as a result of the proposed development.
- **Aboriginal Heritage** – No potential impacts to recorded or unrecorded archaeological deposits are anticipated as a result of the works.
- **Historic Heritage** – Results of the historic heritage assessments indicated that no known historical sites or objects will be impacted as a result of the works, and no further historical archaeological assessment will be necessary.
- **Water and Land** – The construction and operation of the facility will impose no more impact on soils than the pre-existing impact on the site. Measures will be in place to minimise the potential of sediment leaving the site. No impacts to groundwaters or significant impacts from water application of electrolyser inputs are anticipated.
- **Social and Economic** - Social concerns and risks associated with the proposal have been addressed through consultation with relevant authorities and the public and the mitigation measures in place. The proposal aims to assist in understanding the potential development of larger scale green hydrogen. No impact on the value of the lands surrounding the facility is anticipated.
- **Infrastructure –** The impacts to adjacent infrastructure and systems is expected to be minimal and not significantly impact utilities related to the development.

Mitigation measures have been developed to address environmental impacts and risk to the physical, social and environmental impact areas. Management strategies centre on the development of management plans and protocols to minimise and manage identified risks. These measures are precautionary where required and demonstrate that the risks identified within this EIS are highly manageable.

9.3 Ability to be Approved

- The development site is highly appropriate to hydrogen gas generation due to the infrastructure which is already in place at the Jemena Horsley Park Facility. Furthermore, the site is owned and managed by Jemena, who have extensive experience in management of gas facilities.

- The WSGG Project is consistent with local, state and federal planning provisions and has the potential to assist in the reduction of National emissions as technology is improved and better understood.
- The development footprint lies within land which is currently owned and operated by Jemena and has been the subject of a previous EIS. The WSGG Project has been designed in order to avoid or minimise any impacts to vegetation, habitat and heritage areas.

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Appendix A SEARs

General Requirements	The Environmental Impact Statement (EIS) must comply with the requirements of Part 3 of Schedule 2 of the Environmental Planning and Assessment Regulation 2000 (the EP&A Regulation) including:
	• the information required under clause 6 of Schedule 2 of the EP&A Regulation; and
	• the content listed in clause 7 of Schedule 2 of the EP&A Regulation, including, but not limited to:
	  o a stand-alone executive summary;
	  o a statement of the objectives of the project, including a description of the strategic need, justification, objectives and outcomes;
	  o an analysis of feasible alternatives to the carrying out of the project, including an analysis of options considered having regard to the project objectives (including an assessment of the environmental costs and benefits of the project relative to alternatives and the consequences of not carrying out the project), the suitability of the chosen option and whether or not the project is in the public interest;
	  o an analysis of the project, including an assessment, with a particular focus on the requirements of the listed key issues, in accordance with clause 7(1)(d) of Schedule 2 of the EP&A Regulation (where relevant);
	  o an identification of how relevant planning, land use and development matters (including relevant strategic and statutory matters) have been considered in the impact assessment (direct, indirect and cumulative impacts) and/or in developing management/ mitigation measures;
	  o a compilation of the measures proposed to mitigate any adverse effects of the project on the environment;
	  o a justification for the preferred project taking into consideration the objects of the Environmental Planning and Assessment Act 1979 (EP&A Act); and
	• a conclusion evaluating the merits of the project, having regard to the requirements in Section 4.15 of the EP&A Act).
	
	While not exhaustive, Attachment 1 contains a list of some of the environmental planning instruments, guidelines, policies, and plans that may be relevant to the environmental assessment of this development.
	In addition to the matters set out in Schedule 1 of the EP&A Regulation, the development application must be accompanied by a signed report from a suitably qualified person that includes an accurate estimate of the capital investment value of the development (as defined in Clause 3 of the EP&A Regulation), including details of all the assumptions and components from which the capital investment value calculation is derived.

Key Issues	The EIS must address the following specific issues with the level of assessment of likely impacts proportionate to the significance of, or degree, of impact on, the issue, within the context of the project location and the surrounding environment:
	• **Air Quality** – including:
	  o an assessment of the likely air quality impacts of the project in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (EPA, 2016);
	  o demonstrated ability to comply with the relevant regulatory framework, specifically the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations (Clean Air) Regulation 2010; and
	  o an assessment of the likely greenhouse gas impacts of the project;
	• **Hazards and Risk** - including a preliminary hazard analysis (PHA) prepared in accordance with the Department's Hazardous Industry Planning Advisory Paper No. 6,

'Hazard Analysis' and Multi-level Risk Assessment. The PHA must include and not be limited to:

- verification that natural gas injected with a specified quantity of hydrogen can comply with Australian Standard 4564: Specification for general purpose natural gas and that this gas will not adversely impact pipeline integrity and safety;
- description of all plant and processes of the development, gas pipelines, including flowrates, compositions and conditions, and the maximum project duration;
- hazard identification covering all plant and processes of the development and gas pipelines; and
- description on proposed safeguards to be implemented for the development and gas pipelines, including consideration of bushfire vegetation buffer;

- **Waste** - including identification, quantification and classification of the likely waste streams likely to be generated during construction and operation, and describe the measures to be implemented to manage, reuse, recycle and safely dispose of this waste including waste to be used for reclamation or other project activities;
- **Noise and Vibration** – including:
  - an assessment of the likely construction noise impacts of the project under the Interim Construction Noise Guideline (DECCW, 2009);
  - an assessment of the likely operational noise impacts of the project under the NSW Industrial Noise Policy (EPA, 2000);
  - an assessment of the likely road noise impacts of the project under the NSW Road Noise Policy (EPA, 2011); and
  - an assessment of the likely vibration amenity and structural impacts of the project under Assessing Vibration: A Technical Guideline (DEC. 2006) and German Standard DIN 4150-3 Structural Vibration – effects of vibration on structures;
- **Visual and Odour** – including an assessment of:
  - the likely visual and olfactory impacts of the development on the amenity of the surrounding area and private residences near the project; and the lighting impacts of the development;
- **Traffic and Transport** – including:
  - details of traffic types and volumes likely to be generated by the project;
  - details of the proposed transport routes, site access, safety issues and requirements for road work or upgrade;
  - an assessment of the likely impacts of the project on the capacity, condition, safety and efficiency of the road network, in particular heavy vehicles, oversize/ over-mass vehicles; and
  - details of measures to mitigate and / or manage potential impacts during construction, developed in consultation with the relevant road and rail authorities (if required);
- **Biodiversity** – including:
  - an assessment of the biodiversity values and direct and indirect biodiversity impacts of the development throughout its life in accordance with the Biodiversity Conservation Act 2016 (NSW), the Biodiversity Assessment Method, and documented in a Biodiversity Development Assessment Report (BDAR), including a strategy to offset any residual impacts, unless a BDAR waiver is granted; and
  - a detailed description of the proposed regime for minimising, managing and reporting on the biodiversity impacts of the development over time;
- **Heritage** – including an assessment of the likely Aboriginal and historic heritage (cultural and archaeological) impacts of the project, having regard to the Due Diligence

	Code of Practice for the Protection of Aboriginal Objects in New South Wales (OEH 2010); • **Water and Land** – including: o a description of water demand, a detailed water balance, a breakdown of water supplies and the measures to minimise water use; o an assessment of water quality and quantity impacts (particularly any impacts to Prospect Reservoir), surface and groundwater, including from erosion, sedimentation, and drainage, and potential flooding impacts of the project; and o a description of any land tenure and access issues relevant to the project; • **Social and Economic** – including an assessment of the social and economic impacts and benefits of the project for the region and the State as a whole, including consideration of any increase in demand for community infrastructure and services; • **Infrastructure Impacts** – including an assessment of impacts on infrastructure, including other utility servicing infrastructure (such as electricity, gas and water supply); • **Cumulative –** including industrial facilities in the area and other nearby approved and proposed development, particularly in relation to hazards and risk, air quality, noise and vibration, traffic and soil and water; and • **Long Term Management** – including an assessment of impacts associated with the operation and maintenance of the proposed facilities, including inspection arrangements and measures to ensure its integrity.
Environmental Risk Analysis	Notwithstanding the above key assessment requirements, the EIS must include an environmental risk analysis to identify potential environmental impacts associated with the project (construction and operation), proposed mitigation measures and potentially significant residual environmental impacts after the application of proposed mitigation measures. Where additional key environmental impacts are identified through this environmental risk analysis, an appropriately detailed impact assessment of this additional key environmental impact must be included in the EIS.
Consultation	You should undertake an appropriate and justified level of consultation with relevant parties during the preparation of the EIS, including: • local, State and Commonwealth government authorities; • relevant Aboriginal stakeholders, such as the Local Aboriginal Councils; • utilities and service providers; and • the public, including any relevant community groups and adjoining and affected landowners. The EIS must describe the consultation that was carried out, identify the issues raised during this consultation, and explain how these issues have been addressed in the EIS.
Further consultation after 2 years	If you do not lodge a development application and an EIS for the development within 2 years of the issue date of these Environmental Assessment Requirements (EARs), you must consult further with the Planning Secretary in relation to the preparation of the EIS.

Appendix B Biodiversity Development Assessment Report Waiver Approval

Level 3
101 Sussex Street
Sydney NSW 2000
t: (02) 9259 3800

Jemena Gas Networks (NSW) Ltd
C/o –
GPA Engineering Pty Ltd
121 Greenhill Road
Unley, South Australia, 5061

Our ref: 19SYD - 13511

Dear Steve,

RE: Biodiversity Assessment – Western Sydney Green Gas Trial Project – SSD 10313

Eco Logical Australia (ELA) was engaged by GPA Engineering Pty Ltd, on behalf of Jemena Gas Networks Pty Ltd to provide a biodiversity assessment for the proposed Western Sydney Green Gas Trial Project (WSGGTP). The proponent is Jemena Gas Networks Pty Ltd. This biodiversity assessment will accompany an Environmental Impact Statement (EIS) in support of State Significant Development Application (SSD-10313) for the WSGGTP at 194-202 Chandos Road, Horsley Park.

The project is State Significant Development with SEARs issued on 12 June 2019. In relation to biodiversity, the SEARs require:

1. *an assessment of the biodiversity values and direct and indirect biodiversity impacts of the development throughout its life in accordance with the Biodiversity Conservation Act 2016 (NSW), the Biodiversity Assessment Method, and documented in a Biodiversity Development Assessment Report (BDAR), including a strategy to offset any residual impacts, unless a BDAR waiver is granted; and*
2. *a detailed description of the proposed regime for minimising, managing and reporting on the biodiversity impacts of the development over time.*

ELA undertook a site inspection to assess biodiversity values present and the potential impacts of development. The attached figures and table clearly demonstrate that the development will not have a significant impact on biodiversity values and therefore a waiver from the need to prepare a BDAR is recommended.

The following attachments describe the biodiversity values of the site in relation to clause 1.4 of the BC Act 2016 (**Table 1**).

Should you have any questions regarding this assessment, I can be contacted on (02) 9259 3757.

Regards,

Daniel Magdi
Principal Environmental Consultant

Table 1: Information Requirements

Requirement	Description
Admin	Proponent: Jemena Gas Networks (NSW) Ltd Level 16, 567 Collins St, Melbourne, Victoria Contact: Russell.Brooks@jemena.com.au Project ID: SSD-10313 – Prepare EIS Completed by: Roshan Kalugalage – Environmental Consultant (Eco Logical Australia) – B.Sc. (Environmental Science) and Daniel Magdi – Principal Environmental Consultant (Eco Logical Australia) – Bachelor of Landscape Management and Conservation
Site Details	Site address: 194 – 202 Chandos Road, Horsley Park. Lot 1, DP 499001, Lot 3, DP 1002746. Fairfield City Council LGA. The proposed development site is located within Jemena's Horsley Park Facility, which has been previously cleared. The study area will extend over 2 lots, Lot 1 DP 499001 and Lot 3 DP1002746. Location Map: Refer to Figures 1, 2 and 3. Site Map: Refer to Figure 4.
Proposed Development	Jemena is proposing to develop an additional facility at Jemena's Horsley Park Facility located at 194-202 Chandos Road, Horsley Park. The proposed WSGGTP facility will be an extension to Jemena's High-Pressure Gas Facility, and include a hydrogen bus refuelling facility. The project will involve the conversion of electrical energy into combustible hydrogen which will be injected into the Sydney secondary gas distribution network or supplied to the bus refuelling facility. The facility will include a hydrogen buffer storage with a holding capacity of 100kg of hydrogen. All impacts to biodiversity will be contained to within the two lots specified above. Any further environmental impacts will be assessed as part of the EIS which this document will support.

Table 2 Impacts of the proposed development on biodiversity values

Biodiversity Value	Meaning	Relevant	Discussion of values within subject site
			Biodiversity Conservation Regulation (Clause 1.4)
a) Threatened Species Abundance	The occurrence and abundance of threatened species or threatened ecological communities, or their habitat, at a particular site.	N/A	No threatened ecological communities are present within the site. The small amount of vegetation present is not consistent with any listed Plant Community Type (PCT). This is primarily due to the lack of connectivity and small number of individuals present (two individual *Eucalyptus tereticornis* (Forest Red Gum) with an exotic dominated groundcover consisting primarily of *Pennisetum clandestinum* (Kikuyu) and *Trifolium* spp.). No habitat is available for threatened flora species due to the high level of modification and ongoing maintenance of vegetation and soils within the site. Minimal foraging habitat is available for fauna species. Considering the small amount of native vegetation present (two individual trees), the site does not contain sufficient foraging resources to sustain any threatened fauna species. No roosting habitat is available within the subject site for hollow-dependent threatened fauna species due to the absence of hollow-bearing trees.
b) Vegetation Abundance	The occurrence and abundance of vegetation at a particular site.	N/A	Vegetation within the subject site is of low abundance and biodiversity quality. The majority of the site has been cleared for the existing gas facility. Vegetation within the development site is comprised of two native trees and sparse native grass amongst weeds and exotics. The two native trees within the site will not be impacted by the WSGGPT. Vegetation within the site is not consistent with any remnant native vegetation communities and did not conform to any listed PCTs.
c) Habitat Connectivity	The degree to which a particular site connects different areas of habitat of threatened species to facilitate movement of those species across their range.	N/A	Vegetation within the site is highly fragmented and does not contribute to habitat connectivity across the local landscape. Vegetation is limited to the two trees present on site and an exotic dominated groundcover consisting of predominantly exotic species, with scattered native grasses located to the east of the site. The site does not provide any significant level of connectivity to facilitate movement of threatened species across their range.
d) Threatened Species Movement	The degree to which a particular site contributes to the movement of threatened species to maintain their lifecycle;	N/A	The site contains limited vegetation, which has been previously cleared for the current gas facility. Movement for less mobile threatened fauna such as mammals across the site is highly unlikely due to the lack of foraging or roosting habitat. Due to the lack of vegetation, the site is not considered to be significant for the movement of any threatened species to maintain their lifecycle.
e) Flight Path Integrity	The degree to which the flight paths of protected animals over a particular site are free from interference.	N/A	The landscape within and surrounding the site is predominantly cleared of vegetation. The flight paths of protected animals over the site is unlikely to be impacted by the proposed development, and no facilities which may inhibit flight over the development site are proposed.

Biodiversity Value		Meaning	Relevant	Discussion of values within subject site
f)	Water Sustainability	The degree to which water quality, water bodies and hydrological processes sustain threatened species and threatened ecological communities at a particular site.	N/A	A mapped second order watercourse crosses through the northern extent of Lot 4 DP1002746, to the north of the proposed development location (Figure 2). The construction footprint lies approximately 250m south of this mapped second watercourse. Due to this distance, the proposed development will not impact on water quality, water bodies or hydrological processes. The proposed development will not impact on any waterbodies which contribute to hydrological processes that sustain threatened species or ecological communities within or adjacent to the site.
Biodiversity Conservation Act (Clause 1.5 (2))				
a)	Vegetation Integrity	The degree to which the composition, structure and function of vegetation at a particular site and the surrounding landscape has been altered from a near natural state.	N/A	Due to previous and current land management practices, vegetation and soils within the subject site have been highly modified or disturbed and lack natural resilience. Vegetation within the site is comprised of predominantly exotic grasses and herbs, with sparse *Themeda triandra* (Kangaroo Grass) located to the east of the subject site. Two *Eucalyptus tereticornis* (Forest Red Gum) are located within the development footprint of the site and will be retained. Due to their lack of connectivity to any other vegetation, these trees are not representative of any remnant PCTs that would have been present within the development site. Therefore, the development will not compromise the vegetation integrity of the site.
b)	Habitat Suitability	The degree to which the habitat needs of threatened species are present at the particular site.	N/A	Suitable habitat for threatened species is highly limited within the site. No threatened flora species were detected on site during the inspection. Minimal foraging habitat is available for threatened fauna species. Considering the small amount of isolated vegetation present, the site does not contain sufficient foraging resources to sustain any threatened fauna species. No suitable roosting habitat is available within the subject site for hollow-dependent threatened fauna species due to the absence of hollow-bearing trees. The human made structures within the development site are modern and do not consist of potential roosting habitat for threatened microbat species such as open roof crevices, culverts, bridges, railway tunnels or stormwater tunnels. The development will not compromise habitat suitability for threatened species. The proposed development will not impact upon any habitat specified under Clause 6.1 (1) (a) of the *Biodiversity Conservation Regulation*.

Figure 1: Location Map

Figure 2: Mapped vegetation and Strahler streams in relation to the study area

Figure 3: Threatened species search (Bionet) in relation to the study area

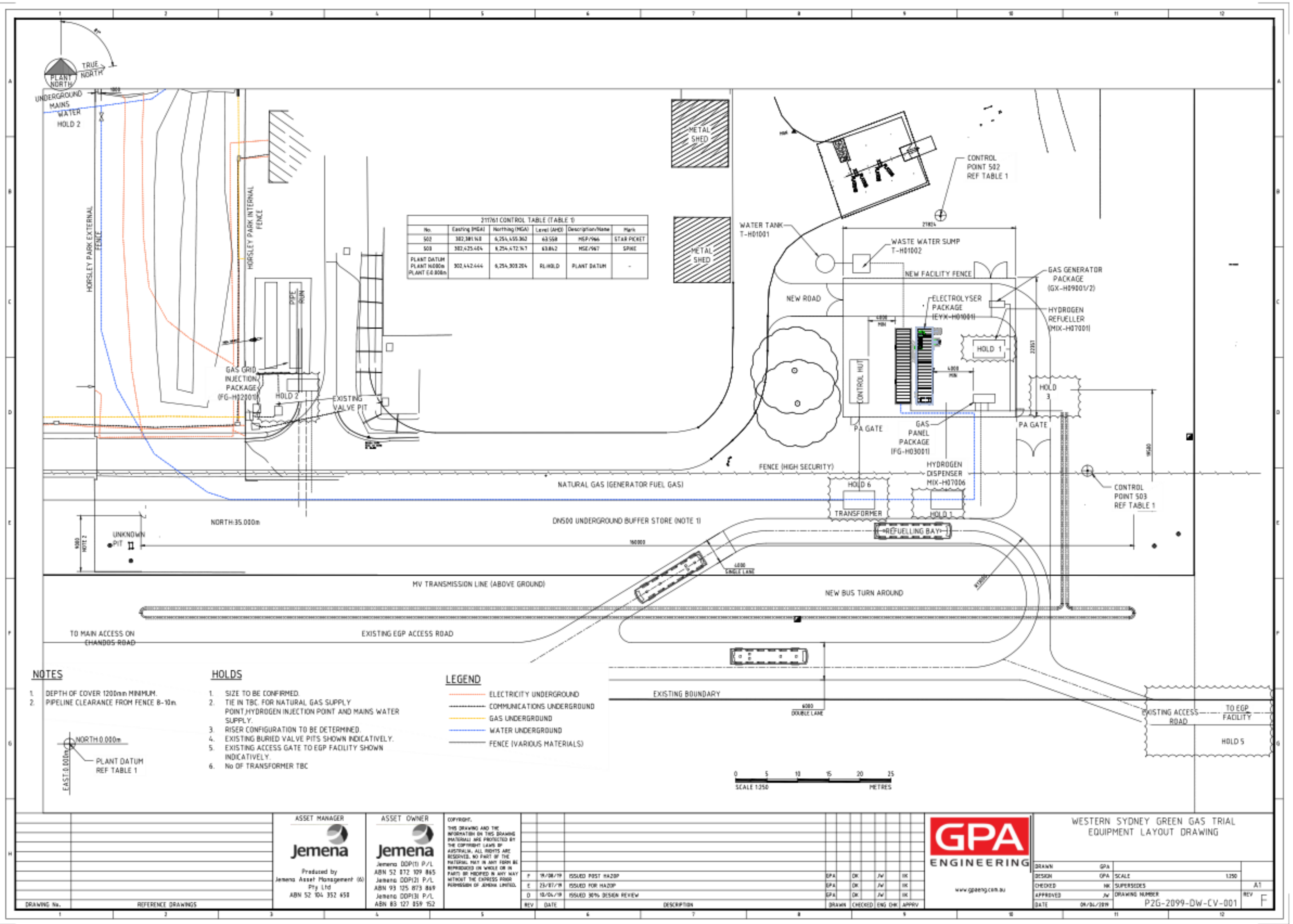

Figure 4: Site Map (Jemena 2018) indicating the proposed layout of the development.

Appendix C Hazard and Risk Assessment

Preliminary Hazard Analysis

Jemena - Detailed Design for Hydrogen Generation (Western Sydney Green Gas Trial)

Jemena Ltd

GPA Document No: 18667-REP-017

Client Project No: P2G-2099-RP-RM-003

Rev	Date	By	Checked	QA	Description
A	15/10/2019	LAH/AMB	SH	LTJ	DRAFT Issued for Preliminary Review Meeting
0	29/10/2019	LAH/AMB	SH	AS	Issued for Use
		LAH	SH		

EXECUTIVE SUMMARY

Introduction

Jemena Gas Networks is the asset owner of the Horsley Park High Pressure Gas Facility, comprising of a number of pressure let down and pipeline pigging facilities, including the Eastern Gas Pipeline (EGP) pipeline, Jemena Gas Network (JGN) Trunk, Sydney Primary Loop and local secondary network, located on Chandos Road in Horsley Park, NSW.

Jemena has proposed construction of a demonstration hydrogen production plant within and adjacent to their existing high pressure gas facilities at Horsley Park in New South Wales. The project, called the Western Sydney Green Gas Trial (WSGGT), will initially produce 100 Nm^3/h of hydrogen gas with a 500 kW Hydrogenics PEM electrolyser using electricity from the local power grid. Produced hydrogen gas will either be injected into the existing natural gas distribution network for sale as blended natural gas / hydrogen, used to generate electricity using a gas fuelled generator package or be available for vehicle refuelling.

As one element of the planning approval process, GPA Engineering has been requested to prepare a Preliminary Hazard Analysis (PHA) in accordance with the NSW Department of Planning and Environment (DP&E) requirements set out in the Hazardous Industry Planning Advisory Paper (HIPAP) 6: Guidelines for Hazard Analysis and for the risk to be evaluated and compared with the risk criteria in use in NSW, as specified in HIPAP 4: Risk Criteria for Land Use Planning. This document has been prepared to inform the Environmental Impact Statement for the proposal. The risk assessment is based on current best practice methodologies and available data and input information.

Scope and Aim of Study

The objectives of this report are to determine the risk of a major incident at the WSGGT facility affecting offsite land users and to compare this with established tolerable risk criteria.

Hazard identification and analysis has been undertaken for the site in the form of HAZID and HAZOP workshops attended by personnel with the required experience levels. In these studies hazards were identified along with existing and proposed safeguards to be incorporated into the design. Scenarios were then developed for consequence modelling. Consequence modelling was undertaken at the specified operating conditions and leak type/size for each case.

Results

The scenarios with the greatest consequences for the site are those which have the potential for offsite consequences. For this facility these were hydrogen fuelled flash fires or jet fires with radiation effects at levels sufficient to cause a fatality that extend beyond the Jemena boundary fence. The following scenarios were identified from consequence modelling with potential offsite impacts:

- Hydrogen high pressure storage equipment full bore leak (15 mm)
- Refueller equipment flange leak (10 mm)
- Refueller – refuelling hose failure (15 mm)

For these scenarios, expected frequencies were determined quantitatively by estimating the mean frequencies of failure of the component parts. The cumulative frequency of the events likely to result in potentially fatal offsite effects was then determined and compared with the tolerable risk target for the land use.

The calculated frequency of potentially fatal offsite individual risk for the Western Sydney Green Gas Trial Plant is estimated to be approximately **8.4×10^{-6}** per year. This value is below the tolerable risk target of **1×10^{-5}** per year for 'active open space areas'.

A firewall will be installed to prevent any unintended releases from the hydrogen high pressure storage facility having potentially fatal offsite consequences.

With the firewall in place, the refueller dispenser is the only part of the proposed design that can have potential offsite consequences. This and associated equipment (HPS) will not be installed in the first phase of this project. If refuelling facilities are to proceed at a later date, further risk analysis can be performed once detailed design information is available. As a minimum, this equipment will be designed to international codes and practices. It will be fitted with preventative and mitigative controls such as; cascade pressure drop monitoring and a 4-tier safety philosophy that will be constantly monitored by a Safety Device that is monitored by the PLC as well as gas, flame and smoke detection.

It should be noted that none of the credible consequence contours modelled are expected to impact the residential dwellings on the other side of Chandos Road approximately 250 m away from the new facility.

In conjunction with design safeguards listed in this report, Jemena will develop an integrity management plan involving inspection and maintenance of critical equipment as well as upgrading and implementing their safety management system for the site. This will be reflected in an update to the Safety Case GAS-999-PA-HSE-002 and the Asset Management System Manual, JEM-AM-MA-001.

Uncertainties and Assumptions

At the time of this assessment the detail design and HAZOP for the refuelling station and associated high pressure storage were not yet available. The assessment was based on preliminary information provided by the preferred vendor.

Consequence modelling for all scenarios was performed using continuous release rates and is therefore conservative.

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1 INTRODUCTION

1.1 BACKGROUND

Jemena Gas Networks is the asset owner of the Horsley Park High Pressure Gas Facility, comprising a number of pressure let down and pipeline pigging facilities, including the Eastern Gas Pipeline (EGP) pipeline, Jemena Gas Network (JGN) Trunk, Sydney Primary Loop and local secondary network, located on Chandos Road in Horsley Park, NSW.

Jemena has proposed construction of a demonstration hydrogen production plant within and adjacent to their existing high pressure gas facilities at Horsley Park in New South Wales. The project, called the Western Sydney Green Gas Trial (WSGGT), will initially produce 100 Nm^3/h of hydrogen gas with a 500 kW Hydrogenics PEM electrolyser using electricity from the local power grid. Produced hydrogen gas will either be injected into the existing natural gas distribution network for sale as blended natural gas / hydrogen, used to generate electricity using a gas fuelled generator package or be available for vehicle refuelling. It is proposed that three buses a day will be refuelled with hydrogen at the facility.

It will also be possible to run the gas fuelled generator package using natural gas from the adjacent natural gas distribution network as fuel.

The WSGGT facility will perform the following key functions:

- Convert mains water into hydrogen gas using grid electricity through electrolysis.
- Store hydrogen gas in a buried onsite steel pipeline. This will be used for backup hydrogen gas supply and injection management.
- Control and safely manage hydrogen gas pressures, temperatures and flowrates for injection into Jemena's secondary gas pipeline network.
- Provide a hydrogen microturbine generator set to convert stored hydrogen into electrical energy.
- Provide on-site hydrogen bus refuelling, including a locally operated hydrogen dispenser and vehicle turnaround adjacent to the Jemena Horsley Park Meter Station.

1.2 SCOPE AND AIM OF STUDY

The objectives of this report are to address the Hazard and Risk requirements of the Secretary's Environmental Assessment Requirements (SEARs) for the WSGGT by quantitatively determining the risk of a major incident affecting offsite land users and to compare this with established tolerable risk criteria.

This preliminary hazard analysis (PHA) has been prepared in accordance with the Department's Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis' and Multi-level Risk Assessment (Ref 2 and Ref 3).

The scope of the study includes:

- Systematic identification of hazards
- Determination of the consequences of identified hazards
- Determination of the likelihood of loss of containment hazards using published data
- Determination of the acceptability of the risk by comparison to the risk criteria specified in NSW Department of Planning HIPAP No. 4 (Ref 1)

The DP&E has advised that a Level 2 assessment is appropriate for this facility. A level 2 assessment is described below:

"*A level 2 assessment is semi-quantitative, in that it should, in addition to all the elements of the level 1 analysis, include sufficient quantification of risk contributors to demonstrate that risk criteria will be met.*

In particular:

- *appropriate modelling tools should be used to calculate the consequences of all events shown by the preliminary assessment to have the potential for harmful offsite effects*
- *there should be an estimate of likelihood for each event confirmed by the consequence modelling to have significant off-site effects, using appropriate failure data and techniques, such as fault and event trees*
- *there should be an indicative estimate of the off-site risk, taking into account the cumulative impact of multiple events*
- *the study must demonstrate that all relevant numerical risk criteria will be met (see also section 2.2.4)"*[1]

1.3 ABBREVIATIONS

CNG	Compressed Natural Gas
EGP	Eastern Gas Pipeline
HAZID	Hazard Identification Study
HAZOP	Hazard and Operability Study
HDCU	High Density Community Use
HRS	Hydrogen Refuelling Station
JGN	Jemena Gas Network (NSW Gas Asset)
LEL	Lower Explosive Limit
LNG	Liquefied Natural Gas
LOPA	Layer of Protection Analysis
MAOP	Maximum Allowable Operating Pressure
P2G	Power to Gas
PHA	Preliminary Hazard Analysis
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition
SCS	Station Control System
SIL	Safety Integrity Level
SIS	Safety Instrumented System
WSGGT	Western Sydney Green Gas Trial

[1] Department of Planning and Environment. Assessment Guideline Multi Level Risk Assessment. 2011.

2 SITE AND PROCESS DESCRIPTION

2.1 SITE LOCATION AND SURROUNDING LAND USES

The facility is located within the boundaries of Jemena's current High Pressure Gas Facility, located at 194 – 202 Chandos Road, Horsley Park, NSW, Australia, 32 km west of Sydney CBD. The project location is within the Fairfield local government area.

The location of the station is shown in Figure 1 and Figure 2. All works associated with the WSGGT will occur within the boundaries of this property. The site is within the area covered by the Western Sydney Parklands. The facilities fall under the Eastern Gas Pipeline location classification of Rural Residential (R2) (Ref 1).

The facility is located 600 m to the east of the Westlink M7 toll road. Eastern Creek runs in a northerly direction in a wooded area between the M7 and the facility. The Horsley Park Meter Station is located directly north of the site (see Figure 2). A market garden is located directly east of the site and a quarry is located to the north.

Private residences are located approximately 250 m to the south of the facility along Chandos Road. The building to the east of the site is a farm shed and the residence for that property is located on Chandos Road. There are no schools, hospitals or other development referred to as *sensitive development* in HIPAP No. 4 (Ref 1) within the potential hazardous impact zone of the development.

The area adjacent to the eastern boundary fence is currently open for tender for farming purposes. There are 3 separate blocks currently being offered to be leased by one tenant. Future possible land uses may include crops, greenhouses, farm sheds, chemical storage sheds or farm gate produce sales. Jemena have engaged with the Western Sydney Parklands Trust and they are aware of the proposed hydrogen facility. The Western Sydney Parklands Trust has agreed to inform Jemena of any potential changes to land use that may result from future tenants.

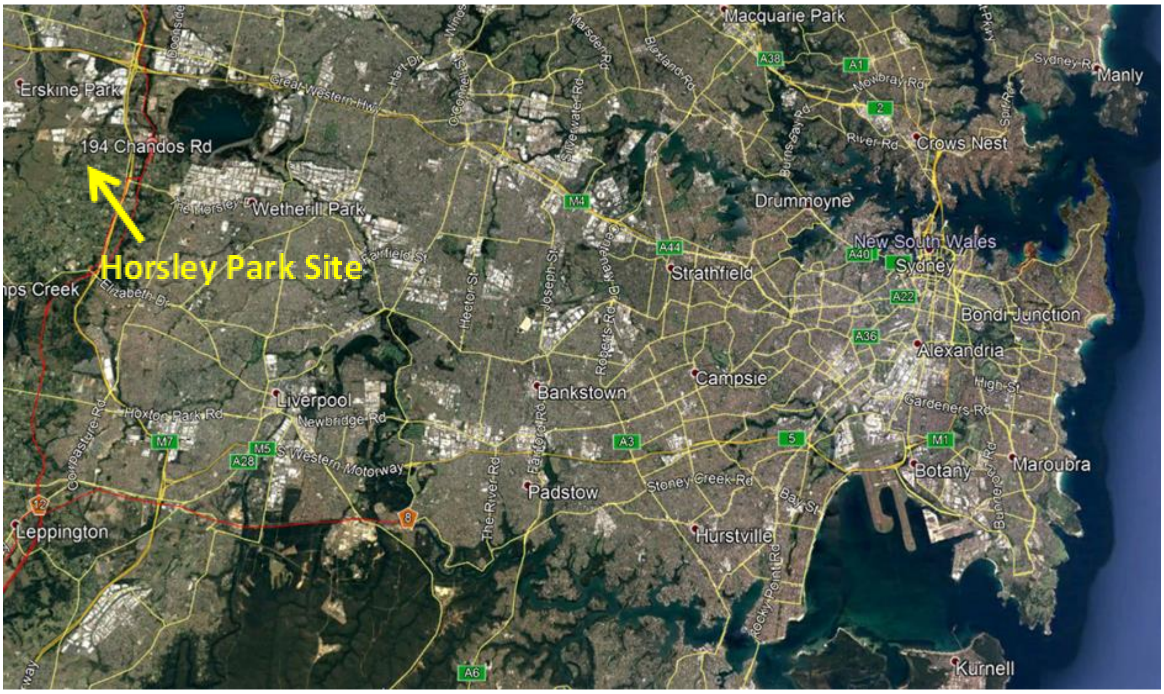

Figure 1: Project Location (32 km west of Sydney CBD)

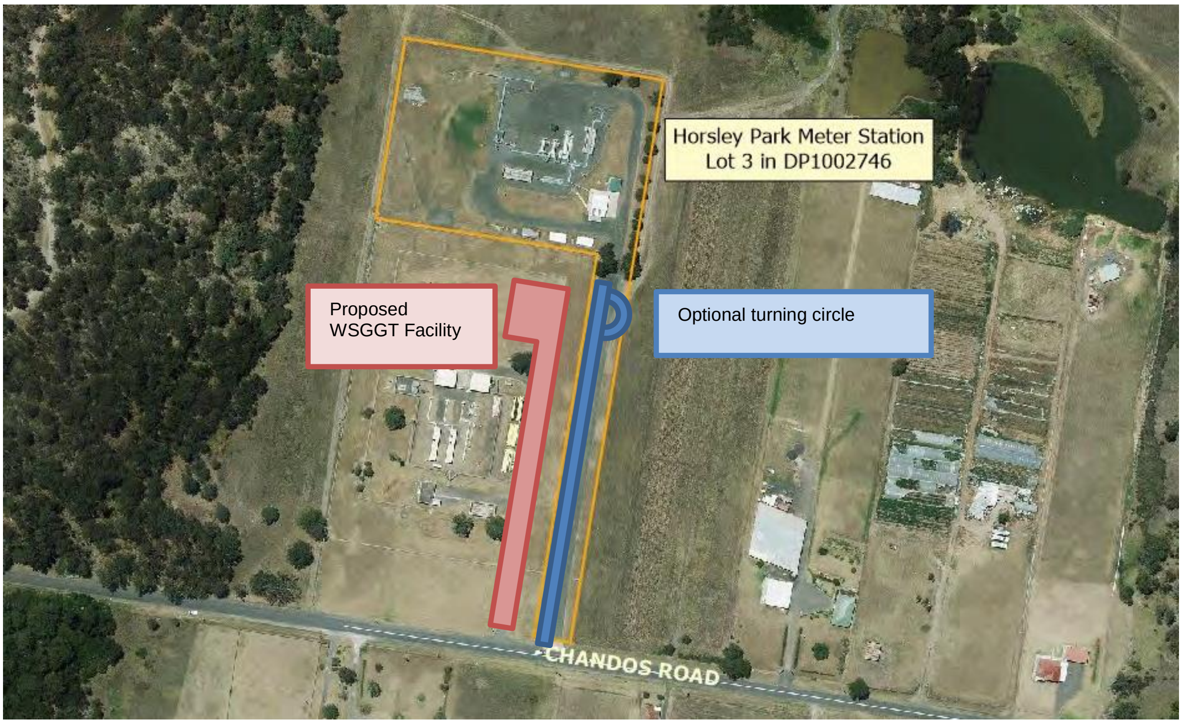

Figure 2: WSGGT Facility Location (within existing Horsley Park Site)

2.2 SITE LAYOUT AND EQUIPMENT

The main plant items and facilities in scope for this project are shown in Table 1.

Table 1: Site Equipment

Item	Description
Electrolyser	Primary plant generates hydrogen gas on-demand from feed of electricity and water.
Buffer store	Manages incoming flow of hydrogen gas from electrolyser for onsite storage and distribution to gas injection, hydrogen refuelling station and microturbine.
Gas grid injection panel	Regulates the injection of hydrogen into the secondary mains. Regulates the flow of natural gas from the secondary mains.
Gas panel	Regulates and controls the flow of gas (hydrogen or natural gas) to and from the major equipment.
Power grid connection	Interconnection between existing power lines and site transformer, including 2 way meter.
Transformer	Voltage step between site and grid power.
Control and instrumentation	Overall site data acquisition, monitoring and control.
Site civil works	Site hard standing, security, weather protection, etc.
Microturbine	Generates electricity on demand for site standby power or for feedback into the power grid.
Hydrogen refuelling station connections	Interfaces and laydown area for future connection to plant associated with a hydrogen refuelling system.
Waste Water Disposal	Waste water from the electrolyser package is sent to the waste water disposal system for storage and removal from site as required.

A schematic of the facility is shown in Figure 3 and the preliminary equipment layout drawing can be seen in Appendix 6.

Figure 3: Schematic of WSGGT Facility Plant Design and Operation

2.2.1 Plant Design

The facilities are described in the Basis of Design (Ref 4) and are listed below. Refer to Figure 5 for the process flow diagram.

2.2.2 Gas Control Panel

The ‘Gas Panel’ will include actuated and manual valving to direct flow to and from the electrolyser, hydrogen delivery refuelling station (HRS), hydrogen-powered generator, and a hydrogen buffer storage pipeline.

The gas panel will be comprised of SS316 tubing and pipe, and will include the natural gas supply to the generator set. The gas control panel structure consists of vertically mounted equipment & instrument panel and a collection hood. The semi-enclosed roof structure is openly ventilated to allow any hydrogen leaks to disperse into the atmosphere. Hydrogen leak detection is also provided.

2.2.3 Electrolyser

The function of the electrolyser is to split water into its constituent parts, oxygen and hydrogen. The oxygen is vented above the electrolyser and the hydrogen is purified before it is transmitted to the buffer store.

The electrolyser is a self-contained unit, operated from the control panel inside the control hut and remote shut down from the Jemena control room. Physical access to the unit is via key entry.

2.2.4 Buffer Store

A buffer store will be provided, in order to accumulate hydrogen inventory to ensure that sufficient quantity is available when required. This additional storage will be provided as an on-site buried pipeline. Approximately 100 – 120 kg of hydrogen can be stored as line-pack in the buried pipeline.

A small volume (30 – 60 kg) of high pressure storage is also provided as part of the HRS, providing a differential pressure so that, throughout filling, the HRS can deliver gas at an appropriate rate and temperature.

2.2.5 Generator Set

The purpose of the generator set (microturbine) is to demonstrate and trial its application as a grid connected back up and grid "battery" when used in conjunction with the electrolyser. The fuel supply for the generator set comes from natural gas or the buffer store via the gas control panel.

2.2.6 Gas Grid Injection Panel

The Gas Grid Injection Panel regulates the flow of natural gas and regulates the injection of hydrogen into the secondary mains.

2.2.7 Hydrogen Refuelling Station

Vendor details for the Hydrogen Refuelling Station are not yet available as this option is yet to proceed commercially. If it is to proceed, risks will be further assessed and managed during the safety in design process. A typical high pressure storage and refuelling system is shown in Figure 4 below. The proposed system will store approximately 100 – 120 kg of hydrogen at 80 to 100 MPa. The dispenser will operate at approximately 35 MPa.

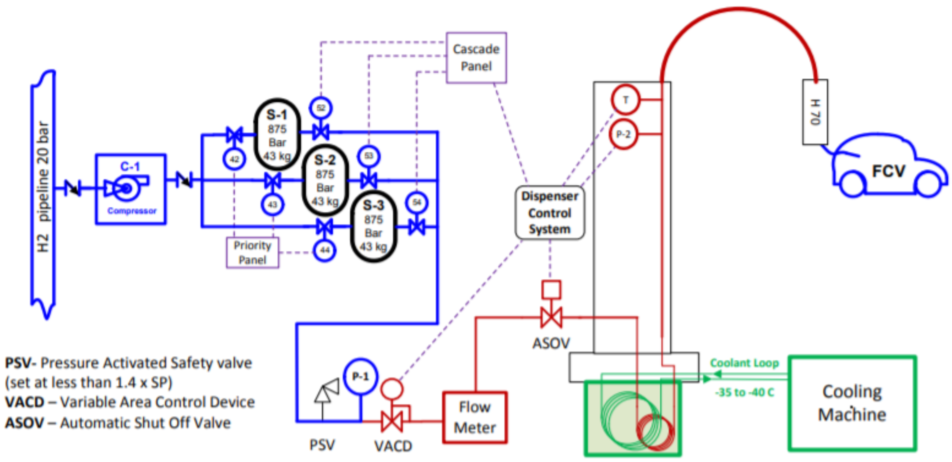

Figure 4: Typical high pressure storage and cascade refuelling system PFD

2.2.8 Waste Water Disposal

The waste water disposal system consists of a waste water sump, sump pump and waste water storage tank. Waste water collected in the sump will transfer under level control via the sump pump to the waste water storage tank. The waste water storage tank will be emptied and waste water taken offsite and disposed of by a water removal contractor as required.

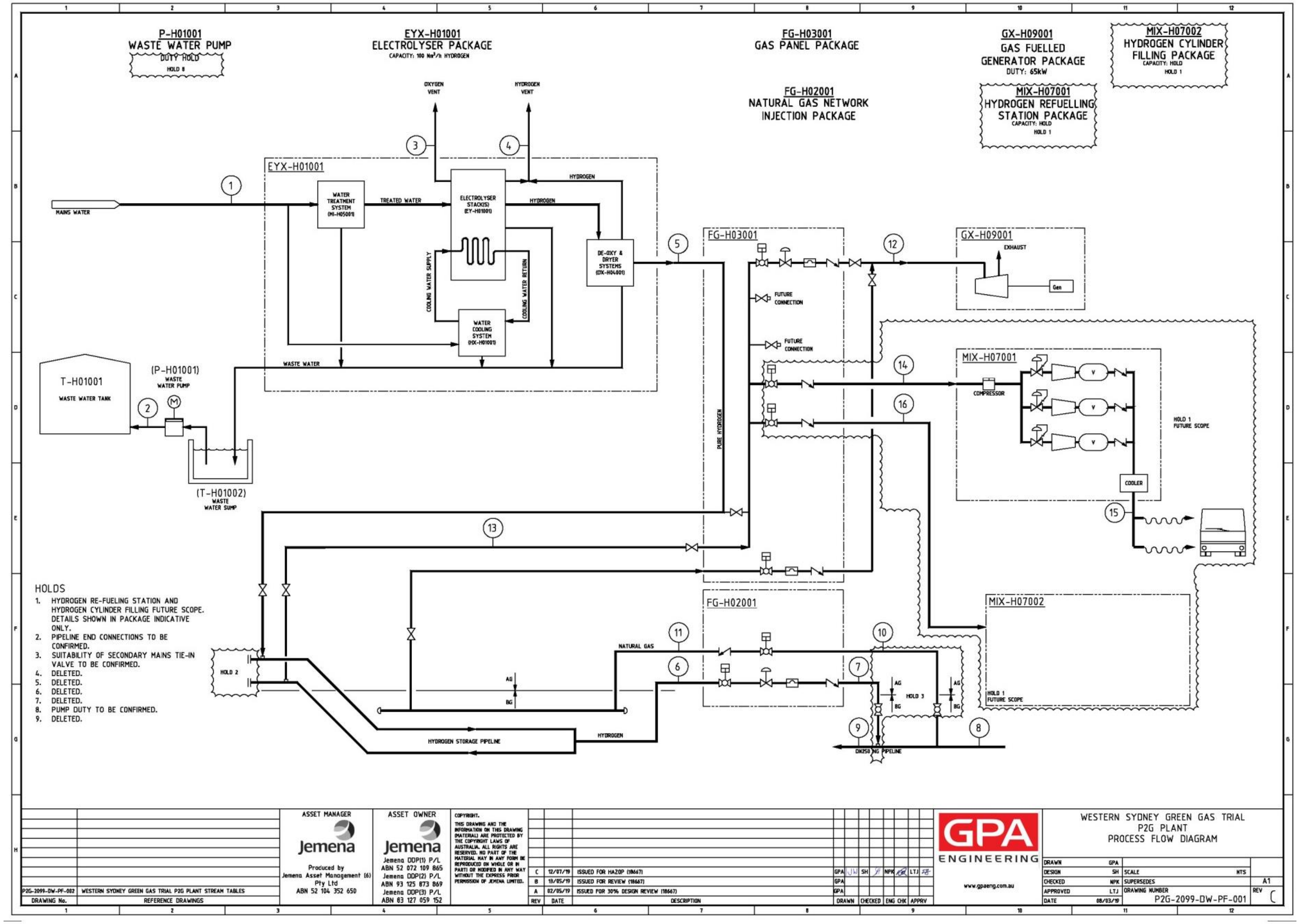

Figure 5: Process Flow Diagram

2.3 SECONDARY MAINS NETWORK

Jemena own and operate the Sydney Secondary Mains Network. The network directly or indirectly supplies gas to over 900,000 domestic and industrial customers across Sydney region. It has a Maximum Allowable Operating Pressure (MAOP) of 1,050 kPag. The Sydney Secondary Mains Network commenced construction in the 1960s. Sections are laid through High Density Community Use (HDCU) areas. The Sydney Secondary Mains Network consists mainly of steel either API 5L Grade B or API 5L Grade X42. Diameters range from 50 mm – 450 mm.

An overview of the location of the Secondary Mains network can be seen in Figure 6 below.

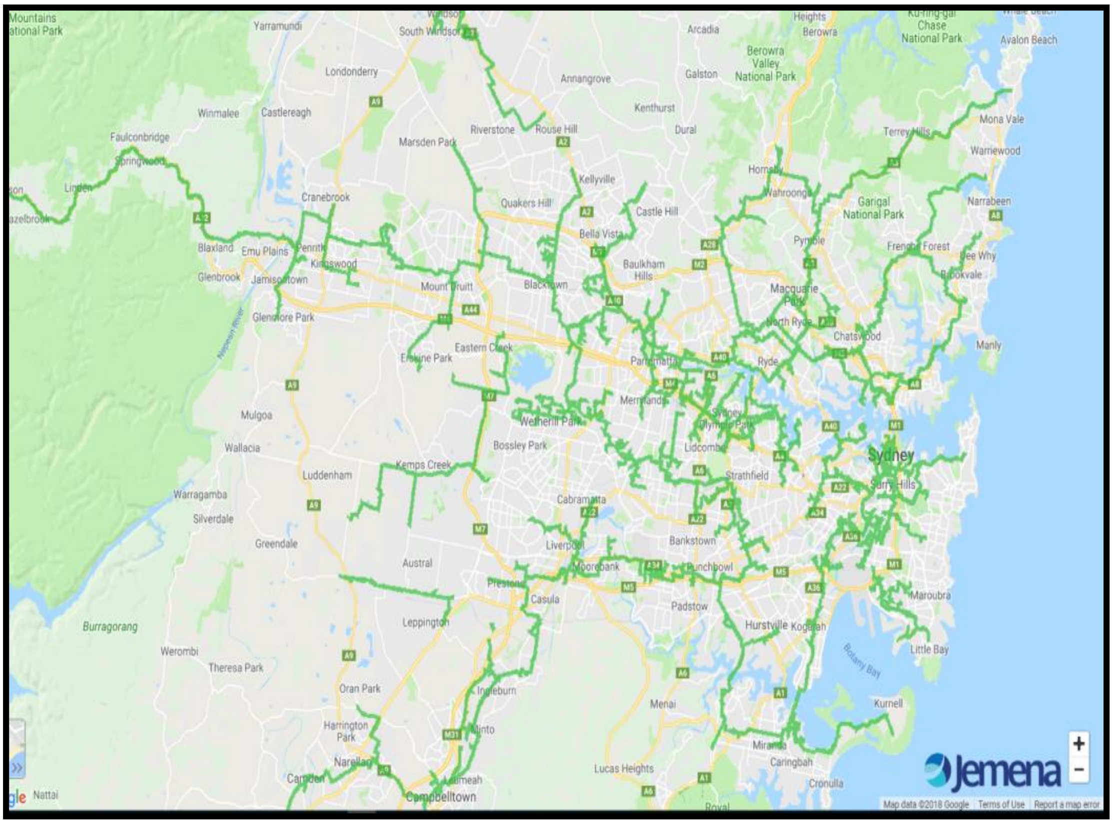

Figure 6: Overview of Secondary Mains Network

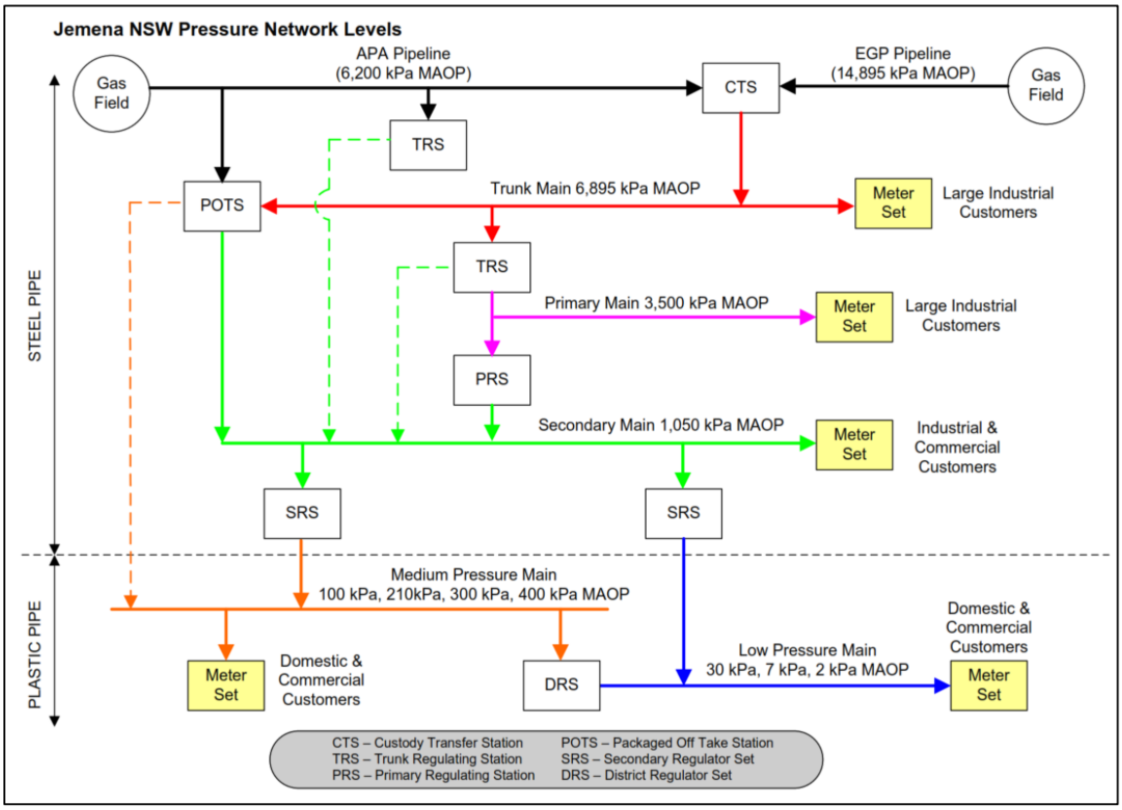

Figure 7: Jemena Network Configuration

Figure 7 shows configuration of Jemena's NSW JGN network. Supply from the Secondary Mains to the downstream medium and low pressure mains are via District Regulator Sets (DRS) or Secondary Regulator Sets (SRS). The medium and low pressure mains and services supply natural gas to domestic, industrial and commercial users.

For this facility, the Hydrogen will be injected downstream of the Horsley Park PRS directly into the Secondary Main. This network is designed to Australian Standard for Gas Distribution Networks AS4645 (Ref 5) and operated under low stress and no rupture conditions (<20% SMYS).

2.4 SITE BUILDINGS

2.4.1 Control Hut

All control and monitoring systems are located within a 20 ft demountable control hut. This hut is equipped with air conditioning, lighting and basic furnishings for 4 persons.

2.5 PROCESS CONTROL

The facility will incorporate both manual (local) and automatic (both local and remote) features that will allow plant and equipment to be operated safely and efficiently.

The primary objective of the control system is to provide control over processing functions, protect plant, equipment and personnel, and enable simple and reliable plant shutdown, and isolation of equipment. As the facility will be unmanned, minimal operator involvement must be required, including for start-up, shutdown, and restart. The systems shall therefore monitor and control the facility on a continuous basis under all operating and environmental conditions.

The WSGGT facility will be provided with a local PLC (station control system, SCS) designed to control all major process functions, and a safety instrumented system (SIS) that will shut down (trip) a range of equipment and equipment packages, and close major isolation valves during emergency events or process trips.

Hydrogen gas quality will be measured by an analyser within the electrolyser package, with data visible to the facility SCADA to enable plant adjustments to be made, if necessary.

Utility systems will be controlled by their respective package controllers, as mentioned above. All packages will be expected to operate without operator intervention.

Refer to the WSGGT control philosophy (P2G-2099-RP-IE-001) for further details.

2.6 DESIGN AND OPERATING CONDITIONS

Table 2: Design Temperatures

Plant Item	Interface	Maximum	Normal	Minimum
Electrolyser	Outlet	80°C	60°C	-20°C
Buffer store	Inlet - Outlet	60°C	20°C	-10°C
Microturbine generator	Inlet	60°C	25°C	-10°C
HRS	Inlet	60°C	25°C	-10°C
Ambient air	N/A	45°C	21°C	-10°C

Table 3: Ambient Temperatures

Parameter	Value	Basis
Electrolyser package	40°C	Selected ambient temperature for cooler sizing.
Microturbine generator package	60°C	Maximum operating temperature.
Lowest one day mean ambient temperature	-6°C	BOM average data for Horsley Park.
Design minimum temperature	-6°C	BOM average data for Horsley Park.

Table 4: Design Pressures

Parameter	Value	Basis
Electrolyser	3,800 kPag	Electrolyser PSV setpoint
Buffer storage	3,800 kPag	Electrolyser PSV setpoint
HRS – inlet	3,800 kPag	Electrolyser PSV setpoint
Hydrogen generator	1,000 kPag	Maximum generator inlet pressure
High Pressure Storage	105 MPag	PRV Setpoint
Refueller Dispenser	105 MPag	PRV Setpoint

Table 5: Operating Pressures

Parameter	Value	Basis
Electrolyser	3,000 kPag	P&ID P2G-2099-DW-PD-005
Buffer storage	1,000 – 3,000 kPag	Datasheet P2G-2099-DS-JJ-002
HRS – inlet	1,000 – 3,000 kPag	Datasheet P2G-2099-DS-JJ-022
Hydrogen generator	700 kPag	P&ID P2G-2099-DW-PD-006

Parameter	Value	Basis
High Pressure Storage	85-100 MPa	H2 Station General (Preliminary vendor information)
Refueller Dispenser	35 MPa	H2 Station General (Preliminary vendor information)

2.7 STANDARDS AND LEGISLATION

2.7.1 NSW Legislation

Compliance to NSW Acts and Regulations are mandatory for plant and equipment installed in the State of NSW. Compliance to all Australian Standards referenced in legislation is mandatory.

Key relevant legislation applicable to plant and equipment in NSW includes the following:

- Work Health and Safety Regulation 2017
- Gas and Electricity (Consumer Safety) Regulation 2018.

In addition to these regulations (and their associated Acts), the following NSW Safework Codes of Practice shall be incorporated into the scope of supply and include, but are not limited to the following:

- Managing Risks of Plant in the Workplace – Code of practice (July 2014)
- Managing Electrical Risks in the Workplace – Code of Practice (September 2016)
- Managing risks of hazardous chemicals in the workplace code of practice – Code of Practice (July 2014).

2.7.2 Australian, International and Hydrogen Specific Standards and Guidelines

Where applicable the codes listed in Table 6 shall apply or be used in part where relevant. The full list of applicable codes and standards is provided in project document P2G-2099-LS-QA-001. The hydrogen specific standards and guidelines shall be observed regarding hydrogen containing equipment where Australian Standards do not cover specific requirements.

Table 6: Standards and Guidelines

Australian Standard	Title
AS/NZS 1170.0	Structural Design Actions – General Principals
AS/NZS 1170.1	Structural Design Actions – Permanent, Imposed and Other actions
AS/NZS 1170.2	Structural Design Actions - Wind Actions
AS/NZS 1170.4	Structural Design Actions – Earthquake
AS 1596	The storage and handling of LP Gas
AS 1768	Lightning Protection
AS 2885.1 (1)	Pipelines – Gas and Liquid Petroleum - Design and Construction
AS 2885.3 (1)	Pipelines – Gas and Liquid Petroleum - Operation and Maintenance
AS/NZS 2885.5 (1)	Pipelines – Gas and Liquid Petroleum - Field Pressure Testing
AS/NZS 3000	SAA Wiring Rules
AS/NZS 3008	Electrical Installation – Selection of Cables - Cables for alternating voltages up to and including 0.6/1 kV
AS 3600	Concrete Structures
AS 4041	Pressure Piping
AS 4100	Steel Structures
AS/NZS 60079.10.1	Classification of areas – Explosive gas atmospheres
AS/NZS 60079 Series	Electrical equipment in hazardous area
NCC 2019	National Construction Code
International Standard	**Title**
ASME B31.12	Process Piping - Hydrogen
ASME B16.5	Pipe, Flanges and Flanged Fittings
ASME B16.21	Non-metallic Flat Gaskets for Pipe Flanges
ASME B1.20.1	Pipe Threads, General Purpose, Inch
ASME VIII	Boiler and Pressure Vessel
NFPA 2	Hydrogen Technologies Code
Hydrogen Plant	**Reference Standard and Title**
Electrolyser	• ISO 22734 Hydrogen generators using water electrolysis process -- Industrial, commercial, and residential applications • ISO 14687:2018 Hydrogen fuel quality – product specification
Gas Panel (and other exposed tubing)	• NFPA 2 Hydrogen Technologies Code • AIGA 033/14 Hydrogen Pipeline Systems (for pipeline pressures between 10bar and 210bar)
Buffer Store	• IGA 15/96 Gaseous Hydrogen Stations • ISO 19884 Gaseous Hydrogen - cylinders and tubes for stationary storage • ASME B31.12 Hydrogen Piping and Pipelines
Hydrogen Refuelling Station	• EIGA 15/96 Gaseous Hydrogen Stations • ISO 19880 Gaseous hydrogen fuelling stations • AIGA 087/14 Standard for Hydrogen Piping Systems at User Locations • SAE J201-2 Fuel Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles

Note (1) Although AS 2885 does not apply to hydrogen service, the general intent and operational considerations shall be observed in lieu of dedicated Australian hydrogen pipeline standards.

2.8 SECURITY AND PROTECTION AGAINST UNLAWFUL ENTRY

The SCADA system shall be used to monitor the site security. All entry points including to the PLC and communication cabinets shall be monitored and an alarm raised when the panel doors are opened. This alarm will be annunciated on the SCADA system. Typical entry points:

- Site entrance
- Emergency access gate
- Gas / Fire detection
- Building entrance
- PLC / Communications Cabinet

2.9 MANNING

The plant will not have a permanent operator presence and is designed to operate autonomously.

Operator attendance will be required to clear an ESD. The plant will be controllable remotely via SCADA.

2.10 LIGHTNING PROTECTION

Lightening protection for the site will be in accordance with AS 1768.

3 SAFETY FEATURES

The inherent risks associated with high pressure gas facilities are managed in accordance with the principles of operational safety through design. The main philosophies that have been adopted to avoid potential high risk situations associated with the operation of this facility are to eliminate the potential risks through design and to ensure appropriate quality control during construction.

3.1 DETECTION OF AN UPSET CONDITION

The operating philosophy for the facility, as detailed in the control philosophy and test plan (P2G-2099-RP-IE-001) is to employ remote telemetry to observe and monitor performance. The site will not have a permanent operator presence and is designed to operate autonomously.

In the event of equipment failure the system is designed to automatically isolate and allow only the natural gas network flow to continue uninterrupted. The telemetry system will provide data via SCADA, which in turn will alert the control room staff of the condition of the site prompting a response in line with the response sheet for the site. Operator attendance will be required to clear an ESD. The plant will be controllable remotely via SCADA.

3.2 GAS LEAK PREVENTION AND PROTECTION

The facility has been designed and constructed in accordance with the requirements of Australian Standards, codes and practices. In general, leaks of natural gas or hydrogen from pipes and equipment are prevented through the following features:

- Minimising the number of flanges and threaded connections, with welded connections and hydrogen suitable compression fittings to be used wherever possible.
- Stringent requirements for material & fabrication inspection prior to fabrication of pipe.
- Non-destructive (x-ray or ultrasonic) testing of welds during construction.
- Hydrostatic testing of equipment prior to commissioning.
- Design and selection of soft components e.g. gaskets, Swagelok compression fittings, threads, valve internals will be selected in conjunction with vendors to ensure hydrogen compatibility.
- Creating a preventative maintenance and inspection program for all equipment and valves associated with the station.
- Leak inspection of above ground hydrogen piping systems (e.g. with helium or other suitable method) prior to commissioning with hydrogen.

Prevention of mechanical failure of above ground equipment due to external impact is achieved through the following:

- Defined access roads
- Access requirements considered when specifying the equipment layout
- Bollards are provided to protect above ground piping from vehicle impact.
- External facility fence to provide security for high risk assets via separation from the general public.

For external interference threats to the buried pipeline, the following safeguards will be in place:

- The buffer store pipeline will be installed within Jemena's new high security fence to provide exclusion from credible third party interference threats.
- The site is operated by Jemena – any work will be under direct supervision (incl. requirements to consult engineering prior to digging / trenching /placing load on site) and subject to work permits.
- Pipeline marker signs indicate the buried pipeline route.
- Company procedures. Jemena procedures require positive location of the pipeline prior to dig-

up, and then restrict the use of mechanical equipment within 500 mm of the pipe wall.

- Marker tape above buried pipe provides pre-warning in case of digging.
- The pipe is expected to resist penetration based on design from;
    - Excavators up to 55 t in weight, fitted with general purpose teeth
    - Excavators up to 25 t in weight, fitted with tiger teeth. For excavators weighing 30 to 55 t using tiger teeth, it is expected that only one tooth will penetrate the pipe.
    - Dozer rippers up to 5 t weight, fitted with single point penetration teeth.

Corrosion prevention achieved for above ground equipment as follows:

- Hydrogen and natural gas are clean and dry gases with a low risk of causing internal corrosion.
- Facility piping is stainless steel, which is less susceptible than carbon steel to external corrosion.

Corrosion prevention achieved for the buried pipe as follows:

- Buried pipeline is coated with fusion bonded epoxy and STOPAQ joint coating and thick walled.
- Buried pipeline is provided with cathodic protection (with regular inspection and monitoring).

Prevention against degradation from hydrogen (e.g. hydrogen embrittlement) as follows;

- Facility piping is 316 stainless steel, which is less susceptible to hydrogen embrittlement.
- Buried pipe is designed with low design factor and relatively low-strength grade (X52) material to ensure low stress conditions to protecting against rupture due to hydrogen embrittlement.
- Assessment of the loss of fatigue life due to embrittlement has been completed, confirming that the fatigue risk is significantly beyond the operating profile for the pipeline.

Prevention of overpressure is managed as follows:

- Where a source of pressure is capable overpressuring downstream equipment, a pressure switch to initiate closure of an XSV in the event of a control valve failure, to isolate the source from downstream lower rated piping or equipment is included in the design. The switches are local, hardwired and act independently of the Programmable Logic Controller (PLC). A Layers of Protection Analysis assessment has been completed on overpressure instrumented functions (Ref 9).
- Buried pipeline will be designed to withstand considerable overpressure by being thick walled, welded & hydrotested well above required design limits.

3.3 HYDROGEN LEAK DETECTION

The following locations will be fitted with gaseous hydrogen detection systems:

Table 7: Hydrogen Leakage Sensors

Location	Requirement
Electrolyser	Leak detector located by supplier with high alarm back to Control Room and High-High to automatic local shutdown.
Gas Panel and Injection Panel	Leak detector located in the enclosure high point with alarm back to Control Room and alarm to indicate a leak.

Location	Requirement
High Pressure Storage and Refuelling Station	Leak detector located in roof/canopy high point with high alarm back to Control Room and High-High to automatic local shutdown. Additionally, the PLC program will show a fault if the cascade pressure drops unexpectedly. This will isolate the buffer storage and vent off the lines, unless the leak is from the buffer connection, in which case that buffer is vented. During any of these incidents the extraction fan will ramp speed up, removing the hydrogen from inside the Hydrogen Refuelling Station package (HRS).

Additionally the following actions were taken in the Balance of Plant HAZOP regarding leak detection:

- Include a short-term isolation function has been added to the design and will be included as a routine test in operating procedures. This isolates the system for 15 minutes and monitors pressure change during shut-in to detect a leak
- Any hydrogen leak detection will initiate a local beacon/siren. The siren will interlock with facility gate and will alarms upon attempted entry.
- Include a pressure switch low low (PALL-06015) to shut down the electrolyser in the event of a significant downstream pressure loss.

3.4 SEPARATION DISTANCES

Equipment within the WSGGT will be generally arranged following a logical process gas flow. Pipe racks will be provided for routing process piping, providing plant services and electrical and instrumentation routes. Pipe racks will be located close to grade away from vehicle access routes.

The set-out of the process equipment shall consider maintenance and access requirements and separation distance requirements to minimise risk of escalation of emergency events.

Utility systems will be co-located outside of hazardous areas wherever possible.

The control room/office/amenities and maintenance facilities shall be located adjacent to the local access road.

The layout shall consider requirements for the future electrolyser stack and balance of plant piping for the additional 100 Nm^3/h of hydrogen gas production.

An outcome of this report is to determine the required separation distance for equipment with potentially fatal offsite consequences and to ensure such consequences do not extend beyond the site boundary at grade in the vicinity of the general public or adjacent residents or land holders.

3.5 FIREWALLS

Firewalls are to be designed to achieve a Fire Resistance Level (FRL) of 240/240/240 in accordance with AS 1596 “The storage and handling of LP Gas”. While AS 1596 is not specific to hydrogen stored under pressure, a comparative review of AS 1596 against American standard NFPA 2 “Hydrogen Technology Code” has determined 240/240/240 to be more conservative.

Firewalls are to be free standing and able to withstand ultimate and serviceability loads as defined in AS 1170 primarily wind and earthquake. The FRL for the wall is to be in accordance with the National Construction Code and the Australian Standard applicable to the structural and or non-structural material being designed for (i.e. AS 3600 for concrete structures and AS4100 for steel structures).

Firewalls are to be constructed in order to prevent the spread of fire due to either flash or jet fire events as described in this report. Therefore, firewall separation distances and sizes are to be sized in accordance with distances determined as part of the consequence analysis modelling and where consequence analysis modelling provides no guidance, AS 1596 and/or NFPA 2 is to be adopted with the most conservative result being selected.

Firewalls are to be designed to withstand normal loads in accordance with AS 1170 only and not designed to act as blast resistant structures. Explosion risk is to be managed by prevention methods and firewalls are to be designed to ensure they do not increase risk of explosion.

A firewall will be installed around the hydrogen high pressure storage to remove potential offsite consequences. Detailed design will confirm required specifications of the firewall.

3.6 CONTROL OF IGNITION SOURCES

Ignition sources are controlled through:

- Design of site and equipment as per Hazardous Area requirements
- Earthing of all equipment to an earth grid
- All electrical equipment having surge diverters installed for protection of the control system
- Adherence to the Permit to Work requirements (including Hot Work permit).
- Prohibiting smoking or naked flames allowed on site and specifying no spark ignition vehicles allowed in designated hazardous areas
- Delineated area with bollards and warning signs, as per Australian Standards requirements

Additionally, a HAZOP action was identified for Jemena to conduct a review to determine if any modifications to their existing ignition control management procedures are required such as antistatic/flame retardant clothing, non-sparking tooling specific to hydrogen and oxygen service.

3.7 PLANT ISOLATION

Emergency shutdown of the facility can be triggered by the following (to be further assessed during detailed design):

- Electrolyser package
    - Gas detection
    - Fire detection
- Remote SCADA ESD push button
- Physical onsite ESD push button
- Greater Horsley Park facility ESD
- Automatic leak detection from refueller dispenser
- Automatic leak detection from high pressure storage compressor
- Emergency shutdown will result in all packages and systems reverting to their fail safe position.

There is no provision for automatic blowdown of the hydrogen storage pipeline due to the short length and limited inventory – pipeline blowdown is via a dedicated manual blowdown vent.

Refer to the WSGGT Control Philosophy, Ref 15.

3.8 HYDROGEN HIGH PRESSURE STORAGE AND REFUELLING STATION – SAFETY SYSTEMS

Vendor details for the Hydrogen Refuelling Station (HRS) are yet to be confirmed. The following preliminary information has been provided which will be confirmed in detailed design by the vendor when the inclusion of refuelling is confirmed in the project scope:

Safety Instrumented Systems

The Emergency shutdown (ESD) will be a hardwired system, directly isolating power to the relevant control devices, and be independent from the PLC system. The safety circuits should comprise of PILZ™ manufactured components, or similar, and will be designed to meet the assessed required safety criteria.

The PLC logic will monitor the safety circuits and mimic the operation of the hardwired system in de-energising appropriate outputs and will require operator prompt following ESD reset before equipment can resume operation.

Safety Philosophy

The HRS will operate under a 4-tier safety philosophy that will be constantly monitored by the Safety Device that is monitored by the PLC.

Tier 1 – Minor Fault / Soft Stop: Triggered by an out of specification reading from a sensor or a soft stop signal from another source.

- Safety / Integrity of the HRS is not deemed to be at risk.
- Processes related to the origin of the fault signal are paused.
- Dispensing may still be permitted depending on where the fault has originated.
- System able to automatically resume once out of specification signal is no longer present and has not been present for a pre-determined period.
- Fault code recorded in PLC.

Tier 2 – Major Fault / Hard Stop: Triggered by an escalation of a Tier 1 fault or a hard stop signal from another piece of equipment.

- Safety / Integrity of the HRS may be at risk.
- Related process stopped immediately.
- Dispensing not permitted.
- Gas pipework in relevant process vented.
- Intervention required to re-start system (can be physical or remote).

Tier 3 – Emergency Stop Activation: Triggered by the activation of a manual Emergency Stop call point

- Safety / Integrity of the HRS may be at risk.
- Related process stopped immediately.
- Dispensing not permitted.
- Gas pipework in relevant process vented.
- Manual Intervention required to re-start system

Tier 4 – Fire Detection System Activation*: The Fire detection system will be activated automatically upon the detection of a fire or by the activation of a manual fire call point

- Safety / Integrity of the HRS is at serious risk
- All process' put into hard stop.
- All gas pipework is vented.
- All equipment is mechanically isolated.
- Hydrogen storage is discharged.

* NOTE: Loss of power to the HRS can cause an activation of the fire safety system, a 24-hour duration UPS battery backup will be fitted.

3.9 FIRE DETECTION AND SUPPRESSION

The site shall be adequately equipped with fire detection (as per ISO 26142) and compliant to federal and state requirements, local planning conditions and Australian Standards as minimum.

It is assumed no fire suppression is required given the low inventory of fuel gas stored in instrument tubing above ground.

Infrared cameras will be installed on site and personnel accessing the facility with be provided with portable infrared cameras.

3.10 FIRE PREVENTION – GENERAL

Fire extinguishers are provided at the WSGGT facility as required.

The existing Control Building and new Plant Building have been designed following the requirements under the Australian Building Code.

3.11 PREVENTION FROM EXPOSURE TO HARMFUL MATERIAL

There will be very limited amounts and types of potentially harmful material available at the facility. . Nitrogen will be available for equipment purging. Nitrogen can displace oxygen and cause rapid suffocation. Jemena will manage nitrogen use using existing procedures and practices. Compressed natural gas and hydrogen are harmful if allowed to escape, due to their flammability. These risks are well understood and managed by the people performing the maintenance tasks, and procedures and work permit systems are in place. There are also requirements for PPE, such as the use of gloves, safety glasses etc. Further, a Permit to Work system applies on site.

3.12 BUSH FIRE PROTECTION

The WSGGT facility will be gravelled and kept clear for several metres beyond the site perimeter.

In the event of a bush fire, the hydrogen plant will be remotely shutdown by control room operators.

3.13 PROTECTION IN CASE OF LOSS OF SERVICES

Supply of hydrogen to customers is not critical; interruption to hydrogen supply will not impose a contractual loss as the facility is for demonstration purposes only.

Mains electrical power is supplied to the site. All critical instruments, safety systems, and control systems in the balance of plant will be powered by a DC UPS (Direct Current Uninterruptible Power Supply), powered directly from a battery bank (24V DC). The battery bank will be designed to supply power for critical instrumentation, control and equipment for up to 3 hours for balance of plant equipment. A 0.5 hour uninterruptible power supply (UPS) is used in electrolyser for control/communications and will return instruments to a safe condition so that monitoring of parameters can continue while site is shut down. Backup power will supply lighting of exit signs in enclosures. Loss of power to the Refuelling Station can cause an activation of the fire safety system, a 24-hour duration UPS battery backup will be fitted to prevent this.

Valves will be opened and shut using instrument air or natural gas. In case of loss of power gas to the actuator, the valves will be designed to fail safely (either open or close depending on their duty).

3.14 PREVENTION OF FLOODING ON SITE

Flooding in this area is regarded as a low risk scenario from a land use planning point of view.

The drainage system at the WSGGT will be considered in the detailed design, with suitable hardstand slope and drainage channels to avoid water ponding on site.

3.15 ROAD TRANSPORT RISKS

Road transportation would use Chandos Rd and then turn north into the access road to the site, adjacent the existing gate entry to the Horsley Park site.

Regular access to the site will be required by:

- Busses for refuelling – three times per day
- Tankers for load out of water waste from RO Plant

These two facilities will be installed outside of Jemena's main security fence line and protected by local bollards.

Other than this, under normal operating conditions the existing facility is unmanned and requires only infrequent vehicular access. Increased site access is required during facility maintenance activities, including heavy vehicles trips associated with site deliveries. Such activities occur infrequently.

3.16 SAFETY MANAGEMENT SYSTEMS

Jemena have a commitment to workplace health and safety and have numerous policies and procedures to achieve a safe workplace. Their established safety management system will be applied to this new facility.

An incident reporting and response system is established, providing 24 hour coverage.

The WSGGT Plant needs to comply with all codes and statutory requirements with respect to work conditions. Special precautions are observed as required by the site conditions, in particular, standards and requirement on the handling of pressurised, flammable gases. All personnel required to work with these substances are trained in their safe use and handling, and are provided with all the relevant safety equipment. Emergency procedures will be developed and personnel are trained to respond to emergencies. Response plans will be updated to include remote shutdown of hydrogen facility in the event of a fire at a neighbouring facility or in the adjacent bush.

The site will have operations manager with overall responsibility and who is supported by experienced personnel trained in the operation, maintenance and support of the facility.

A Permit to Work system (including Hot Work Permit for any work that could provide an ignition source) and control of modification systems will be in use on site to control work and to control plant and structure from substandard and potentially hazardous modifications. The existing hot work permitting system will be reviewed for hydrogen and oxygen service.

Protective systems are inspected and tested to ensure they are, and remain, in a good state of repair and function reliably when required to do so. This will include scheduled testing of shutdown valves, trips and alarms, and relief devices.

All persons on the premises will be provided with appropriate personal protective equipment suitable for use with the specific hazardous substances.

A first aid station will be provided comprising an appropriate first aid kit and first aid instructions, i.e. Material Safety Data Sheets (MSDS), for all substances kept or handled on the premises.

Refer Safety Management Manual GAS-999-OM-HSE-001 for additional details.

4 PIPELINE INTEGRITY & IMPACTS TO DOWNSTREAM USERS

The potential impacts to the distribution network downstream of the injection point at the Horsley Park Trunk Receiving Station have been summarised in Document P2G-2099-RP-RM-004.

This includes the Sydney Secondary Mains distribution network, including the downstream medium and low pressure mains and the downstream industrial commercial and domestic users when:

- Hydrogen of up to 2% (by volume), the target injection percentage, is added to the natural gas mixture.
- Hydrogen of up to 10% (by volume) is temporarily released into the network. This scenario is only possible during failure of the hydrogen injection flow control valve and coincident low flow of natural into the Secondary Mains. A shutdown has been included in the design to isolate hydrogen injection in the event of low natural gas flow for a predetermined set point to limit volume to less than 10%.

The assessment includes analysis of the impacts of 2-10% hydrogen on the following:

- **Network materials**; including the carbon steel Secondary Mains and downstream polyethylene, nylon, cast iron, and carbon steel low pressure and medium pressure mains.
- **Gas composition & quality**; including assessment against the requirements and limits of AS 4564 and analysis of the change in properties introduced by the blend.
- **Safety**; including impact on gas build-up in buildings, radiation distance and odorisation.
- **Downstream user appliance operation**; including domestic, commercial and industrial cases.

Management of the impacts will be further assessed independently to this report in Jemena's Safety and Operating Plan (SAOP).

5 STUDY METHODOLOGY

5.1 HAZARD ANALYSIS METHODOLOGY

5.1.1 Introduction

The methodology for the PHA is well established in Australia. The assessment has been carried as per the DP&E's HIPAP No. 4 (Ref 1) and HIPAP No. 6 (Ref 2). These documents describe the methodology and the criteria to be used in PHAs, as required by the DP&E for major "potentially hazardous" development. There are five stages in risk assessment (as per Ref 2):

1. Hazard Identification:

   Review of possible accidents and impacts that may occur based on previous experience, industry research and judgements.

2. Consequences and Impact Analysis

   Define the characteristics of the identified possible accidents and the facility thresholds for each consequence type e.g. jet fire, flash fire, vapour cloud explosion.

3. Frequency Analysis

   Define the probability of the identified possible consequences

4. Risk Analysis

   Define the acceptable risk levels and compare against the determined location specific individual tolerable risk targets.

5. Review Mitigation Options

   Review options for mitigation or management where tolerable limits have been exceeded.

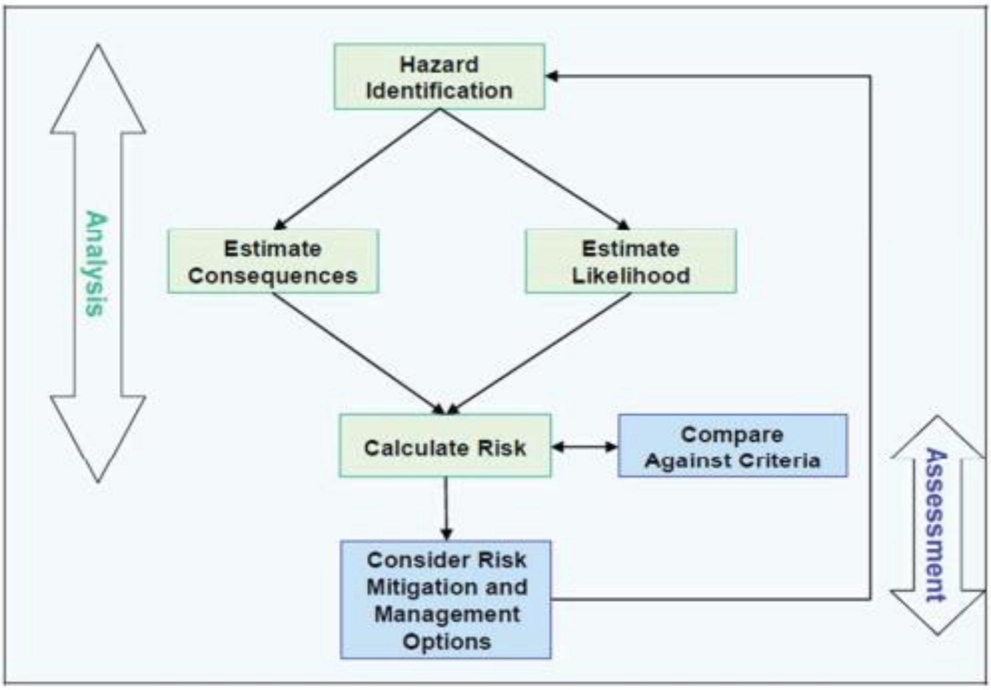

Figure 8: Hazard Analysis Methodology

6 HAZARD IDENTIFICATION

6.1 HAZARDOUS MATERIALS

6.1.1 Hydrogen

Hydrogen is flammable over a very wide range of concentrations in air (4 – 75%) and is explosive over a wide range of concentrations (15 – 59%) at standard pressure and temperature. As a result, even small leaks of hydrogen have the potential to burn or result in an explosion. Where leaked hydrogen can accumulate in an enclosed environment, the risk of combustion and explosion is significantly increased. Hydrogen flames are very pale blue and are almost invisible in daylight due to the absence of soot.

The hydrogen molecule is smaller and lighter than that of all other gases, and therefore is highly buoyant in air and diffuses easily. Leaking hydrogen will rise and become diluted quickly, especially outdoors.

Prolonged exposure to hydrogen can affect some materials to compromise their facture and fatigue properties. In particular, carbon steel and other metals can experience hydrogen embrittlement. Hydrogen embrittlement is primarily exhibited by a reduced tolerance to defects, reduction in fracture toughness, loss of ductility and a reduction in fatigue life; this can be accommodated in design by ensuring that materials are defect-free, selecting materials that are more resistant to embrittlement (i.e. stainless steel) by keeping the stress in the material low, and by avoiding cyclic loading. Factors known to influence the rate and severity of hydrogen embrittlement include hydrogen concentration, pressure, the chemical composition of the equipment material, stress level, metal tensile strength, grain size and microstructure (Ref 7).

The storage quantity of hydrogen on site will be approximately 280 kg including the buffer storage and high pressure hydrogen storage.

Table 8: Properties of Hydrogen Gas

Property	Value
Molecular weight (g/mole)	2.02
Relative density of the gas (atmospheric temp. and pressure)	0.07
Heat of combustion (MJ/kg)	119.9
Flammable range (vol. % in air)	4 – 75%
Ratio of specific heats (Cp/Cv)	1.4
Flash point	Gas
Auto-Ignition Temperature	560 °C
UN Number	1971

6.1.2 Natural Gas

The natural gas to be present in the facility is composed predominantly of methane gas (>92 mole %) with the residual mainly ethane (approx. 4 mole %) and carbon dioxide (<2 mole %). The properties of natural gas are represented by methane and are presented in Table 9.

There is no storage of natural gas on site beyond the inventory in the adjacent Horsley Park facility piping and buried EGP transmission pipeline and distribution pipelines.

Table 9: Properties of Methane Gas

Property	Value
Molecular weight (g/mole)	16
Relative density of the gas (atmospheric temp. and pressure)	0.55
Heat of combustion (MJ/kg)	50
Flammable range (vol. % in air)	4.4 to 17
Ratio of specific heats (Cp/Cv)	1.31
Flash point	Gas
Auto-Ignition Temperature	595°C
UN Number	1049

6.1.3 Oxygen

Oxygen reacts with most materials. The higher the oxygen concentration and pressure in the atmosphere or in an oxygen system then:

a) the more vigorously a combustion reaction or fire takes place;
b) the lower the ignition temperature and ignition energy to get a combustion reaction started; and
c) the higher the flame temperature and destructive capability of the flame.

Some materials that do not burn in air, including some fire resistant materials, can burn vigorously in oxygen-enriched air or pure oxygen. Oxygen enrichment of the atmosphere can occur in the vicinity of oxygen vents. Areas near oxygen vents can be particularly hazardous.

In enriched oxygen atmospheres, a common combustible material that most directly affects safety of personnel is clothing. All clothing materials will burn fiercely in oxygen enriched atmosphere. The same applies to plastics and elastomers (Ref 8).

There is no storage of oxygen on site. Oxygen will only be present in the Electroylser building where it is contained and vented to a safe location above the height of the electrolyser package.

Table 10: Properties of Oxygen Gas

Property	Value
Molecular weight (g/mole)	32
Relative density of the gas (atmospheric temp. and pressure)	1.11
Heat of combustion (MJ/kg)	N/A
Flammable range (vol. % in air)	N/A
Ratio of specific heats (Cp/Cv)	1.4
Flash point	N/A
Auto-Ignition Temperature	N/A

6.2 HAZARD IDENTIFICATION

A Hazard Identification (HAZID) and Hazard and Operability (HAZOP) studies were completed on the Balance of Plant FEED on the 25th and 26th July and were attended by representatives from Jemena, GPA Engineering, ANT and Hydrogenics. Minutes from these workshops can be seen in Appendix 1 and Appendix 2.

The objective of these reviews was to identify all significant hazards associated with a proposed activity with a view to eliminating or reducing hazards though the application of inherent safe design at an early stage of the project.

The methodology used in these reviews is as follows:

- In a facilitated session with subject matter experts, a set of predetermined guidewords is used to prompt the team to identify potential hazardous events
- The potential consequences of the events are then identified – safety, environmental and or financial
- The existing/proposed (in the design) safeguards are identified
- If the safeguards are considered inadequate, further actions are proposed to reduce the risk

Following the HAZID/HAZOP, a layer of protection analysis (LOPA) was undertaken on the following three identified safety instrumented functions to determine if Safety Integrity Levels were required.

- High-High Injection Pressure PAHH-06006 closing XSV-06001.
- High-High gas fuelled generator Hydrogen Fuel Gas Pressure PAHH-03006 closing XSV-03001.
- High Hydrogen Injection protection of the downstream distribution network, detected by FAHH-06007 closing Hydrogen Injection Isolation Valve XSV-06001 via the PLC.

Of these functions, one was assigned a SIL 1 based on safety criteria (FAHH-06007). Details of the study can be found in SIL Study Report P2G-2099-RP-RM-001 (Ref 9). The purpose of this function is to prevent injection in excess of specifications into the natural gas network.

An AS2885 Safety Management Study (SMS) was conducted on the 9th September 2019 for the buffer storage pipeline (Ref 9), meeting the requirements of AS.NZS 2885.6. The SMS catalogued all identified threats to the pipeline and how those threats are to be controlled.

A HAZOP (Ref 11) was conducted by the vendor (Hydrogenics) for the Electrolyser Package on the 9th September 2019. Minutes from this workshop can be seen in Appendix 3.

Future Safety in Design Studies are scheduled to occur throughout this project and include:

- 60% and 90% Design Reviews
- HAZOP for the Gas Microturbine
- HAZOP for the High Pressure Storage and Dispenser Refueller package

The objective of these reviews is to identify all significant hazards associated with the design, with a view to eliminating or reducing hazards through the application of inherently safe design early enough in the process to minimise any impacts on cost and schedule.

The outputs of the hazard studies conducted to date have been summarised in a Hazard Identification Word Diagram which can be seen in Section 6.3.

6.3 SUMMARY OF HAZARDS IDENTIFIED

The following Hazard Identification Word diagram has been prepared using inputs from the HAZID and HAZOP workshops and equipment vendors:

Table 11: HAZID Word Diagram

Facility Event	Cause/Comment	Possible Results/Consequences	Prevention/Detection Required
Release of flammable gas from pipes, equipment, valves, fittings, tubing	Corrosion (external or internal); flange of valve leak, failure in maintenance procedure	Loss of containment of hydrogen gas. Hydrogen is lighter than air and will disperse into the atmosphere. If ignition occurs there is potential for a fire.	Prevention of corrosion failure or failure due to embrittlement is achieved as follows: • Buried pipe is designed with low design factor and relatively low-strength grade (X52) material to ensure low stress conditions protecting against rupture due to hydrogen embrittlement. This pipe is also coated and has cathodic protection and will have an established integrity management plan. • There is a further action to review requirements relating to hydrogen-assisted fatigue crack growth (HA-FCG), relating to defect inspection, weld defect tolerances, and monitoring etc. • Facility piping is stainless steel, which is less susceptible than carbon steel to hydrogen embrittlement. It is also operating under low stress conditions which will prevent a rupture. • Design and selection of soft components e.g. gaskets, Swagelok, threads, valve internals will be done in conjunction with vendors to ensure hydrogen compatibility. • Hydrogen and Natural gas are clean dry hydrocarbons with a low risk of internal corrosion.
Release of flammable gas during commissioning	Design, material and or construction defects	Loss of containment of hydrogen gas. Hydrogen is lighter than air and will disperse well into the atmosphere. If ignition occurs there is potential for a fire.	All new equipment will be hydro tested. Prefabricated and site installed piping systems will be leak tested with air, nitrogen or helium. Jemena and subcontractor quality control procedures will be applied.

Facility Event	Cause/Comment	Possible Results/Consequences	Prevention/Detection Required
Release of flammable gas due to external impact – above ground equipment	Mechanical damage caused by external impact e.g. vehicle or dropped object	Loss of containment of hydrogen gas. Hydrogen is lighter than air and will disperse into the atmosphere. If ignition occurs there is potential for a fire.	Design will propose a layout which minimises vehicle traffic whilst considering access requirements for maintenance/production etc. A further layout review will be conducted to minimise the potential for vehicle impact. Bollards will be installed where required; specifically there will be a defined exclusion zone around the pipeline risers. Other exclusion zones will be defined and a light barrier installed to demark. The proposed layout will also be reviewed against existing buried services to determine optimum locations for vehicle access to the site. A specific vehicle turnaround access will be provided for water storage tank load-out. Laydown areas for construction will be allocated in development of the layout. Jemena lifting procedures will be applied for any heavy lifts, including requirement to isolate and depressure equipment during lifts if required.
Release of flammable gas due to external impact – buried pipe	Mechanical damage caused by external impact e.g. excavator, vehicle or dropped object	Loss of containment of hydrogen gas. Hydrogen is lighter than air and will disperse into the atmosphere. If ignition occurs there is potential for a fire.	The site is operated by Jemena – any work will be under direct supervision (incl. requirements to consult engineering prior to digging / trenching /placing load on site) and subject to work permits. The buried buffer store pipeline will be installed wholly within Jemena's high security fenceline. Pipeline marker signs indicate the buried pipeline route. Company procedures. Jemena procedures require positive location of the pipeline prior to dig-up, and then restrict the use of mechanical equipment within 500 mm of the pipe wall. Marker tape above buried pipe provides pre-warning in case of digging. The pipe is expected to resist penetration from -Excavators up to 55 t in weight, fitted with general purpose teeth -Excavators up to 25 t in weight, fitted with tiger teeth. For excavators weighing 30 to 55 t using tiger teeth, it is expected that only one tooth will penetrate the pipe.
Release of gas due to propagation from neighbouring plant incident	Bushfire, and knock-on effects from adjacent facilities (this plant is within radiation contour of adjacent facilities). Propagation damage from neighbouring facilities eg thermal radiation, projectiles	Damage to equipment, Hydrogen facility potentially harmed if a pipeline incident occurs, but will not cause escalation beyond the existing risk.	Hydrogen facility will be manually shutdown in the event of a neighbouring facility fire. Emergency response plans will be created/updated to include remote shutdown of hydrogen facility in the event of nearby fire.

Facility Event	Cause/Comment	Possible Results/Consequences	Prevention/Detection Required
Release of flammable gas due to overpressure	PLC error or failure, pressure control failure, operator error.	Loss of containment of hydrogen gas through flanges, fittings, connections, piping. If ignition occurs there is potential for a fire.	Prevention of overpressure is through basic process control and local hardwired trips, independent from the PLC, isolating pressure sources. Piping and equipment are designed with adequate wall thickness and are hydrotested.
Explosion/flash within piping	Human error. Air ingress following commissioning or maintenance.	Explosion/flash within piping	Strict use of nitrogen purging after maintenance to be enforced in hydrogen service, and included in all start-up/re-commissioning operating procedures. Competency based training module will be developed and made a compulsory requirement for hydrogen service operators. A register will be created for management of accredited personnel. Jemena will ensure regular field auditing of procedural activities occurs for the new facility. This will occur more intensively during initial operation.
Fire/Explosion/Incident within Electrolyser Building	Overpressure, corrosion, external impact	Jet fire/explosion within the building	The Electrolyser building is equipment with an exhaust fan which will ensure continuous purging flow through the electrolyser building enclosure. Detection of exhaust fan failure will initiate an ESD in Electrolyser building. Hydrogen gas detectors are also fitted in the building and will initiate an ESD if hydrogen is detected.
Oxygen enriched fire	Loss of containment of oxygen within or from electrolyser building	Loss of containment of oxygen gas through flanges, fittings, connections, piping.	All oxygen vents from the electrolyser are designed to be at a height promoting dispersion and are located at a safe distance from hydrogen vents. A procedure will be created for management of spare parts specific for hydrogen and oxygen service. A HAZID action was recorded for Jemena to contact existing hydrogen/oxygen industries (industrial gases) to further understand specific risks and risk management controls for this application.
Electrical flash/explosion	Arc flash may occur due to electrolyser current discharge. Considered a low risk in this application. Failure of battery on generator or the two UPS's	Personnel injury. Stored energy release if battery fails. Potential for fire/explosion.	The Electrolyser vendor will minimise potential for arc flash in the electrical design. There is a HAZID action to determine if arc flash detection is required and if so to include it in the design. GPA are also reviewing their design regarding arc flash requirements. Jemena and battery vendor management procedures to be applied for battery management. Preventative maintenance work orders to be created for battery inspection/testing.

Facility Event	Cause/Comment	Possible Results/Consequences	Prevention/Detection Required
Malicious damage; theft etc.	Intruders/ vandalism	Damage to equipment	Secure location, away from the roadside, on an existing industrial facility. Signposting will not draw unwanted attention to the facility. Facility will be fenced and locked with authorised personnel entry only signage. Jemena is carrying out an action to review designs from a site security perspective.
Third Party Impact	Aircraft crash / false landing. This site is in vicinity of training area with light aircraft.	Damage, loss of containment, fire.	General aircraft safety regulations make the event of a crash unlikely. The plant has a relatively small footprint making it unlikely to be hit in the event of a crash. Determine if the facility is directly under any new flight paths and potential consequences. Liaise with relevant authorities.
High Pressure Hydrogen Storage	Overpressure, external impact, corrosion, defects	Loss of containment of hydrogen gas.	This area will have automatic leak detection which will activate an ESD as well as the provision of multiple manual ESD buttons at various locations around the site. There will be a manual ESD button located at the Refueller dispenser which will shut down and isolate this equipment. For the compressor, both inlet and outlet pressure will be monitored by a pressure indicator/switch, with the control system instigating a shutdown of compressor on detection of a leak. The high pressure storage will be located in the north west corner of the site at a maximum possible separation distance from the refueller dispenser. A firewall will be installed on the eastern side to prevent any potential offsite consequences from occurring.
Refueller	Bus drives away still connected Flexible filling hose failure	Loss of containment of high pressure hydrogen, personnel injury.	Prior to any system being despatched, a full leak check of the entire system will be conducted followed by a factory acceptance test programme with Hydrogen. Additionally: • The refueller nozzle will be fitted with a break-away device that stops the flow of gas • A leak check will be conducted before every dispense process to confirm hose integrity • The PLC program and mass flowmeter will measure the flow of hydrogen and stop the system if fill deviates outside of expected parameters i.e. in the instance of a leaking hose during dispensing Dispensers will have automatic shut-off in the event of a line break and there will also be remote emergency shutdown buttons around the site that will isolate the dispenser from the high pressure storage. Activation of the emergency shutdown function shall cut off the flow of hydrogen gas to the dispenser and vehicle which initiated the shutdown by closing the automatic isolation valves.

Facility Event	Cause/Comment	Possible Results/Consequences	Prevention/Detection Required
Microturbine Overpressure in turbine	Failure of upstream pressure regulators	Loss of containment of fuel gas. Both fuel sources are lighter than air and will disperse well into the atmosphere. If ignition occurs there is potential for a fire.	Active-monitor pressure regulator arrangement; regulators fail closed. Maximum pressure from upstream is 1,050 kPag (10% above transient is possible), and generator is actually rated for 1,000 kPag. The likelihood of exceeding full rating is low. Local independent hardwired trips PAHH03006 (hydrogen fuel), PAHH03012 (natural gas fuel) set at 1,000 kPag closes upstream XSV. HAZOP action taken to check with turbine manufacturer to test and re-rate/certify to 1,050 kPag.
Microturbine/Refueller compressor - Small fitting failure	Vibration or fatigue failure of small fittings.	Loss of containment of fuel gas. Both fuel sources are lighter than air and will disperse well into the atmosphere. If ignition occurs there is potential for a fire.	High vibration switches will shut down the microturbine. Small fittings to be designed with minimal weight/load stress and pipe supports. Jemena to implement a routine vibration monitoring program.

6.4 SCENARIOS FOR CONSEQUENCE MODELLING

A number of scenarios were identified in the HAZID and HAZOP studies that could lead to a loss of containment of flammable gasses. The scenarios chosen for consequence modelling are shown in Table 12. The logic for the selection of scenarios is described below:

All above ground pipework in the production and refuelling facilities is 25 mm NB or 15 mm NB for the High Pressure Hydrogen Storage/Refueller areas and therefore any leaks are likely to be small. For frequent small releases (level 1) the EI Model (Ref 12) recommends using a hole size of 1mm. However, for conservatism and based on advice from the DPIE, a hole size of 10 mm has been assumed for this assessment. This hole size has been applied for 'pinhole' piping leaks and small flange leaks. A pinhole piping leak is unlikely to be as large as 10 mm due to the controls in place and the small diameter of the above ground equipment, so this is a conservative estimate. A 1 mm hole size was modelled for the refueller dispenser, in addition to the 10 and 15 mm cases.

All piping has been designed to operate in low stress conditions and hydrotested well in excess of the design pressure, therefore rupture or full bore/guillotine failure of piping is not considered credible. However, for conservatism, full bore releases have been modelled for all small bore above ground equipment. This also covers the potential scenario of tube connection pull-out from the compression fitting due to an impact (though this is unlikely with the protections measures, such as bollards, in place,).

Rupture of the buried hydrogen piping is not considered credible due to the low stress conditions and therefore has not been modelled. Similarly, a third party strike on the buried pipeline is not considered credible as it is within the facility boundary fence line and all excavations will be strictly controlled by Jemena. Excavation equipment capable of penetrating the pipeline will not be permitted to be used on the site.

There are two blind flanges (500 mm NB) present on the buried hydrogen storage pipeline risers in the facility. Gasket failures (segment and full) have been modelled. Hole sizes were calculated based on the method described in UK HSE Item FR 1.2.4 Flanges and Gaskets (Ref 13).

Details on the high pressure hydrogen storage equipment and refueller will be finalised once the vendor is assigned. Preliminary design indicates that piping, fitting and connections will be 15 mm NB. Therefore leaks have been conservatively modelled at 10 mm and full bore failure at 15 mm.

The scenarios for consequence modelling can be seen in Table 12 below.

Table 12: Scenarios for Consequence Modelling

Scenario	Location	Substance	Piping / Equipment Size	Causes	Hole Size	Potential Consequence
1 (a) 1(b)	Above ground hydrogen piping and equipment	Hydrogen	25 NB	Overpressure resulting in leak from a flange or valve, corrosion (internal or external); external impact.	10 mm (Flange Leak/Pinhole) 25 mm (full bore)	Potential jet fire or flash fire
2 (a) 2 (b)	Hydrogen piping and equipment within the electrolyser container	Hydrogen	25 NB	Overpressure resulting in leak from a flange or valve, corrosion (internal or external); external impact.	10 mm (Flange Leak/Pinhole) 25 mm (full bore)	Potential jet fire or flash fire, vapour cloud explosion.
3 (a) 3 (b) 3 (c) 3 (d)	Buried hydrogen piping and risers.	Hydrogen	500 NB	Corrosion (internal or external); Third party strike – (considered not credible at this site) Gasket Failure (overpressure, poor installation etc) Note: Rupture case not credible due to design and low stress conditions.	10 mm (Pinhole) 50 mm (excavator strike) 20 mm (Gasket Segment) 78 mm (Full Gasket)	Potential jet fire or flash fire
4 (a) 4 (b)	Above ground natural gas piping and equipment	Natural Gas	25 NB	Overpressure resulting in leak from a flange or valve, corrosion (internal or external); external impact.	10 mm (Flange Leak) 25 mm (full bore)	Potential jet fire or flash fire
5 (a) 5 (b)	High pressure hydrogen storage equipment	Hydrogen	15 NB	Overpressure resulting in leak from a flange or valve, corrosion (internal or external); external impact vibration small fitting failure.	10 mm (Flange Leak) 15 mm (full bore)	Potential jet fire or flash fire
6 (a) 6 (b) 6 (c)	Refueller	Hydrogen	15 NB	Flexible Hose Failure; overpressure leak from flange, corrosion (internal or external); external impact.	10 mm (Flange Leak) 15 mm (full bore) 1 mm (pinhole)	Potential jet fire or flash fire
7a 7b 7c	Electrolyser hydrogen vent/automatic blowdown Buffer Storage manual vent Underground piping (natural gas) manual vent	Hydrogen Hydrogen Natural Gas		Electrolyser will automatically vent hydrogen following an ESD The buffer storage pipe / underground natural gas piping can be manually blown down to atmosphere via a vent.	DN80 hydrogen vent, 7.4 m height DN50 manual vent, 3.9 m height DN25 manual vent, 4.0 m height	Potential jet fire or flash fire

6.5 CREDIBLE HAZARD CONSEQUENCES

Due to the properties of natural gas and hydrogen being lighter than air, the most probable consequences have been determined to be as follows:

Jet Fire

A jet fire occurs when a flammable liquid or gas, under some degree of pressure, is ignited after release, resulting in the formation of a long, stable flame. Jet fires can be very intense and can impose high heat loads on nearby plant and equipment but are very directional in nature.

Flash Fire

A flash fire occurs when a cloud of flammable gas mixed with air is ignited. If the cloud is sufficiently large, it is also possible that the flame may accelerate to a sufficiently high velocity for a vapour cloud explosion (VCE) to occur. Though very brief, a flash fire can seriously injure or kill anyone within the burning cloud. Its effects are confined almost entirely to the area covered by the burning cloud. Incident propagation, sometimes called domino effects, can occur through ignition of materials or structures within the cloud.

Explosion

Explosions can occur through a variety of mechanisms, but in each case damage or injury is caused by a pressure wave which is created by rapid expansion of gases. The magnitude of the pressure wave is usually expressed in terms of blast overpressure. However, in order to properly predict the destructive capacity, it is necessary to consider the rate of increase/decrease in pressure as the wave passes. Explosions involving flammable gases are of particular concern in industrial facilities.

Explosions can occur if a mixture of flammable gas and air within the flammable range is ignited. The magnitude of overpressure developed is strongly influenced by factors such as:

- degree of confinement;
- the size of the cloud;
- degree of turbulence;
- the combustion properties of the gas; and
- the location of the ignition source relative to the cloud.

Explosions may also occur as a result of catastrophic rupture of a pressurised vessel, ignition of dust clouds, thermal decompositions, runaway reactions and detonation of high explosives such as TNT. Both blast waves and projectile fragments may result.

7 CONSEQUENCE ANALYSIS

A set of representative incident scenarios was determined, based on the current design of the WSGGT facility, applicable codes and standards, and engineering practice. These scenarios include a range of hazardous events that have some potential to occur in each area of the facility. In general, these events can be divided into the following categories:

- Moderate releases (punctures) caused by overpressure resulting in a leak from a flange / valve, corrosion (internal or external), flexible hose failure, vibration small fitting failure, etc, characterised by a hole of 10 mm equivalent diameter;
- External impact, characterised by a hole with a diameter equal to the pipe diameter or, for vessels and certain process equipment, a hole with a diameter equal to the diameter of the largest attached pipe;
- Third party strike to the buried hydrogen storage pipeline, characterised by a hole of 50 mm equivalent diameter;
- Gasket failure due to overpressure, poor installation, etc. For the 500 NB buffer storage risers, leaks have been characterised by a hole of 20 mm equivalent diameter for a gasket segment and a hole of 78 mm equivalent diameter for full gasket failure.

7.1 MODELLING SOFTWARE

Consequence analysis was undertaken using the DNV GL process hazard analysis software program Phast (version 8.1). DNV's Phast dispersion modelling software is capable also of modelling the effects of a gas cloud igniting resulting in flash fires, explosions, or jet fires. Based on the specific scenario, Phast can then predict radiation contours from fires and overpressure contours from explosions. The software is based on empirical models, as opposed to theoretical models, and are adjusted and calibrated based on information returned to DNV from partners who provide data following real-world events. The software has also been validated against other models such as:

- Skottene, M., Holm, A., 2008. H2 Release and Jet Dispersion - Validation of Phast and KFX, Report 2008-0073. DNV Research, Høvik, Norway.

- Witlox, H.W.M., et al., Modelling and validation of atmospheric expansion and near-field dispersion for pressurised vapour or two-phase releases, Journal of Loss Prevention in the Process Industries (2017), http://dx.doi.org/10.1016/j.jlp.2017.05.005

Evaluation Techniques

7.1.1 Leak Rates

Phast models the release behaviour for compressed gas releases from vessels and pipelines. Input data includes the type of release, location of release with respect to vessel geometry, pipe lengths etc. and initial conditions of the fluid (i.e. before release). The release rate is assumed to remain constant until isolation can be achieved - this is a conservative approach as in reality there will be pressure reduction due to the limited inventory and hence reduction in leak rate.

7.1.2 Duration

The results in Table 17 are based on continuous release rates. This is conservative as it is noted that in the final system design there will be emergency shutdown and isolation provision designed to detect leaks and isolate the inventory in as short a time as possible.

7.1.3 Dispersion Distances

A gas release will disperse in the atmosphere. A gas is flammable at concentrations between the upper flammable limit (UFL) and lower flammable limit (LFL). For the gases present in the WSGGT facility these limits are:

- Hydrogen: UFL = 75%. LFL = 4%.
- Natural gas: UFL = 15%. LFL = 4.4%.

Phast is used to estimate the distance to which a release of either hydrogen or natural gas will disperse to its LFL based on pressure, velocity and release rate.

7.1.4 Terrain Effects

Ground roughness effects the turbulent flow properties of wind, hence dispersion of a released material. Terrain effects are taken into account to some degree in dispersion modelling by use of a surface roughness length.

The roughness length used for all release scenarios is described as *Regular large obstacle coverage (suburb, forest)* in the modelling software. This corresponds to a surface roughness length of 1 m, appropriate to a plant located in a rural area, with some buildings, trees and fences in the vicinity, as well as some undulation of the surrounding land.

7.1.5 Weather Conditions

Consequence modelling was performed with the weather conditions presented in Table 13. Cases were determined based on weather data from the Australian Bureau of Meteorology (BOM) for the Horsley Park Equestrian Centre AWS for the years 1997-2019.

Table 13: Weather Conditions

Weather Parameter	Case 1	Case 2	Case 3	Case 4
Case Description	Typical Hot Summer Day	Typical Average Spring or Autumn Day	Typical Cold Winter Day	Typical Calm Autumn Day
Wind Speed (m/s)	5.2	3.8	3.0	0.5
Pasquil Stability	A/B	D	F	F
Atmospheric Temperature (°C)	36.7	18.2	2.5	18.3
Relative Humidity (%)	50	56	76	66
Solar Radiation Flux (kW/m^2)	1.2	0.99	0.68	0.93
Surface Temperature (°C)	36.7	18.2	2.5	18.3

Consequences for each weather condition were modelled with results reported for the worst case.

7.2 HEAT RADIATION AND EXPLOSION OVERPRESSURES

7.2.1 Modelling Techniques – Heat Radiation – Theory

The effect of impact of heat radiation on people from a jet fire is shown in the table below:

Table 14: Jet Fire Consequences

Radiant Heat Level kW/m²	Physical Effect (dependant on exposure duration)
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 1 5-20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur)
12.6	• Significant chance of fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure. • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
23	• Likely fatality for extended exposure and chance of fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved or failure would occur
53	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of fatality for people exposed instantaneously

The effect of impact of heat radiation on people from a flash fire is shown in the table below:

Table 15: Flash Fire Consequence

Criteria	Physical Effect (dependant on exposure duration)
Lower Flammability Limit	Potentially fatal from people in the ignited flammable cloud path. Assume 100% fatal in cloud area.

7.2.2 Modelling Techniques – Explosion Overpressures – Theory

The effect of impact of overpressure on facilities and people are shown in the table below:

Table 16: Overpressure Consequence

Overpressure kPag	Physical Effect
3.5	• 90% glass breakage • No fatality and very low probability of injury
7	• Damage to internal partitions and joinery but can be repaired • Probability of injury is 10%. No fatality
14	• House uninhabitable and badly cracked
21	• Reinforced structures distort • Storage tanks fail • 20% chance of fatality to a person in a building
35	• House uninhabitable • Wagons and plants items overturned • Threshold of eardrum damage • 50% chance of fatality for a person in a building and 1 5% chance of fatality for a person in the open
70	• Threshold of lung damage • 100% chance of fatality for a person in a building or in the open

Overpressure kPag	Physical Effect
	• Complete demolition of houses

In Phast, the Multi-Energy method is used to predict the overpressures from flammable gas explosions. The key feature of the Multi-Energy method is that the explosion is not primarily defined by the fuel air mixture but by the environment in which the vapour disperses.

Partial confinement is regarded as a major cause of blast in vapour cloud deflagrations. Blast of substantial strength is not expected to occur in open areas. A strong blast is generated only in places characterized by partial confinement while other large parts of the cloud burn out without contributing to the blast effects. The vapour cloud explosion is not regarded as an entity but is defined as a number of sub-explosions corresponding to various sources of blast in the vapour cloud, i.e. each confined part of the cloud is calculated as a separate vapour cloud explosion.

The initial strength of the blast is variable, depending on the degree of confinement and on the reactivity of the gas. The initial strength is represented as a scale of 1 to 10 where 1 represents slow deflagration and 10 represents detonation. For explosions in process plant environments the initial strength is thought to lie between 4 and 7 on the scale.

The Multi-Energy model selected for the electrolyser container was the uniform confined model, with an explosion strength of 10 and an explosion efficiency of 12.5%.

Phast can also perform explosion modelling for the parts of the vapour cloud that do not cover an area of strong confinement. The degree of confinement for the unconfined parts of the cloud must be set and is typically be around 1 (completely unconfined, e.g. open farmland) or 2 (slight confinement, e.g. fences, bunds, or hedges).

For the uncongested plant environment of the WSGGT facility, a user-defined Multi-Energy explosion model was used with the unconfined explosion strength set to 2 and an unconfined explosion efficiency of 100%.

7.2.3 Calculated Jet Fire Dimensions

Flame dimensions will vary depending on the wind weather conditions. Phast calculates the flame dimensions for each wind weather category and the worst case scenario is reported.

7.2.4 Calculated Blast Overpressure Dimensions

For a release of pressurised gas into an unconfined environment the chances of an explosion is extremely small (or of negligible risk).

A vapour cloud explosion is possible however if some degree of confinement is present.

7.3 POPULATION DENSITY

The population density in the area is very low, equivalent to the description of 'Farmland, scattered houses' with a density of 5 persons per hectare (Ref 3). There are a number of residential dwellings on the opposite side of Chandos Road from the facility (approximately 250 m away), but the area most likely to be affected by an incident - that which is adjacent to the facility - consists of vacant land within the Western Sydney Parklands Trust with future use allocated for market gardens and has no permanent residents.

7.4 CONSEQUENCE CALCULATION RESULTS

Table 17 below summarises the heat radiation and overpressure effects for each of the scenarios modelled. The table indicates whether the specified impacts are expected to exceed the defined site boundaries. Full results overlayed on the site map with the preliminary proposed equipment layout can be seen in Appendix 5.

Table 17: Consequence Modelling Results – continuous release rates

Scenario	Release Rate kg/s	Jet Fire Distance m Note 5						Explosion Overpressure Distance m				Flash Fire Note 4 Distance m	Exceeds site?
		Injury Radiation (4.7 kW/m²)	Exceeds site?	Fatal Radiation (12.6 kW/m²)	Exceeds site?	Propagation Radiation (23 kW/m²)	Exceeds site?	7 kPag	Exceeds site?	14 kPag	Exceeds site?		
1a	0.16	8.0	N	7.5	N	7.5	N	n/a	-	n/a	-	13.5	N
1b	0.99	20.5	N	17.5	N	16.5	N	n/a	-	n/a	-	31.0	N
2a Note 1	0.16	7.5	N	6.5	N	5.5	N	19.5 Note 3	N	16.5 Note 3	N	-	-
2b Note 1	0.96	20.0 Note 2	N	17.0 Note 2	N	15.5 Note 2	N	47.0 Note 3	N	39.0 Note 3	N	25.5	N
3a	0.16	11.0	N	7.0	N	5.0	N	n/a	-	n/a	-	2.0	N
3b	3.83	48.5	Y	26.5	N	14.5	N	n/a	-	n/a	-	2.0	N
3c	0.61	20.5	N	12.0	N	7.5	N	n/a	-	n/a	-	3.0	N
3d	9.31	73.5	Y	39.5	N	21.5	N	n/a	-	n/a	-	2.0	N
4a	0.15	6.5	N	6.5	N	6.5	N	n/a	-	n/a	-	-	-
4b	0.94	15.5	N	13.5	N	13.0	N	n/a	-	n/a	-	-	-
5a	3.34	34.0	N	28.5	N	27.0	N	n/a	-	n/a	-	51.0	N
5b	7.51	50.5	N	42.0	N	39.0	N	n/a	-	n/a	-	62.0	**Y**
6a	1.46	24.5	N	21.0	N	19.5	N	n/a	-	n/a	-	42.0	**Y**
6b	3.28	37.0	Y	30.5	N	28.5	N	n/a	-	n/a	-	56.5	**Y**
6c	0.0146	n/a	-	n/a	-	n/a	-	n/a	-	n/a	-	-	-
7a	0.0025	n/a	-	n/a	-	n/a	-	n/a	-	n/a	-	-	-
7b	0.13	n/a	-	n/a	-	n/a	-	n/a	-	n/a	-	-	-
7c	0.087	n/a	-	n/a	-	n/a	-	n/a	-	n/a	-	-	-

Note 1. Modelled as open air.

Note 2. Container dimensions are 12.19 x 2.44 x 2.9 m (L x W x H) therefore these jet fires will impinge upon the container walls/roof.

Note 3. Explosion overpressure within the container will reach over 70 kPag. Blast assumed to destroy the shipping container it is housed in or lift explosion hatch/hatches (to be confirmed in detailed design). There will be some residual overpressure effects as shown in the table.

Note 4. Distance downwind to LFL at height of interest of 1.8 m (representing average human height). For maximum distance to LFL at any height, refer to raw data in 18667-CALC-002-r0 Appendix 2A.

Note 5. Distances shown are at height of interest of 1.8 m (representing average human height).

7.5 MAJOR OFFSITE CONSEQUENCES

The scenarios with the greatest consequences are those which have the potential for offsite consequences. In this case, flash fires or jet fires with radiation effects at the level sufficient to cause a fatality (*12.6 kW/m^2) that extend beyond the Jemena boundary fence are further considered in the risk assessment.

For the continuous release rates modelled these are:

- 5b – Hydrogen high pressure storage equipment full bore leak (15 mm)
- 6a – Refueller equipment flange leak (10 mm)
- 6b – Refueller – refuelling hose failure (15 mm)

Fatal radiation levels for jet fires did not extend beyond the site boundaries in any of these cases; it was only the flash fire cases that had consequences extending beyond the boundary.

An event tree frequency analysis for these scenarios has been conducted to be compared with defined tolerable risk targets, this is further described in Section 8. An outcome of this report was to install a firewall around the HPS, removing case 5 b from the final offsite risk analysis.

There were two scenarios that had jet fires with potential radiation effects at the levels sufficient to cause an injury (4.7 kW/m^2) that extended beyond the Jemena boundary fence. For the continuous release rates modelled these are:

- 3d – Full gasket failure of a 500 mm NB flange
- 6b - Refueller – refuelling hose failure (15 mm)

Notes:

- Scenario 3B – an excavator strike on the buried buffer storage pipeline has potential injury consequences beyond the site boundary, however due to the controls in place this scenario is considered not credible.
- *Assuming that the heat radiation from a jet fire of 12.6 kW/m^2 will potentially result in an offsite fatality is a conservative approach as it would require extended exposure for a fatality to result as described in Table 14

8 FREQUENCY ANALYSIS

The frequency of an event is the number of occurrences of the event in a specific time period, typically one year. The event tree below shows the possible eventualities for this study for a gaseous hydrogen (GH) release

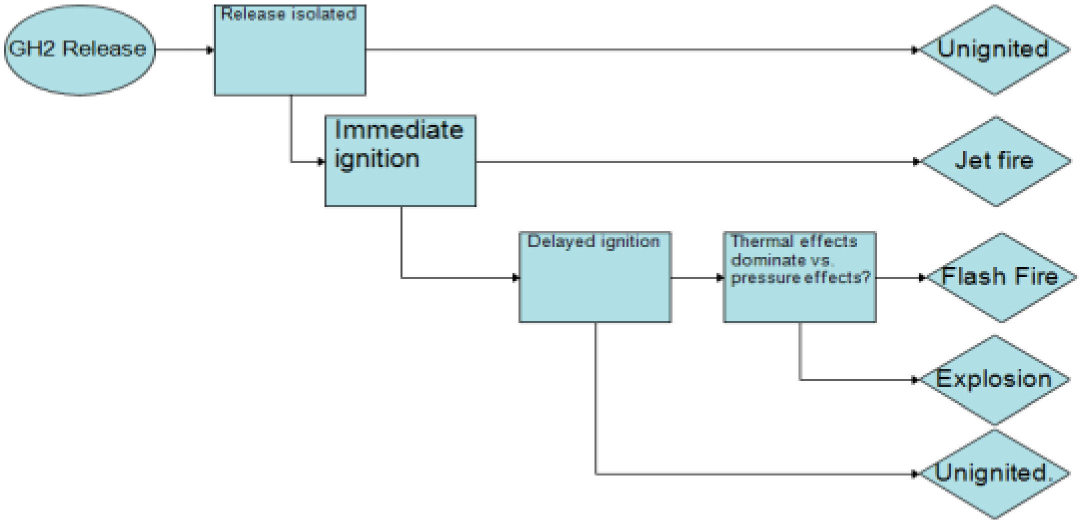

Figure 9: Event tree for gaseous hydrogen release

For each of the scenarios in the areas (buffer storage, high pressure storage and refueller dispenser) that have the potential for a fatal offsite consequence, an event tree analysis has been conducted to determine the total individual fatality risk. The total individual fatality risk for the site is the cumulative total of risks.

$$\text{Risk} = \sum p \times c$$

p = probability of occurrence

c = the consequences associated with each scenario

Assumptions:

The high pressure storage and refueller dispenser areas all have leak detection systems installed. For the purposes of this assessment it has been assumed that 80% of leaks will be isolated by the leak detection and the automatic shutdown system will act before an event occurs. 80% is a very conservative estimate as it assumes that 2 in 10 times a critical component in the system will fail. In reality, high integrity components will be used which will have much lower failure frequencies.

Jet fires are directional and only those angled at human height are potentially fatal. For this assessment, only those angled at the site boundary can result in a potentially fatal offsite consequence. It has been assumed that 30% of jet fires could meet these criteria.

Modelling has indicated that due to the open air nature of the facilities and lack of congestion, an explosion is not a credible scenario.

An explosion may be possible within the confines of the electrolyser building only if the ventilation has and an undetected leak occurs resulting in an unignited hydrogen cloud accumulating before igniting resulting in a vapour cloud explosion. In the unlikely event of this occurring, modelling has indicated that the consequences will not extend beyond the site boundaries, and therefore has not been assessed in the frequency analysis.

An equipment parts count has been approximated based on preliminary drawings.

8.1 FAILURE RATES

Performing quantitative risk assessments (QRA) specific to hydrogen equipment and service is relatively new. To date, most of the published leak frequency data available for use in QRAs is based on historical data from the oil and gas industries (OGP Risk Assessment Data Report) or in the case of UK HSE, based on chlorine plant data.

Research has been completed and data has been published by Sandia National Laboratories for leak frequencies of equipment in hydrogen service. Sandia have produced a tool kit for quantifying accident scenarios in hydrogen service called Hydrogen Risk Analysis Model HyRAM.

HyRAM is a methodology developed to provide a platform for integration of state-of-the-art, validated science and engineering models and data relevant to hydrogen safety. The software itself was not utilised in this level 2 assessment for the following reasons:

- HyRAM does not produce an individual risk number. It factors in site occupancy when calculating Average Individual Risk i.e. the expected number of fatalities per exposed individual
- Level 2 assessments do not require a full QRA

The frequency of component failure data and the ignition probability data has been sourced from the HyRAM technical reference manual (Ref 14). HyRAM incorporates generic probabilities for equipment failures for nine types of hydrogen system components and generic probabilities for hydrogen ignition.

The frequency of a random leak (release) in HyRAM is calculated from the parameters of a lognormal distribution using Bayesian statistical analysis with inputs from multiple validated sources, based on actual industry data as well as applying expert judgement for hydrogen application such as *"Guidelines for Quantitative Risk Assessment: The Purple Book," Committee for the Prevention of Disasters, The Hague, The Netherlands, 1999* and *A.J.C.M. Matthijsen, E.S. Kooi, "Safety Distances for Hydrogen Filling Stations," Journal of Loss Prevention in the Process Industries.* The quote below is from the paper cited in Ref 17 used to develop the leak frequencies utilised by HyRAM:

"Because data on hydrogen systems is extremely limited, sources from commercial operations may be used as a baseline for a Bayesian statistical analysis. Component leakage frequencies have been historically gathered by the chemical processing, compressed gas, nuclear power plant, and offshore petroleum industries; however, there has been little consistency across the disciplines and studies performed. Variances in leakage definitions, component classification, and data reliability make it difficult to directly apply the information to hydrogen specific processes. Unique physical challenges, such as hydrogen embrittlement, provide additional uncertainty when applying statistically determined leakage frequencies to the risk assessment. Nevertheless, the identification of the component failure rates and severity of ensuing leaks by performing an extensive review of industrial sources is an appropriate initial phase to the Bayesian process described.

Sources used in data analysis were obtained from a narrow range of available data and studies. They varied in nomenclature, component specifics, and data determination; however, at the present time it was the most widely accessible information. The existing frequencies may be found in reports and studies from the chemical processing, compressed gas, nuclear power plant, and offshore petroleum industries. It was important to consider the origin of this data and determine whether the information was derived from actual component failures or based on expert judgment. Making this distinction should provide a greater amount of confidence through the assessment process."

Due to the unfamiliarity of applying the HyRAM data in Australia, a sensitivity analysis has been conducted for some of the critical components (pressure vessels and hoses) using UK HSE leak frequency data (Ref 18). Table 19 has also been included to show UK HSE Failure rate data for all the relevant components in this assessment for comparison.

In this assessment, the consequences that have been determined to have potential offsite impacts are for 10 mm leaks and full bore release in the in the areas described in section 7.5. Mean frequency values listed in Table 18 were adopted for the relevant components using 10% release size frequencies for the 10 mm leak and 100% release size frequency for the full bore leak as shown below.

Table 18: Leak Frequency Data from HyRAM – Frequencies of random leaks for individual components

Component	Release Size	Mean frequency
Compressor	10%	2.06×10^{-4}
Compressor	100%	3.04×10^{-5}
Pressure Vessel (Cylinders)	10%	3.9×10^{-7}
Pressure Vessel (Cylinders)	100%	2.9×10^{-7}
Flanges	10%	3.74×10^{-5}
Flanges	100%	1.55×10^{-5}
Hoses	10%	1.6×10^{-4}
Hoses	100%	7.47×10^{-5}
Pipes	10%	9.12×10^{-7}
Pipes	100%	6.43×10^{-7}
Valves	10%	4.13×10^{-5}
Valves	100%	1.49×10^{-5}
Instruments	10%	1.84×10^{-4}
Instruments	100%	1.11×10^{-4}

The HyRAM methodology calculates the risk over a full range of frequencies for % of flow area of the leak (0.01, 0.1, 1, 10 and 100%) as the program does not differentiate between on and offsite risk. For this assessment, where offsite risk is the focus, only two frequencies have been assessed since smaller leaks such as the 1 mm leak modelled do not have offsite consequences.

The hose leak frequencies listed above account for random hose failures only. To account for failures that can occur per usage such as human error caused by drive-offs, HyRAM offers the following for 'per use' applications:

$$f(other\ releases) = 5.5\ \times\ 10^{-9}\ \times\ (n\ Demands\ per\ day\ \times\ n\ Operating\ Days)$$

In this case, it is proposed there are 3 buses refuelling per day for 350 days per year.

Therefore: $f(other\ releases) = 5.8\ \times\ 10^{-6}$

This additional frequency applies to the 100% release case only.

Table 19: Leak Frequency Data from UK HSE – for comparison

Component	Release Size	Leak frequency
Compressor	Hole <25 mm	2.7×10^{-4}
Compressor	Rupture	2.9×10^{-6}
Pressure Vessel	10 mm hole	4×10^{-5}
Pressure Vessel	Catastrophic median	4×10^{-6}
Flanges 25 NB	Gasket Segment	5×10^{-6}
Flanges 500 NB	20 mm	5×10^{-6}
Hoses and Couplings – multi safety system facilities (per operation)	Leak (15 mm diameter hole)	4×10^{-7}
Hoses and Couplings – multi safety system facilities (per operation)	Guillotine	2×10^{-7}
Pipes	<10 mm hole	5×10^{-5}
Pipes	Guillotine	1×10^{-6}
Valves	Spray release	2.4×10^{-4}

There are some variations in the leak frequencies quoted between UK HSE and HyRAM. Similarly, as the paper states above, there are differences between UK HSE and other published sources such as DNV's Purple book and the OGP Risk Assessment Data Directory Report no 434 for similar pieces of equipment. In comparison to the chlorine and oil and gas facilities this data is based on, hydrogen is a clean, dry service and uses much smaller bore equipment, so this data is likely to be conservative. Based on the specific research conducted and summarised in Ref 17, it is our view that the HyRAM leak frequencies are the best available to be applied in this assessment.

The HyRAM data is for the specific application of hydrogen fuelling and associated storage infrastructure, applicable in this case to the high pressure storage and refueller dispenser. For the 500 NB flanges in place at the buffer storage risers failure data for UK HSE was utilised. There are no potentially fatal offsite consequences from a partial gasket failure, however, there is a potential offsite injury consequence from a full gasket failure and this was assessed.

8.2 IGNITION PROBABILITY

Ignition probabilities for hydrogen were sourced from data from HyRAM specific for hydrogen (refer to Ref 14).

Table 20: Default Ignition Properties in HyRAM

Hydrogen Release Rate kg/s	Immediate Ignition Probability	Delayed Ignition Probability
<0.125	0.008	0.004
0.125 – 6.25	0.063	0.027
>6.25	0.23	0.12

These were determined from the paper cited in Ref 18.

8.3 LIKELIHOOD OF OFFSITE EFFECTS

8.3.1 Potential Fatalities

To determine the cumulative frequency of events, for each of the areas capable of causing a potentially fatal offsite impact, event trees were created and resultant frequencies calculated. Results are summarised in the table below and detailed calculations can be seen in Appendix 4A.

Table 21: Likelihood of Potentially Fatal Offsite Effects with a continuous release rate

Scenario	Frequency Per Year
High Pressure Hydrogen Storage – Leak 100%	7.9×10^{-5}
Refueller dispenser – Hose Leak 10%	4.3×10^{-6}
Refueller dispenser - Hose Full Bore (random failure)	2×10^{-6}
Refueller dispenser - Hose Full Bore (1050 uses per year)	1.6×10^{-7}
Total	$\mathbf{8.8 \times 10^{-5}}$

The results of the partial quantification have shown that the aggregate frequency of all events which could have significant offsite consequences is approximately **8.8×10^{-5}** per year.

Sensitivity Analysis:

Based on preliminary feedback from the NSW DPIE The same frequency analysis was performed using the UK HSE data for pressure vessel failure (in place of cylinders used in HyRAM) rates and road tanker transfer hoses and couplings data (in place of ‘hoses’) for the dispenser.

Results are summarised in Table 22 and can be seen in detail in Appendix 4B.

Table 22: Likelihood of Potentially Fatal Offsite Effects with a continuous release rate sensitivity

Scenario	Frequency Per Year
High Pressure Hydrogen Storage – Leak 100%	8.0×10^{-5}
Refueller dispenser – Hose Leak 10%	1.1×10^{-5}
Refueller dispenser - Hose Full Bore	5.7×10^{-6}
Total	$\mathbf{1.3 \times 10^{-4}}$

Note: Number of operations was assumed to be 3 buses for 350 days per year i.e. 1050.

An outcome of this preliminary assessment was for the final design to include a firewall on the east side of the High Pressure Hydrogen Storage facility. This will eliminate the consequence of potentially fatal radiation crossing the site boundary. This leaves only leaks from the refueller/dispenser with potentially fatal offsite consequences. The leak frequencies for the refueller dispenser failures are as follows:

Using HyRAM leak frequency data:

Refueller dispenser – Hose Leak 10%	4.3×10^{-6}
Refueller dispenser - Hose Full Bore (random failures)	2×10^{-6}
Refueller dispenser - Hose Full Bore (1050 uses per year)	1.6×10^{-7}
Total	**8.4×10^{-6}**

A sensitivity analysis using UK HSE Data for tanker load out hose failures with 1050 operations per year was conducted:

Refueller dispenser – Hose Leak 15 mm	1.1×10^{-5}
Refueller dispenser - Hose Guillotine	5.7×10^{-6}
Total	**1.7×10^{-5}**

There is a difference of 1.1×10^{-5} between the results. The final result using the UK HSE data is within the order of magnitude required for the tolerable risk target for open spaces. The UK HSE data is mainly derived from equipment in chlorine service which is considered a harsher service and therefore offers a conservative estimate. As stated above, based on the research conducted in Ref 17, it is our view that the HyRAM frequency data is most suitable and is used in the conclusion and results for this study.

8.3.2 Potential Injuries

There were two scenarios that had jet fires with potential radiation effects at the levels sufficient to cause an injury (4.7 kW/m^2) that extended beyond the Jemena boundary fence. For the continuous release rates modelled these are:

Failure of 500 mm NB Gaskets (full)	7.6×10^{-10}
Refueller dispenser - Hose Full Bore	2.8×10^{-7}
Refueller dispenser - Hose Full Bore (per use failures)	2.2×10^{-8}
Total	**3.1×10^{-7}**

The probability of these events occurring is 3.1×10^{-7} is above the below risk target of 50×10^{-6} listed in HIPAP 4. The event tree calculations can be seen in Appendix 4C.

8.4 RISK CRITERIA

8.4.1 Individual Risk Criteria

The risk criterion to be assessed against is defined in HIPAP No. 4 Risk Criteria for Land Use and Planning (Ref 1) shown in Table 23 below.

Table 23: Fatality Risk Criteria

Risk in a million per year	Land Use
0.5	Hospitals, schools, child-care facilities, old age housing
1	Residential, hotels, motels, tourist resorts
5	Commercial developments including retail centres, offices and entertainment centres
10	Sporting complexes and active open space
50	Industrial

All of the offsite risk impacts are in the region on the eastern side that is owned by the Western Sydney Parklands Trust. The adjacent land is primarily used for market gardening and has no permanent residents and therefore is classified as 'active open space areas' which has a tolerable risk target of **1×10^{-5}.**

Propagation Risk

Heat radiation levels of 23 kW/m² and explosion overpressure levels of 14 kPag are considered sufficient to cause damage at neighbouring industrial operations to the extent where further potentially hazardous incidents can occur.

Incidents with these impacts shall not exceed a risk of 50 in a million a year.

Injury Risk

Heat radiation level of 4.7 kW/m² and explosions over 7 kPag are considered to cause injury to the public. Incidents with these impacts shall not exceed a risk of 50 in a million a year in residential and sensitive areas.

8.4.2 Societal Risk Criteria

Societal risk provides estimates of overall risk to the population. Societal risk takes into account whether an incident occurs in time and space with a population by taking into account the size of the population that would be affected by each incident. By integrating the risk by the local population density over spatial coordinates, the global risk for a given accident scenario is obtained. By adding up the several risk functions (one for each scenario), a global risk function is obtained. In order to estimate the number of people affected, the population density outside of the industrial site under review is determined. Therefore, two components are relevant, namely:

- The number of people exposed in an incident, and
- The frequency of exposing a particular number of people.

The Department of Planning have published a set of indicative societal risk criteria (HIPAP 4) as presented in tabular form in Table 24.

Table 24: Interim Criteria for Tolerable Societal Risk, NSW

Number of fatalities (N) [-]	Acceptable limit of N or more fatalities per year	Unacceptable limit of N or more fatalities per year
1	3×10^{-5}	3×10^{-3}
10	1×10^{-6}	1×10^{-4}
100	3×10^{-8}	3×10^{-6}
1000	1×10^{-9}	1×10^{-7}

9 RISK RESULTS

The partially quantitative calculated frequency of potentially fatal offsite individual risk is estimated to be approximately 8.8 x 10^{-5} per year for the hydrogen high pressure storage and refueller dispenser combined.

With a firewall in place on the eastern side of the HPS, the potential for fatal offsite consequences from the high pressure storage facility is removed and the resultant potentially fatal offsite individual risk is estimated to be approximately **8.4 x 10^{-6}** per year for the refueller dispenser which is below the tolerable risk target of **1 x 10^{-5}** per year the 'active open space areas'.

9.1 SOCIETAL RISK CALCULATIONS

The region that is impacted is owned by the Western Sydney Pipelines Trust. The adjacent land is primarily used for market gardening and has no permanent residents and therefore is classified as 'active open space area' with a population less than 5 people per hectare.

Given the location of the facility and the low population of the surrounding land it is conservatively estimated that people would be present in the open space area next to the facility approximately 10% of the time. It is also assumed that no more than one fatality would occur as a result of an incident.

Applying this risk reduction factor for exposure to the offsite risk frequency of risk 8.4 x 10^{-6}, a residual risk of **8.4 x 10^{-7} p.a** remains. This is below the negligible risk requirements of 3 x 10^{-5} listed in Table 24.

This is a conservative estimate as there is a probability of escaping the consequences of a fatality even if someone is present.

9.1.1 Potential Future Land Use

If the land use changes and structures such as farm sheds and greenhouses are constructed, there may be higher temporary populations present on the surrounding land. At this stage, given the uncertainty of the potential future land use it could be assumed that 10 people may be present for 10% of the time. The acceptable limit for 10 fatalities listed in Table 24 is 1 x 10^{-6}. The residual risk of 8.4 x 10^{-7} p.a is still below this target.

9.2 PROPAGATION RISK CALCULATIONS

Consequence modelling shows that none of the heat radiation contours at 23 kW/m^2 necessary for propagation impact any of the neighbouring Jemena equipment.

9.3 INJURY RISK CALCULATIONS

There were two scenarios that had jet fires with potential radiation effects at the levels sufficient to cause an injury (4.7 kW/m^2) that extended beyond the Jemena boundary fence. For the continuous release rates modelled these are:

- 3d – Full gasket failure of a 500 mm NB flange
- 6b - Refueller – refuelling hose failure (15 mm)

The probability of these events occurring is 3 x 10^{-7} is above the below risk target of 50 x 10^{-6} listed in HIPAP 4. The event tree calculations can be seen in Appendix 4C.

10 CONCLUSION AND RECOMMENDATIONS

The calculated frequency of potentially fatal offsite individual risk for the Western Sydney Green Gas Trial Plant is estimated to be approximately **8.4 x 10^{-6}** per year. This value is below the tolerable risk target of **1 x 10^{-5}** per year for 'active open space areas'.

A firewall will be installed to prevent any unintended releases from the hydrogen high pressure storage facility having potentially fatal offsite consequences.

The refueller dispenser is the only part of the proposed design that can have potential offsite consequences. This and associated equipment (HPS) will not be installed in the first phase of this project. If refuelling facilities are to proceed at a later date, further risk analysis can be performed once detailed design information is available as well as development of preventative and mitigative safeguards. As a minimum, this equipment will be designed to international codes and practices. It will be fitted with controls such as; cascade pressure drop monitoring and a 4-tier safety philosophy that will be constantly monitored by a Safety Device that is monitored by the PLC as well as gas, flame and smoke detection.

It should be noted that none of the credible consequence contours modelled are expected to impact the residential dwellings on the other side of Chandos Road approximately 250 m away from the new facility.

In conjunction with design safeguards listed in this report, Jemena will develop an integrity management plan involving inspection and maintenance of critical equipment as well as upgrading and implementing their safety management system for the site. This will be reflected in an update to the Safety Case GAS-999-PA-HSE-002 and the Asset Management System Manual, JEM-AM-MA-001.

11 REFERENCES

Ref 1 Department of Planning and Environment. Hazardous Industry Planning Advisory Paper No. 4: Risk Criteria for Land Use Safety Planning. 2011.

Ref 2 Department of Planning and Environment. Hazardous Industry Planning Advisory Paper No. 6: Guidelines for Hazard Analysis. 2011.

Ref 3 Department of Planning and Environment. Assessment Guideline Multi Level Risk Assessment. 2011.

Ref 4 Jemena. WSGGT, Basis of Design. 2019. Rev 3. P2G-2099-DG-DN-001.

Ref 5 Australian/New Zealand Standard™ Gas distribution networks AS/NZS 4645.1:2018

Ref 6 Jemena - Detailed Design for Hydrogen Generation (Western Sydney Green Gas Trial) Downstream Impacts Report GPA Document 18667-S2909

Ref 7 Hydrogen Fuel Cell Engines and Related Technologies: Rev 0, December 2001 Module 1 Hydrogen Properties. https://www.energy.gov/sites/prod/files/2014/03/f12/fcm01r0.pdf

Ref 8 AIGA 005/10: Fire Hazards of Oxygen and Oxygen Enriched Atmospheres

Ref 9 WSGGT SIL Study Report P2G-2099-RP-RM-001

Ref 10 18667-REP-014 Safety Management Study Report

Ref 11 Hydrogenics P195947_Boundary Hazop_Rev.00

Ref 12 EI Model code of safe practice Part 15: Area classification for installations handling flammable fluids.

Ref 13 UK HSE Failure Rate and Event Data for use within Risk Assessments (28/06/2012)

Ref 14 HyRAM 1.1 Technical Reference Manual. KM Groth, ES Hecht, JT Reynolds, ML Blaylock, EE Carrier. Methodology for assessing the safety of Hydrogen Systems: SAND2017-2998. March 2017

Ref 15 WSGGT Control Philosophy P2G-2099-RP-IE-001

Ref 16 HyRAM 2.0: Brian D. Ehrhart, Cianan Sims, Ethan Hecht, Alice B. Muna, Katrina M. Groth, John T. Reynolds, Myra L. Blaylock, Erin Carrier, Isaac W. Ekoto, and Gregory W. Walkup. HyRAM (Hydrogen Risk Assessment Models), Version 2.0. Sandia National Laboratories (4/29/2019); software available at http://hyram.sandia.gov

Ref 17 "Analyses to support development of risk-informed separation distances for hydrogen codes and standards," Sandia National Laboratories, Albuquerque, NM, SAND2009-0874, March 2009 J. LaChance, W. Houf, B. Middleton, and L. Fluer,

Ref 18 A. V. Tchouvelev, "Risk assessment studies of hydrogen and hydrocarbon fuels, fuelling stations: Description and review," International Energy Agency Hydrogen Implementing Agreement Task 19, 2006

Ref 19 Failure Rate and Event Data for use within Risk Assessments (28/06/2012)

APPENDIX 1 BALANCE OF PLANT HAZID

GPA ENGINEERING

Client	Jemena			Document Title	Document Subtitle	Document No.
Client	-	GPA	18667	HAZOP Minutes		18667-REP-008
Project	Western Sydney Green Gas Trial					

HAZOP Minutes - Overview

Node		Problem Description			Safeguards and Controls		Action			
ID	**System / Plant**	**Guideword**	**Cause**	**Consequence**	**Existing Proposed Safeguards**	**New Proposed Safeguards**	**Priority**	**Responsible**	**Complete Yes/No**	**Comments / Notes**
H-1	**Hydrogen Systems**	CHEMICAL ENERGY	Corrosion - internal or external Underground pipeline is carbon steel pipe, which is susceptible to hydrogen embrittlement.	Release of Hydrogen to atmosphere, ignition occurs instantaneously or delayed resulting in a jet or flash fire. Property damage and potential fatality/s	Buried pipe is designed with low design factor and relatively low-strength grade (X52) material to ensure low stress conditions protecting against rupture due to H2 embrittlement. This pipe is also coated and has cathodic protection. Facility piping is stainless steel, which is less susceptible than carbon steel to H2 embrittlement, and is also operating under low stress conditions which will prevent a rupture. As part of the quality management plan, defect testing of the piping and equipment will occur post manufacture. Exhaust fans and H2 gas detectors initiating an ESD in Electrolyser building. Operator clothing will be antistatic and flame retardant.	To further control ignition sources, determine whether non-sparking tooling is required for all maintenance work. Provide training and equipment per specifications. HAZOP action O-4 Review requirements relating to hydrogen-assisted fatigue crack growth (HA-FCG), relating to defect inspection, weld defect tolerances, and monitoring etc.	2	AW		
H-2	**Buried Steel**	ELECTRICAL ENERGY	Stray currents	Compromised cathodic protection leading to corrosion - including of existing assets.		Consider cross-bonding to existing buried assets. HAZOP action 1-25.				
H-3	**Electrolyser**	CHEMICAL ENERGY	Mole sieve material passing through into filters - on the electrolyser package.	Loss of performance	Maintenance procedures and operations monitoring.					
H-4	**SS Piping**	CHEMICAL ENERGY	Dissimilar metals.	Galvanic corrosion.		Include isolation joints in the design.	1	NK		
H-5	**Buried Steel**	CHEMICAL ENERGY	CP Interference	-	The potential for CP Interference will be mitigate in the CP design. Submission of the new design to the Electrolysis committee is required for approval.					
H-6	**Steel**	HARM TO PLANT	Hydrogen effects on steel	Embrittlement and fatigue crack growth.	To be susceptible, a combination of three factors is required: presence of (and diffusion of) hydrogen, susceptible material, and stress. The design of piping will be 'no rupture' to ensure that any potential fatigue cracks will not propagate due to the low stress conditions. Material susceptibility is being managed by material selection (compatible with hydrogen), post manufacture defect testing such as hydotest and radiography.					
H-7	**Buried Steel**	CHEMICAL ENERGY	Soil corrosion - potential for acid sulphate soils.	Corrosion of piping.	Coating and CP of buried pipe.	Procedure for handling of piping and equipment during construction to be created to avoid soil contact. Training of construction personnel is requirements.	2	AW		
H-8	**Electrolyser**	ELECTRICAL ENERGY	Vents - sparking due to flaps/moving components and velocity.	Ignition of hydrogen when venting.		Design of all vents to be non-sparking.	1	AP		
H-9	**Pipeline**	ELECTRICAL ENERGY	Vents - sparking due to flaps/moving components and velocity.			Design of all vents to be non-sparking. Use a sock.	1	NK		
H-10	**Electrolyser**	THERMAL ENERGY	Failure of electrolyser chilling systems- max temp 80°C.	Potential burns to personnel touching pipe.	Electrolyser package will trip on high discharge temperature.					

GPA ENGINEERING

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Project	Western Sydney Green Gas Trial					

HAZOP Minutes - Overview

Node		Problem Description			Safeguards and Controls		Action			
ID	System / Plant	Guideword	Cause	Consequence	Existing Proposed Safeguards	New Proposed Safeguards	Priority	Responsible	Complete Yes/No	Comments / Notes
H-11	Electrolyser	THERMAL ENERGY	No low temperature issues. Considered Joule-Thompson, and chiller system harm to personnel (it operates to min. 5°C)							
H-12	Generator	THERMAL ENERGY	Hot components, and exhaust temperatures. Potential for hydrogen attack (on steel components).	Personnel injury, corrosion.	Controlled by design. Cladding will be installed to protect operators. Internal materials are designed to prevent hydrogen attack. Vent stack has air shrouded combustion.					
H-13	Whole site	RADIANT ENERGY	Fire from adjacent facility, or bushfire.	Hydrogen facility potentially damaged if a neighbouring natural gas pipeline incident occurs, but it unlikely to cause an escalation that is beyond the existing risk. There is bushland adjacent to the facility but only 2 trees on site.	In the event of a bush fire or incident at a neighbouring facility, the hydrogen plant will be remotely shutdown.					
H-14	Whole site	ELECTRICAL ENERGY	Battery on generator, and two UPS'.	Stored energy release if battery fails. Potential for fire/explosion.	Jemena and battery vendor management procedures to be applied for battery management.	Preventative maintenance work orders to be created for inspection/testing.	3	AW		
H-15	Electrolyser	ELECTRICAL ENERGY	Electrolyser current discharge.	Arc flash may occur resulting in personnel injury. Considered a low risk in this application.	Low risk. Reviewing design. Arc flash detection? Bus bars may be heavy.	ANT to minimise potential for arc flash in the electrical design. Determine if arc flash detection is required and include in the design.	1	AP		
H-16	Transformer	ELECTRICAL ENERGY	Supplied pad-mount from the grid by electricity supplier.							
H-17	Whole site	ELECTRICAL ENERGY	Ignition of releases.	Fire if loss of containment occurs.	A hazardous area study will be completed. The equipment will hazardous area designed and rated as per report requirements. The existing Jemena permit system will be reviewed for the new application and applied in operation. Equipment will be procured with IecEx compliance suitable for hydrogen. - (International Electro technical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System))					
H-18	Whole site	ELECTRICAL ENERGY	Static risks - ignition source for explosive environment. Numerous visitors expected to the site, including media.	Fire if loss of containment occurs.	Anti-static clothing a requirement for anyone entering the site. Mobile phones and other devices that may be potential ignition sources to be managed by Jemena's reviewed permitting system. for this site. No-go / exclusion zones to be marked out e.g. electrolyser building.	Induction process to be created for workers / visitors. Hydrogen gas detectors a requirement for personnel.	3	AW		
H-19	Whole site	ELECTRICAL ENERGY	Mowers, vehicles	Fire if loss of containment occurs.	Jemena's permit to work system Reference XXX	Define exclusion zone around pipeline riser using bollards.	1	SH		

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HAZOP Minutes - Overview

Node		Problem Description			Safeguards and Controls		Action			
ID	System / Plant	Guideword	Cause	Consequence	Existing Proposed Safeguards	New Proposed Safeguards	Priority	Responsible	Complete Yes/No	Comments / Notes
H-20	Whole site	CHEMICAL ENERGY	Small leaks.	Loss of product, potential fire. May go undetected.	Hydrogen detectors are located in in the electrolyser building. Detection will trip the electrolyser (confirm). Jemena personnel will be required to wear H2 detectors when entering the site, exclusion zones will be created for areas with a higher potential for leaks of venting. HAZOP action 1-19 Balance of plant design to include use of hoods with gas detectors in locations with multiple fittings and valves. E.g.. gas panel, injection panel, pipeline end connections.	Create leak response procedure for hydrogen leak detection. Add short-term isolation function, which shuts in system for 15 minutes and monitors pressure change during shut-in to detect leak. Include as routine test in operating procedures.	3 1	AW SD		
H-21	Whole site	CHEMICAL ENERGY	Large leaks	Fire	Video cameras reporting to remote control room are a part of the design. Remote shut-down of the facility is available. An ESD button will be available at the entrance gate.	Determine requirements for an infrared camera to be installed on site. Provide Infrared cameras for personnel entering the site. Leak detection to initiate a local beacon/siren. Make siren interlock with gate (so only alarms if someone is there).	3 1	AW SD		
H-22	Whole site	KINETIC ENERGY	Impact from vehicle	Loss of containment.	Design will propose a layout to minimise vehicle traffic considering access requirements for maintenance/production etc.	Conduct further layout review to minimise potential for vehicle impact. Consider all access requirements. Install bollards where required.	1	NK		
H-23	Whole site	NOISE ENERGY	Noise	Residential disturbances/complaints.	A noise study will be conducted in the design phase.					
H-24	Electrolyser	GRAVITATIONAL ENERGY	Working on top of electrolyser package	Fall from height	Jemena working at heights procedures will be applied.	Consider moving maintainable components to the side. Confirm roof railings are provided.	1	AP		
H-25	Whole site	GRAVITATIONAL ENERGY	Soil settlement	Stress on fittings causing leaks.	Tubing flexibility, civil design to consider local conditions.					
H-26	Electrolyser	NATURAL ENERGY	Hailstones	Damage to the cooling fans on the electrolyser roof.		Hydrogenics to advise on requirements for protection from hail damage.	1	AP		
H-27	Electrolyser	NATURAL ENERGY	Lightning	Electrolyser damage.		ANT/Hydrogenics to advise on required protection mechanisms against lightning damaging the electrolyser package.	1	AP		
H-28	Oxygen System	CHEMICAL ENERGY	Oxygen loss of containment.	Oxygen enriched fire in the electrolyser building, from pipework or around vents	Continuous purging flow through the enclosure with exhaust fans.	Hydrogenics to provide input from package HAZOP on management of oxygen risks. Is O2 building analyser included in the package? Confirm SIL rating of exhaust fan failure detection as well as H2 and O2 detection in the building. HAZOP action 3-12 Action for Hydrogenics to identify all feeds to drains. If gas breakthrough can occur in O2 or H2 scrubbers connected to drains, a SIL study will be required on the Low level instrumented functions.	1	AP		

HAZOP Minutes - Overview

Node		Problem Description			Safeguards and Controls		Action			
ID	**System / Plant**	**Guideword**	**Cause**	**Consequence**	**Existing Proposed Safeguards**	**New Proposed Safeguards**	**Priority**	**Responsible**	**Complete Yes/No**	**Comments / Notes**
H-29	**Whole site**	CONTROLS AND CONTROLLERS	Human error - maintenance activities.	Hydrogen and oxygen services are new to Jemena. Will require some additional training ad new practices.	HAZOP action 1-23 Develop competency based training module for the new facility. Make competency based training a requirement for hydrogen service operators . Create register for management of accredited personnel.	Jemena to contact existing hydrogen/oxygen industries (industrial gases) to further understand specific risks and risk management. Create procedure for management of spare parts specific for hydrogen and oxygen service. Ensure field auditing of procedural activities occurs for the new facility. More intensively during initial operation.	3	AW		
H-30	**Whole site**	THIRD PARTY HAZARDS	Malicious damage; theft etc. (this has happened before at this location)	Damage	Secure location, away from the roadside, on an existing industrial facility. Signposting will not draw unwanted attention to the facility. Facility will be fenced and locked with authorised personnel entry only signage.					
H-31	**Whole site**	CHEMICAL ENERGY	Air ingress during commissioning, start up after maintenance	Explosion within piping	HAZOP action 1-22 Strict use of nitrogen purging after maintenance to be enforced in hydrogen service, and included in all start-up/re-commissioning operating procedures. HAZOP action 1-23 Develop competency based training module for the new facility. Make competency based training a requirement for hydrogen service operators . Create register for management of accredited personnel.					
H-32	**Whole site**	KINETIC ENERGY	Distortion of soft components in hydrogen service e.g. gaskets, swagelock, treads, valve internals	Loss of containment.	Design and liaison with material vendors. Leak detection					
H-33	**Whole site**	THIRD PARTY HAZARDS	Aircraft crash / false landing. This site is in vicinity of training area with light aircraft.	Damage, loss of containment, fire.	General aircraft safety regulations make the event of a crash unlikely. The plant has a relatively small footprint making it unlikely to be hit in the event of a crash.					
H-34	**Whole site**	HARM TO HUMANS / BIOLOGY	Cooling water system - legionnaires?		Cooling uses refrigerant, no cooling tower (Hydrogenics to confirm) .					
H-35	**Whole site**	HARM TO ENVIRONMENT	Prospect reservoir - 1km away. Drains to creek. Only potential effluent is Brine.	Contamination of water ways		Water treatment and disposal options to be reviewed and specified. Consider EPA regulations and minimising harm to the environment.	1	SH		
H-36	**Whole site**	HARM TO ENVIRONMENT	NG venting through instrument gas system.	negligible contribution						
H-37	**Whole site**	HARM TO PUBLIC / COMMUNITY	Potential push-back from the consumer community on increased hydrogen in the product.		Jemena public affairs to develop engagement program with the local community and broader consumers.					
H-38	**Whole site**	HARM TO ADJACENT PROPERTY	Harm to aircraft flying overhead due to released flammable gas cloud during venting of storage pipeline.	Aircraft disturbance		Determine if the facility is directly under any flight paths and potential consequences. Lease with relevant authorities.	2	AW		

Client	Jemena			Document Title	Document Subtitle	Document No.
Client	-	GPA	18667	HAZOP Minutes		18667-REP-008
Project	Western Sydney Green Gas Trial					

HAZOP Minutes - Overview

Node		Problem Description			Safeguards and Controls		Action			
ID	System / Plant	Guideword	Cause	Consequence	Existing Proposed Safeguards	New Proposed Safeguards	Priority	Responsible	Complete Yes/No	Comments / Notes
H-39	Whole site	DOWNSTREAM / UPSTREAM EFFECTS	Electrical generation - synchronisation system	Generator supplies to the grid	Design is compatible with grid supply.					

APPENDIX 2 BALANCE OF PLANT HAZOP

Document Title	Document No.
HAZOP Minutes	**18667-REP-008**

Client Name	Jemena			Date	5/08/2019	By	NPK
Client Project No.	-	GPA Project No.	18667	Rev	0	Chkd	LH
Project Name	Western Sydney Green Gas Trial					QA	

HAZOP Details

Facilitator	Lisa Hein
Scribe	Nick Kastelein
Workshop Date	25-26 July 2019
Workshop Location	Jemena, Level 16 457 Collins St, Melbourne
HAZOP Sponsor	Jemena
HAZOP Stage	Detailed Design

HAZOP Participants

Name	Initials	Role / Position	Company	Day 1	Day 2
Nick Kastelein	NK	Mechanical Engineer	GPA Engineering	X	X
Briony O'Shea	BO	Senior Project Manager	GPA Engineering	X	X
Daniel Krosch	DK	Mechnical Engineer	GPA Engineering	X	X
Sam Hatwell	SH	Process Engineer	GPA Engineering	X	X
Steve Drinkald	SD	Senior Project Engineer (E&I, Elec)	GPA Engineering	X	X
Nathan Tickle	NT	Mechanical Technical Officer	Jemena	X	X
Paul Dixon	PD	E&I Technical Officer	Jemena	X	X
Frank Libri	FL	Commissioning Manager	Jemena	X	X
Norman Sim	NS	Prn. Mechanical Engineer	Jemena	X	X
Andrew MacKay	AM	Prn. Process Engineer	Jemena	X	X
Siva Thiru	ST		Jemena	-	-
Mark Rathbone	MR	Snr. Project Manager	Jemena	X	X
Aldo Pace	AP	Project Manager	ANT	X	-
James de Gois	JDG	Projects / Engineering	ANT	X	-
Marcoen Stoop	MS	Sales Director	Hydrogenics	X	-
Leon Terenyi	LT	Project Engineer	Jemena	X	X
Alistair Wardrope	AW	Technical Lead	Jemena	X	X
J.P. Van Der Vyer	JVDV	Principal E&I Engineer	Jemena	-	X
Bessim Geusher	BG	O&M Integration	Jemena	PT	-

Background

Jemena has proposed construction of a demonstration hydrogen production plant within and adjacent to their existing high pressure gas facilities at Horsley Park in New South Wales. The project, called the Western Sydney Green Gas Trial (WSGGT), will initially produce 100 Nm^3/h of hydrogen gas with a 500 kW Hydrogenics PEM electrolyser using electricity from the local power grid. Produced hydrogen gas will either be injected into the existing natural gas distribution network for sale as blended natural gas / hydrogen, or used to generate electricity using a gas fuelled generator package. It will also be possible to run the gas fuelled generator package using natural gas from the adjacent natural gas distribution network as fuel.

The plant includes the following equipment, packages and utilities:

- Electrolyser package (including water treatment system, hydrogen production, hydrogen purification, cooling system and analyser systems)
- Waste water disposal system
- Hydrogen storage pipeline
- Natural gas network injection package (including provision for natural gas withdrawal)
- Gas panel package (for regulating hydrogen flow to other users)
- Gas fuelled generator package (capable of running on natural gas and in the future hydrogen)

The plant will be designed with the following provisions for expansion:

- Electrolyser package, balance of plant piping and natural gas distribution network injection system designed for an additional 500 kW electrolyser stack and associated additional 100 Nm^3/h of hydrogen gas.
- Electrolyser electrical supply designed to be powered via a proposed solar farm adjacent the facility.
- Connection to a proposed future hydrogen refuelling station package.
- Connection to a proposed future hydrogen cylinder filling package.

The electrolyser package, including associated cooling and water treatment system and the gas fuelled generator package will be vendor designed packages that will interface with the plant.

The scope of this HAZOP is the balance of plant equipment; including the waste water disposal system, hydrogen storage pipeline, natural gas network injection package, and gas panel package; and the plant interfaces to mains water and natural gas distribution network.

Detailed indicative P&IDs of the electrolyser package will be available for reference during the workshop but are excluded from the scope.

Node Definitions

Node	Description	Drawings:	Plant & Equipment:	Instrumentation:	Line Numbers:
1	Electrolyser outlet, hydrogen storage pipeline and bypass	P2G-2099-DW-PD-005, P2G-2099-DW-PD-006, P2G-2099-DW-PD-004	EYX-H01001, FG-H03001, FG-H02001	PIT-06015, XSV-06001, PIT-03016, XSV-03001	HG-H01001-SH3D-25, HG-02001-SH3D-25, HG-02001-CH5D-500, G-H02003-SH3D-25
2	Electrolyser Package Water Supply	P2G-2099-DW-PD-005	EYX-H01001		PW-H01001-C1TD-50
3	Waste Water Disposal System	P2G-2099-DW-PD-005	T-H01002, P-H01001, T-H01001	LSHH-01005, LIT-01004, PI-01001, LIT-01002, LSHH-01003	n/a
4	Electrolyser Vents	P2G-2099-DW-PD-005	EYX-H01001		n/a (oxygen vent and hydrogen vent)
5	Natural Gas Distribution Network Injection Run	P2G-2099-DW-PD-004	FG-H02001	XSV-06001, PI-06002, FV-06003, PIT-06005, PIT-06006, TIT-06007	HG-06001-SH3D-25
6	Natural Gas Distribution Network Withdrawal Run HAZOP NOTE: During the workshop Node 6 and Node 8 were considered simultaneously and recorded against Node 6.	P2G-2099-DW-PD-004, P2G-2099-DW-PD-006	FG-H02001, FG-H03001	XSV-06011, PIT-06008, XSV-03003	G-H02003-SH3D-25, G-H02001-PE HOLD-50, G-H02001-SH3D-25
7	Gas Fuelled Generator Package Hydrogen Pressure Regulation Run	P2G-2099-DW-PD-006, P2G-2099-DW-PD-003	GX-H09001	XSV-03001, PI-03003, PCV-03017, PI-03018, PCV-03019, PIT-03006, UT-03007, TE-03007	HG-H09001-SH3D-25, G-H09003-SH3D-25
8	Gas Fuelled Generator Package Natural Gas Pressure Regulation Run HAZOP NOTE: During the workshop Node 6 and Node 8 were considered simultaneously and recorded against Node 6.	P2G-2099-DW-PD-005	GX-H09001	XSV-03003, PI-03009, PCV-03020, PI-03021, PCV-03022, PIT-03012, UT-03013, TE-03013	G-H09001-SH3D-25, G-H09003-SH3D-25
9	Natural Gas Distribution Network Instrument Gas Offtake	P2G-2099-DW-PD-004	F-HOLD	PCV-06014, PI-06013, PSV-06012	n/a
10	Instrument Air Package (HOLD) and Instrument Air Header HAZOP NOTE: During the workshop it was agreed that instrument air be supplied from the electrolyser package instrument air system rather than a separate balance of plant instrument air compressor. Therefore no review of this node was required.	P2G-2099-DW-PD-002, P2G-2099-DW-PD-003, P2G-2099-DW-PD-005	CX-H1001 (HOLD)	PIT-10001 (HOLD)	IA-H10002-CT1D-25, IA-10001-CT1D-25

HAZOP Minutes - Nodes

	Problem Description			Safeguards and Controls		Action			
ID	**Guideword**	**Cause**	**Consequence**	**Existing safeguard**	**Action required**	**Priority**	**Responsible**	**Complete Yes/No**	**Close-out Comments and References**
1-1	HIGH FLOW / LEVEL	High amperage into the electrolyser package.	Design sized for maximum hydrogen production.	Current control and current meters which trigger shut-down of the electrolyser. Stack cannot physically generate more than 200 Nm3/h.					
1-2	HIGH FLOW / LEVEL	Downstream rupture / leak occurs.	Loss of containment of H2 and production continues to atmosphere. Gas pressure decreases as the buffer store inventory depletes.	Back-pressure regulator on electrolyser stack prevents low discharge pressure.	Add trip to PALL-06015 to shut down the electrolyser in the event of rupture (consider pressure rate-of-change trip). Confirm Back-pressure regulator on electrolyser stack prevents low discharge pressure.	1 1	SD		
1-3	LOW FLOW / LEVEL	Closed or partially closed manual valve (such as H03003 or other downstream valves).	Loss of production. High pressure in the electrolyser and continuous hydrogen venting from the vent stack.	Electrolyser controls current in response to discharge pressure. High downstream pressure would reduce electrolyser settings to minimum turn-down, manual vent will relieve pressure, and finally an electrolyser PSV will relieve hydrogen to protect the electrolyser.					
1-4	NO FLOW / EMPTY	See low flow							
1-5	NO FLOW / EMPTY	Downstream end of pipeline is not flowing in some operating conditions, such as if the valve line-up on the gas panel means that the buffer storage is bypassed.	The downstream end of the pipeline will be a "dead leg".	Pipeline is dry and clean and hence internal corrosion risk is not expected even in zero flow conditions.					
1-6	REVERSE FLOW	Backflow from secondary mains during empty/low pressure conditions of the buffer store.	Natural gas contamination into the hydrogen piping. Hydrogen purity is compromised, which will do damage to any customers using fuel cells or other sensitive technology.	PALL-06015 to XSV-06001 will inhibit injection system from opening if the pressure is less than 1,050 kPag (the MAOP of the secondary mains). Check valve on natural gas injection line.	Jemena's preference is for anti-feedback of NG into H2 is a primary method plus two additional layers of protection. Primary Protection in this case would be from PALL-06015 which closes XSV-06001. Check valve is a layer of protection. Consider second check valve (different type) or closing FV-06003 on PALL-06015 (although not independent to closing XSV-06001) as a second layer of protection. Specify soft seats check valves with zero leak.	1	NK		
1-7	REVERSE FLOW	Rupture / leak or venting of the electrolyser package.	The buffer store is emptied via the electrolyser package.		Add a check valve adjacent H03003.	1	SH		

HAZOP Minutes - Nodes

	Problem Description			Safeguards and Controls		Action			
1-8	HIGH PRESSURE	Locked in gas warms up after being shut in.	The pressure increases, ultimately exceeding the pressure design conditions.	The pipeline will not reach more than 3,500 kPag due to high pressure electrolyser shut-down trips. The piping is designed for 3,800 kPag and hence can handle any thermal pressure increase during shut-in conditions. Pipeline is buried, and hence not subject to short-term heating.	Increase pipeline design pressure from 3,800 kPag to full class 300, and hydrotest to that pressure. DRAFTING NOTE: Correct set-points on PIT-06015	1	NK		
1-9	LOW PRESSURE	Consumption of gas in the buffer store depletes the inventory, e.g. because multiple users take the gas simultaneously.	The buffer store pressure reduces below the minimum pressure for the gas turbine, which is 540 kPag. This will initiate a trip for the gas turbine.	PALL-03016 interlocked to XSV-03001 will prevent use of gas turbine if the inlet pressure to the turbine is below 540 kPag.					
1-10	HIGH TEMPERATURE	Electrolyser supplies high temperature hydrogen at discharge due to incorrect operation of the dryer in its recharge cycle.	The pipeline downstream is designed to a maximum of 65°C; potential damage to coatings of other soft components if the temperature is exceeded. Also harm to personnel if they contact piping at high temperatures.	Electrolyser high temperature alarm on each dryer, trip on discharge vessels. TTZ 1160 is a temperature switch set at 80°C, the gas sent to the vent stack will never exceed this temperature, not even during regeneration, this is because heat exchanger X-1156 is present. Length of buried pipeline will allow for cooling to occur.	Determine maximum allowable temperature for the piping. Set electrolyser's high temperature trip to shut down the electrolyser if temperatures exceed maximum allowable for downstream piping.	1	NK / AP		
1-11	LOW TEMPERATURE	Low temperatures may occur after rapid depressurisation of the system. The minimum temperature would occur after depressurisation at minimum ambient temperature.	No significant consequence.	Pipeline minimum design temperature is -10°C, and minimum ambient is -6°C. Thermal mass of steel will prevent low steel temperatures.					
1-12	IMPURITIES	Failure / reduction of performance of upstream deoxy / drier systems in the electrolyser skid.	Impure hydrogen is sent to the gas panel, which will damage fuel cells that use the gas.	The electrolyser package has a gas analyser which will vent off-specification gas and control logic to reduce impurities. Set points: O_2 = 2ppm, Dew point = -75°C.					
1-13	IMPURITIES	Residual debris, water remains in pipeline after the hydrotest.	Required hydrogen purity cannot be achieved. Product off spec, potential damage to fuel cell users.		Prepare a commissioning procedure involving cleaning, drying and purging to achieve required purity.	2	NK		
1-14	IMPURITIES	Residual debris, water remains in pipeline after the hydrotest.	Required hydrogen purity cannot be achieved. Product off spec, potential damage to fuel cell users.		Determine need for filtration to be installed downstream near users. To be used as a post commissioning check before selling product.	1	SH		
1-15	CHANGE IN COMPOSITION	*No issues identified*							
1-16	CHANGE IN CONCENTRATION	*No issues identified*							

HAZOP Minutes - Nodes

	Problem Description			Safeguards and Controls		Action			
1-17	REACTIONS	Use of incompatible materials, that fail in hydrogen service.	Failure of materials.	Pipeline designed to "no rupture" and use of low design factor (guidance per ASME B31.12).	Confirm that hot tap and all soft component fittings have hydrogen-compatible materials.	1	NK		
1-18	REACTIONS	Use of incompatible materials, that fail in hydrogen service.	Failure of materials.	Pipeline designed to "no rupture" and use of low design factor (guidance per ASME B31.12).	Sparing philosophy to ensure that natural gas service components are not used in hydrogen system when incompatible.	2	AW		
1-19	TESTING	Hydrogen leaks from fittings.	Flammable mixture forms around fitting.	Personal gas detection, permit to work procedures.	Design to include use of hoods with gas detectors in locations with multiple fittings and valves. E.g. gas panel, injection panel, pipeline end connections. Add short-term isolation function, which shuts in system for 15 minutes and monitors pressure change during shut-in to detect leak. Include as routine test in operating procedures.	1 1	SH SD		
1-20	TESTING	Regular functioning testing of the gas Pressure Reducing Station PRS results in pressure pulses in the gas line.	Reverse flow into hydrogen system.		PRS testing procedure to be updated to include manual isolation and lock-out of the hydrogen injection line during testing of PRS. Provide manual lockout valve to isolate hydrogen.	1	NK		
1-21	OPERABILITY / MAINTAINABILITY	Pipeline blowdown for maintenance	Ignition of released hydrogen due to expansion/velocity.		Design venting procedure. E.g. limit velocity, nitrogen dilution at vent, flow control valve, or calculate radiation distance and provide exclusion zone. Include requirements in the shutdown procedure. Also consider noise attenuation as part of blow down system design and consider cross bonding and earthing across all components. Ensure pipework is clearly labelled i.e. H_2, CH_4, O_2 & H_2O.	1	SH		
1-22	OPERABILITY / MAINTAINABILITY	Air ingress after maintenance. Including from incorrectly connected instrument air tubing.	Flammable mixture forms in pipe and ignites. Localised release of hydrogen		Strict use of nitrogen purging after maintenance to be enforced in hydrogen service, and included in all start-up/re-commissioning operating procedures.	3	AW		
1-23	OPERABILITY / MAINTAINABILITY	Air ingress after maintenance. Including from instrument air.	Flammable mixture forms in pipe and ignites.		Develop competency based training module for the new facility. Make competency based training a requirement for hydrogen service operators . Create register for management of accredited personnel.	1	AW		

HAZOP Minutes - Nodes

		Problem Description			Safeguards and Controls		Action			
1-24	OPERABILITY / MAINTAINABILITY	Potential for a high leak rate at connections, especially large-bore flanged connections.	Loss of containment of product. Wastage of inventory.		Review potential alternatives for mechanical connections on large diameter joins, which may have high leak-rate.	1	NK		
1-25	ELECTRICAL	Cathodic protection current on buried pipeline.	Current discharges through the above-ground piping making CP ineffective.	*None identified.*	Consider cross-bonding to existing buried assets. DRAFTING NOTE: mark up connections from pipeline to tubing as isolation joints with surge diverters.	1	NK		
1-26	ELECTRICAL	Electrolyser has 200V DC stack. Design for potentials and touch potentials is mitigated by earthing on the electrolyser package.	Discharge through the piping could damage soft components or shock personnel/operators and may cause corrosion over time.	Earthing system design of electrolyser package.	Review putting isolation joints at electrolyser connections to isolate electrically.	1	NK		
1-27	INSTRUMENTS	*No issues identified*							
2-1	HIGH FLOW / LEVEL	Downstream rupture.	Continuous flow from the water main. Water accumulates at the leak site, e.g. the utility area in the electrolyser container.	Site water can be isolated at the custody transfer from Sydney water.					
2-2	LOW FLOW / LEVEL	Filter blockage.		Filter monitoring and change-out requirements to be specified in water treatment package.					
2-3	NO FLOW / EMPTY	Closed valve upstream of electrolyser.	Electrolyser shuts down on low water.	Package trips; about 20 minutes at maximum production between detection and electrolyser shut-down.					
2-4	REVERSE FLOW	*No issues identified*							
2-5	HIGH PRESSURE	High supply pressure from water mains.	Design pressure for water inlet is exceeded.	High pressure trip on electrolyser inlet line.	Confirm what water network pressure is, and determine the maximum inlet pressure to the electrolyser. Design pressure regulator if required.	1	AW		
2-6	LOW PRESSURE	*No issues identified*							
2-7	HIGH TEMPERATURE	*No issues identified*							
2-8	LOW TEMPERATURE	Low ambient temperatures.	Below freezing. Potential blockage of pipe while not running overnight.	No history of this occurring in this location. Unlikely and short-term.					
2-9	IMPURITIES	*No issues identified*							
2-10	CHANGE IN COMPOSITION	*No issues identified*							
2-11	CHANGE IN CONCENTRATION	*No issues identified*							
2-12	REACTIONS	*No issues identified*							
2-13	TESTING	*No issues identified*							
2-14	OPERABILITY / MAINTAINABILITY	Material of supply line.			Change to Polyethylene pipe.	1	NK		
2-15	ELECTRICAL	*No issues identified*							
2-16	INSTRUMENTS	*No issues identified*							

HAZOP Minutes - Nodes

	Problem Description			Safeguards and Controls		Action			
3-1	HIGH FLOW / LEVEL	RO plant malfunction or reduced function (e.g. off-specification water is rejected by water purity or safety function and dumps load of water into reject water system. (Design flow rate is less than 500 L/d) OR - Long duration between load-out of storage tank and hence it accumulates inventory until full.	Tanks are full, initiating overflow and leading to shut-down of electrolyser and loss of production.	LSHH 01004/5 on sump trigger shut-down of electrolyser. LSHH01002/3 on storage tank shut-down pump.	DRAFTING NOTE: Pump on/off wrong way around. High level on storage tank to shut down pump, rather than electrolyser. Conduct review to minimise wastewater production. Design pre-filtration system to reduce waste water production rate from RO system from 30% to target 1% Determine sizing of tanks.	1	SH		
3-2	LOW FLOW / LEVEL								
3-3	NO FLOW / EMPTY								
3-4	REVERSE FLOW	Open DN20 ball valve.	Siphon out tank volume through outlets.		Prevent siphon through inlet by removing internal fill tube.	1	SH		
3-5	HIGH PRESSURE	Blocked discharge on pump due to closed valves.			Determine over-pressure requirements on pump to suit pump type; fully-rate piping if possible.	1	SH		
3-6	LOW PRESSURE	Low sump level.	Vapour at pump suction / cavitation.		Determine NPSH potential. Size sump so that there is sufficient time for pump to self-prime if required.	1	SH		
3-7	HIGH TEMPERATURE								
3-8	LOW TEMPERATURE								
3-9	IMPURITIES	Debris accumulates in sump or storage tank, such as leaves, dirt or snakes.	Blockage accumulates over time, most likely of sump pump suction line.	Sump and tank have cover (but are still atmospheric).					
3-10	CHANGE IN COMPOSITION								
3-11	CHANGE IN CONCENTRATION								
3-12	REACTIONS	Enriched oxygen or hydrogen environment forms in drain due to gas break-through.	Fire/explosion potential.		Confirm that gas break-through is not feasible from oxygen or hydrogen streams in electrolyser. Action for Hydrogenics to identify all feeds to drains. If gas breakthrough can occur in O2 or H2 scrubbers connected to drains, a SIL study will be required on the Low level instrumented functions.	1	AP		
3-13	TESTING	Requirement to test the level indicators and switches.	Access to tank internals may be required.		Confirm access requirements to get into sump and tank for clean-out, and access to instruments for testing/calibration.	1	NK		
3-14	OPERABILITY / MAINTAINABILITY	Connection of suck truck to load-out.	Truck will bring their own hose.		Remove unnecessary hose from storage tank discharge.	1	SH		
3-15	ELECTRICAL	*No issues identified*							
3-16	INSTRUMENTS	*No issues identified*							

HAZOP Minutes - Nodes

	Problem Description			Safeguards and Controls		Action			
4-1	HIGH FLOW / LEVEL	All O2 and all H2 in vents are directed into just two vents. These are 5m apart, and also separated in height by ~1m.	H2 can ignite in the vent when doing deliberate venting (larger volume vented), which does not have significant consequences apart from making noise--receptors are only sensitive to noise at night, generally. A noise study is being completed.		Include ignition noise in noise study.	1	BOS		
4-2	LOW FLOW / LEVEL	Proximity of trees to O2 vent.	Potential for fire.		Consequence modelling for oxygen vents to be conducted. Results to include offset requirements to nearby foliage.	1	SH		
4-3	NO FLOW / EMPTY	*No issues identified*							
4-4	REVERSE FLOW	*No issues identified*							
4-5	HIGH PRESSURE	*No issues identified*							
4-6	LOW PRESSURE	*No issues identified*							
4-7	HIGH TEMPERATURE	*No issues identified*							
4-8	LOW TEMPERATURE	*No issues identified*							
4-9	IMPURITIES	*No issues identified*							
4-10	CHANGE IN COMPOSITION	*No issues identified*							
4-11	CHANGE IN CONCENTRATION	*No issues identified*							
4-12	REACTIONS	*No issues identified*							
4-13	TESTING	*No issues identified*							
4-14	OPERABILITY / MAINTAINABILITY	*No issues identified*							
4-15	ELECTRICAL	*No issues identified*							
4-16	INSTRUMENTS	*No issues identified*							
5-1	HIGH FLOW / LEVEL	Incorrect reading of natural gas flow at the pressure reduction station metering upstream.	Higher hydrogen flows, resulting in high concentrations of hydrogen in the pipeline stream (higher than the upper limit agreed with the technical regulator).	Specified maximum blend percentage is very low so that no expected impact on appliances. Hydrogen disperses very well in natural gas.	Conduct a LOPA/SIL study to determine integrity requirements for flow metering to prevent over injection of H2 into the gas mains. Remove both existing natural gas flow meters and calibrate to within 1% on Jemena meter calibration rig. Put on a PM program.	1 3	SH MR		

HAZOP Minutes - Nodes

	Problem Description			Safeguards and Controls		Action			
5-2	HIGH FLOW / LEVEL	During PRS testing there is no gas flow. If there is no gas customer demand and a gas flow instrument error, hydrogen could continue to be injected.	Slug of hydrogen could accumulate in the secondary gas main. Potential for consumer burner flame-out.	Limited hydrogen inventory can be injected in the line due to physical constraints of design. Hydrogen disperses well in natural gas. Gas demand is usually high.	Add low natural gas flow shut-off of hydrogen injection, so that there is a minimum NG flow required to be injecting. Prepare a LOPA for the potential consumer flame-out scenario, determine if any SIL rated instrumentation is required to prevent too much hydrogen injection.	1	SH		
5-3	LOW FLOW / LEVEL	*No consequences identified.*							
5-4	NO FLOW / EMPTY								
5-5	REVERSE FLOW	*Already covered - ref. node 1*			Close FV-06003 on PALL-06015. Increase low pressure set-point to 1,050 + 10%. Add interlock so that XSV is opened before the FV.	1	SD		
5-6	HIGH PRESSURE	Hydrogen pressure is up to 3,000 kPag operating pressure (and 3,800 kPag design).	Hydrogen supply can overpressure the natural gas line.	PAHH-06005 closes FV-06002, and PAHH-06006 closes XSV-06001.	Review overpressure control equipment, with consideration to integrity level achieved and Jemena's existing requirements for JGN.	1	SH		
5-7	HIGH PRESSURE	Slow leak across FV.	Over-pressure downstream tubing.		Move pressure spec. break to downstream manual valve.	1	SH		
5-8	LOW PRESSURE	Low inventory	Low injection flow rate	Sizing basis for FV at low-inventory pressures.					
5-9	HIGH TEMPERATURE								
5-10	LOW TEMPERATURE								
5-11	IMPURITIES								
5-12	CHANGE IN COMPOSITION								
5-13	CHANGE IN CONCENTRATION								
5-14	REACTIONS								
5-15	TESTING								
5-16	OPERABILITY / MAINTAINABILITY	preparation for maintenance			Add vent downstream of panel for double-block-and-bleed.	1	SH		
5-17	ELECTRICAL	Corrosion			Add isolation joint to secondary main tie-in	1	NK		

HAZOP Minutes - Nodes

	Problem Description			Safeguards and Controls		Action			
5-18	INSTRUMENTS	Use of instrument gas.	Complaints from neighbours due to odorant from continuous venting of control valves.	Low flowrate from instruments unlikely to reach neighbouring dwelling.					
6-1	HIGH FLOW / LEVEL	Line rupture / leak. (Note Nodes 6 and 8 combined)	Loss of containment. Generator out of operation.	Quality and integrity management.	DRAFTING NOTE: Change PCVs to fail open.	1	SH		
6-2	LOW FLOW / LEVEL	Pressure drop through second regulator may reduce discharge pressure below 700 kPag. (Sensor line currently between the two regulators)	Low flow conditions due to excessive pressure reduction across regulator arrangement.	Regulators to be designed for active-monitor arrangement to achieve 700 kPag min downstream.	DRAFTING NOTE: Active and Monitor labelled wrong way around.	1	SH		
6-3	NO FLOW / EMPTY	Expected future operation to take line out of service but leave gassed up.	Dead legs.	Use of SS and PE.					
6-4	REVERSE FLOW	Future tie-in of hydrogen.	Potential for hydrogen/NG mixing in line.	The generator will be fuelled by hydrogen or natural gas not blends. P&ID note added: Positive isolation will be provided in future case. The drawings will be updated with an MOC to show positive isolation of the gas line once hydrogen fuel is available.					
6-5	HIGH PRESSURE	Regulator failure.	Overpressure of the inlet to the generator.	Active-monitor arrangement; regulators fail closed. Maximum pressure from upstream is 1,050 kPag (10% above transient is possible), and generator is actually rated for 1,000 kPag. The likelihood of exceeding full rating is low.	Check with manufacturer to test and re-rate/certify to 1050kPa	1	SH		
6-6	LOW PRESSURE	Reduced operating pressure in the secondary main.	Generator inlet pressure too low.	Generator will trip at low supply pressure.					
6-7	HIGH TEMPERATURE	*No issues identified*							
6-8	LOW TEMPERATURE	*No issues identified*							
6-9	IMPURITIES	Nitrogen purging.	Nitrogen flow back into NG network.	Check valve at offtake.					
6-10	CHANGE IN COMPOSITION	*No issues identified*							
6-11	CHANGE IN CONCENTRATION	*No issues identified*							
6-12	REACTIONS	*No issues identified*							
6-13	TESTING	*No issues identified*			Critical function testing of ESD valves will be required. Create PMs	3	AW		
6-14	OPERABILITY / MAINTAINABILITY	*No issues identified*			DRAFTING NOTE: Add bleed to secondary main offtake to form double-block-and-bleed, and upstream of turbine.	1	SH		
6-15	ELECTRICAL	*No issues identified*							
6-16	INSTRUMENTS	Flow metering does not require temperature correction.	Opportunity to simplify.	Temp data is available from the outlet of PRS if correction is required.	Remove temperature element.	1	SH		

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	Problem Description			Safeguards and Controls		Action			
9-1	HIGH FLOW / LEVEL	PSV-06012 remains open.	Continuous venting. This PSV is instrumentation type; due to continuous acting, they can release frequently. Neighbourhood complaints due to odorant.	Operator rounds	Maximise difference between PCV and PSV set-points to minimise potential for unintended PSV opening. Identify re-seating pressure for PSV from manufacturer, search for PSV with lower re-seat pressure	1	SH		
9-2	LOW FLOW / LEVEL	Blocked filter.	Low flow resulting in actuated valves closing.	Routine maintenance. Bypass around filter to continue IG services during change-out.					
9-3	NO FLOW / EMPTY	Closure of upstream manual isolation valves (e.g. future case of not using the natural gas supply any more)	Instrument gas cut off, and hence fail closed of injection valves.	No consequence of loss of injection.					
9-4	REVERSE FLOW	*No issues identified*							
9-5	HIGH PRESSURE	PCV-06014 stops closing properly due to particulates accumulating in the seals.	Potential overpressure downstream.	PSV-06012 protects from over-pressure. Gas is sales gas. Filter installed upstream.	DRAFTING NOTE: Mark fail state of PCV Confirm need for PSV, as IG components may be fully rated.	1	SH		
9-6	HIGH PRESSURE	Transient high pressure due to operational checks upstream.		PSV-06012 protect from over-pressure.					
9-7	LOW PRESSURE	Low supply pressure of network.	Lose IG supply, and valves fail closed.	No consequence of loss of injection.					
9-8	HIGH TEMPERATURE	*No issues identified*							
9-9	LOW TEMPERATURE	*No issues identified*							
9-10	IMPURITIES	*No issues identified*							
9-11	CHANGE IN COMPOSITION	*No issues identified*							
9-12	CHANGE IN CONCENTRATION	*No issues identified*							
9-13	REACTIONS	*No issues identified*							
9-14	TESTING	*No issues identified*							
9-15	OPERABILITY / MAINTAINABILITY	-			Change bypass and isolation needle valves for ball valve.	1	SH		
9-16	ELECTRICAL	*No issues identified*							
9-17	INSTRUMENTS	Upstream connection has ball and needle.	Simplify.		Change to just a ball valve. Change vents to ball valve w. ventable plug for all natural gas service lines.	1	SH		

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	Problem Description			Safeguards and Controls		Action			
7-1	HIGH FLOW / LEVEL		(note: micro turbine has not been run in the field off H2 before; control philosophy maybe to control to downstream exhaust temperature)		DRAFTING NOTE: Change PCVs to fail open. The control system of the micro-turbine may react differently when the fuel is changed from Natural Gas over to Hydrogen (different burn and product characteristics) therefore the vendor needs to confirm that a high flow scenario cannot occur, where the fuel control valve demands more fuel than the turbine requires .	1	SH		
7-2	LOW FLOW / LEVEL	Blocked filter.	Low flow, restricted supply to generator and reduced output.	Unlikely due to cleanliness requirements of service.	DRAFTING NOTE: Change name of active and monitor.	1	SH		
7-3	NO FLOW / EMPTY	*No issues identified*							
7-4	REVERSE FLOW	Purge nitrogen migrates back to storage pipeline.	Off-specification H2.		Start-up procedures to ensure purging pressure is below the hydrogen storage pressure.	1	AW		
7-5	REVERSE FLOW	-			DRAFTING NOTE: Remove check valve.	1	SH		
7-6	HIGH PRESSURE	Blocked discharge OR PCVs fail open.	Overpressure of the inlet to the generator.	Active monitor pressure regulation arrangement (PCV 03017, 03019) and PAHH-03006 controlling XSV-03001.	DRAFTING NOTE: Electrical signal should come off PAHH, not PI block. Move design pressure change to downstream manual valve. LOPA assessment required for pressure protection function.	1	SH		
7-7	LOW PRESSURE	*No issues identified*							
7-8	HIGH TEMPERATURE	*No issues identified*							
7-9	LOW TEMPERATURE	*No issues identified*							
7-10	IMPURITIES	*No issues identified*							
7-11	CHANGE IN COMPOSITION	*No issues identified*							
7-12	CHANGE IN CONCENTRATION	*No issues identified*							
7-13	REACTIONS	*No issues identified*							
7-14	TESTING	*No issues identified*							
7-15	OPERABILITY / MAINTAINABILITY	*No issues identified*			Provide connections and layout for future expansion adding second generator.	1	NK		
7-16	ELECTRICAL	*No issues identified*							
7-17	INSTRUMENTS	*No issues identified*			DRAFTING NOTE: Remove thermowell reference, retain 'TE'.	1	SH		
10-1	HIGH FLOW / LEVEL	Supplied from electrolyser package. IA / IG. No longer required.							
10-2	LOW FLOW / LEVEL								
10-3	NO FLOW / EMPTY								
10-4	REVERSE FLOW								
10-5	HIGH PRESSURE								

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	Problem Description			Safeguards and Controls		Action			
10-6	LOW PRESSURE								
10-7	HIGH TEMPERATURE								
10-8	LOW TEMPERATURE								
10-9	IMPURITIES								
10-10	CHANGE IN COMPOSITION								
10-11	CHANGE IN CONCENTRATION								
10-12	REACTIONS								
10-13	TESTING								
10-14	OPERABILITY / MAINTAINABILITY								
10-15	ELECTRICAL								
10-16	INSTRUMENTS								

Client	Jemena			Document Title	Document Subtitle	Document No.
Client	-	GPA	18667	HAZOP Minutes	HAZID	18667-REP-008
Project	Western Sydney Green Gas Trial					

HAZID Minutes

Node		Problem Description			Safeguards and Controls		Action			
ID	**System / Plant**	**Guideword**	**Cause**	**Consequence**	**Existing Proposed Safeguards**	**New Proposed Safeguards**	**Priority**	**Responsible**	**Complete Yes/No**	**Comments / Notes**
H-1	**Hydrogen Systems**	CHEMICAL ENERGY	Corrosion - internal or external Underground pipeline is carbon steel pipe, which is susceptible to hydrogen embrittlement.	Release of Hydrogen to atmosphere, ignition occurs instantaneously or delayed resulting in a jet or flash fire. Property damage and potential fatality/s	Buried pipe is designed with low design factor and relatively low-strength grade (X52) material to ensure low stress conditions protecting against rupture due to H2 embrittlement. This pipe is also coated and has cathodic protection. Facility piping is stainless steel, which is less susceptible than carbon steel to H2 embrittlement, and is also operating under low stress conditions which will prevent a rupture. As part of the quality management plan, defect testing of the piping and equipment will occur post manufacture. Exhaust fans and H2 gas detectors initiating an ESD in Electrolyser building. Ignition control: To be managed by Jemena's permit to work system, operator clothing will be antistatic and flame retardant.	HAZOP action O-4 Review requirements relating to hydrogen-assisted fatigue crack growth (HA-FCG), relating to defect inspection, weld defect tolerances, and monitoring etc.	2	AW		
H-2	**Buried Steel**	ELECTRICAL ENERGY	Stray currents	Compromised cathodic protection leading to corrosion - including of existing assets.		Consider cross-bonding to existing buried assets. HAZOP action 1-25.	1	NK		
H-3	**Electrolyser**	CHEMICAL ENERGY	Mole sieve material passing through into filters - on the electrolyser package.	Loss of performance	Maintenance procedures and operations monitoring.					
H-4	**SS Piping**	CHEMICAL ENERGY	Dissimilar metals.	Galvanic corrosion.		Include isolation joints in the design.	1	NK		
H-5	**Buried Steel**	CHEMICAL ENERGY	CP Interference	-		The potential for CP Interference will be mitigated in the CP design. CP design report to address other buried structures CP interferences. Submission of the new design to the Electrolysis committee may required for approval TBC.	1	MR		
H-6	**Steel**	HARM TO PLANT	Hydrogen effects on steel	Embrittlement and fatigue crack growth.	To be susceptible, a combination of three factors is required: presence of (and diffusion of) hydrogen, susceptible material, and stress. The design of piping will be 'no rupture' to ensure that any potential fatigue cracks will not propagate due to the low stress conditions. Material susceptibility is being managed by material selection (compatible with hydrogen), post manufacture defect testing such as hydrotest and radiography.					

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Node		Problem Description			Safeguards and Controls		Action			
ID	System / Plant	Guideword	Cause	Consequence	Existing Proposed Safeguards	New Proposed Safeguards	Priority	Responsible	Complete Yes/No	Comments / Notes
H-7	Buried Steel	CHEMICAL ENERGY	Soil corrosion - potential for acid sulphate soils.	Corrosion of piping.	Coating and CP of buried pipe.	Procedure for handling of piping and equipment during construction to be created to avoid soil contact. Training of construction personnel is requirements.	2	AW		
H-8	Electrolyser	ELECTRICAL ENERGY	Vents - sparking due to flaps/moving components and velocity.	Ignition of hydrogen when venting.		Design of all vents to be non-sparking.	1	AP		
H-9	Pipeline	ELECTRICAL ENERGY	Vents - sparking due to flaps/moving components and velocity.			Design of all vents to be non-sparking. Use a sock.	1	NK		
H-10	Electrolyser	THERMAL ENERGY	Failure of electrolyser chilling systems- max temp 80°C.	Potential burns to personnel touching pipe.	Electrolyser package will trip on high discharge temperature. TTZ 1160 is a temperature switch set at 80°C, the gas sent to the vent stack will never exceed this temperature, not even during regeneration, this is because heat exchanger X-1156 is present.					
H-11	Electrolyser	THERMAL ENERGY	No low temperature issues. Considered Joule-Thompson, and chiller system harm to personnel (it operates to min. 5°C)							
H-12	Generator	THERMAL ENERGY	Hot components, and exhaust temperatures. Potential for hydrogen attack (on steel components).	Personnel injury, corrosion.	Controlled by design. Cladding will be installed to protect operators. Internal materials are designed to prevent hydrogen attack. Vent stack has air shrouded combustion.					
H-13	Whole site	RADIANT ENERGY	Fire from adjacent facility, or bushfire.	Hydrogen facility potentially damaged if a neighbouring natural gas pipeline incident occurs, but it unlikely to cause an escalation that is beyond the existing risk. There is bushland adjacent to the facility but only 2 trees on site.	In the event of a bush fire or incident at a neighbouring facility, the hydrogen plant will be remotely shutdown.	Response plans to be created/updated to include remote shutdown of hydrogen facility in the event of nearby fire.	1	AW		
H-14	Whole site	ELECTRICAL ENERGY	Battery on generator, and two UPS'.	Stored energy release if battery fails. Potential for fire/explosion.	Jemena and battery vendor management procedures to be applied for battery management.	Preventative maintenance work orders to be created for inspection/testing.	3	AW		
H-15	Electrolyser	ELECTRICAL ENERGY	Electrolyser current discharge.	Arc flash may occur resulting in personnel injury. Considered a low risk in this application.	Low risk. Reviewing design. Arc flash detection? Bus bars may be heavy.	ANT to minimise potential for arc flash in the electrical design. Determine if arc flash detection is required and include in the design. GPA also to review design regarding arc flash requirements.	1 1	AP JD		
H-16	Transformer	ELECTRICAL ENERGY	Supplied pad-mount from the grid by electricity supplier.							

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Node		Problem Description			Safeguards and Controls		Action			
ID	**System / Plant**	**Guideword**	**Cause**	**Consequence**	**Existing Proposed Safeguards**	**New Proposed Safeguards**	**Priority**	**Responsible**	**Complete Yes/No**	**Comments / Notes**
H-17	**Whole site**	ELECTRICAL ENERGY	Ignition of releases.	Fire if loss of containment occurs.	A hazardous area study will be completed. The equipment will be hazardous area designed and rated as per report requirements. The existing Jemena permit system will be reviewed for the new application and applied in operation. Equipment will be procured with IECEx compliance suitable for hydrogen. - (International Electro technical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System))	Review and update if required existing Jemena permit system for application in hydrogen operation. To further control ignition sources, determine whether non-sparking tooling is required for all maintenance work. Provide training and equipment per specifications.	1	AW		
H-18	**Whole site**	ELECTRICAL ENERGY	Static risks - ignition source for explosive environment. Numerous visitors expected to the site, including media.	Fire if loss of containment occurs.	Anti-static clothing a requirement for anyone entering the site. Mobile phones and other devices that may be potential ignition sources to be managed by Jemena's reviewed permitting system. for this site. No-go / exclusion zones to be marked out e.g. electrolyser building	Induction process to be created for workers / visitors. Hydrogen gas detectors a requirement for personnel.	3	AW		
H-19	**Whole site**	ELECTRICAL ENERGY	Mowers, vehicles	Fire if loss of containment occurs.	Jemena's permit to work system Reference XXX	Define exclusion zone around pipeline riser using bollards. Define all exclusion zones and install a light barrier.	1	SH		
H-20	**Whole site**	CHEMICAL ENERGY	Small leaks.	Loss of product, potential fire. May go undetected.	Hydrogen detectors are located in in the electrolyser building. Detection will trip the electrolyser (confirm). Jemena personnel will be required to wear H2 detectors when entering the site, exclusion zones will be created for areas with a higher potential for leaks of venting. HAZOP action 1-19 Balance of plant design to include use of hoods with gas detectors in locations with multiple fittings and valves. E.g.. gas panel, injection panel, pipeline end connections.	Create leak response procedure for hydrogen leak detection. Add short-term isolation function, which shuts in system for 15 minutes and monitors pressure change during shut-in to detect leak. Include as routine test in operating procedures.	3 1	AW SD		
H-21	**Whole site**	CHEMICAL ENERGY	Large leaks	Fire	Video cameras reporting to remote control room are a part of the design. Remote shut-down of the facility is available. An ESD button will be available at the entrance gate.	Determine requirements for an infrared camera to be installed on site. Provide Infrared cameras for personnel entering the site. Leak detection to initiate a local beacon/siren. Make siren interlock with gate (so only alarms if someone is there).	3 1	AW SD		

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Node		Problem Description			Safeguards and Controls		Action			
ID	System / Plant	Guideword	Cause	Consequence	Existing Proposed Safeguards	New Proposed Safeguards	Priority	Responsible	Complete Yes/No	Comments / Notes
H-22	**Whole site**	KINETIC ENERGY	Impact from vehicle	Loss of containment.	Design will propose a layout to minimise vehicle traffic considering access requirements for maintenance/production etc.	Conduct further layout review to minimise potential for vehicle impact. Consider all access requirements. Install bollards where required.	1	NK		
H-23	**Whole site**	NOISE ENERGY	Noise	Residential disturbances/complaints.	A noise study will be conducted in the design phase.					
H-24	**Electrolyser**	GRAVITATIONAL ENERGY	Working on top of electrolyser package	Fall from height	Jemena working at heights procedures will be applied.	Consider moving maintainable components to the side. Confirm roof railings are provided.	1	AP		
H-25	**Whole site**	GRAVITATIONAL ENERGY	Soil settlement	Stress on fittings causing leaks.	Tubing flexibility, civil design to consider local conditions.					
H-26	**Electrolyser**	NATURAL ENERGY	Hailstones	Damage to the cooling fans on the electrolyser roof.		Hydrogenics to advise on requirements for protection from hail damage.	1	AP		
H-27	**Electrolyser**	NATURAL ENERGY	Lightning	Electrolyser damage.		ANT/Hydrogenics to advise on required protection mechanisms against lightning damaging the electrolyser package.	1	AP		
H-28	**Oxygen System**	CHEMICAL ENERGY	Oxygen loss of containment.	Oxygen enriched fire in the electrolyser building, from pipework or around vents	Continuous purging flow through the enclosure with exhaust fans.	Hydrogenics to provide input from package HAZOP on management of oxygen risks. Is O2 building analyser included in the package? Confirm SIL rating of exhaust fan failure detection as well as H2 and O2 detection in the building. HAZOP action 3-12 Action for Hydrogenics to identify all feeds to drains. If gas breakthrough can occur in O2 or H2 scrubbers connected to drains, a SIL study will be required on the Low level instrumented functions.	1	AP		
H-29	**Whole site**	CONTROLS AND CONTROLLERS	Human error - maintenance activities.	Hydrogen and oxygen services are new to Jemena. Will require some additional training ad new practices.	HAZOP action 1-23 Develop competency based training module for the new facility. Make competency based training a requirement for hydrogen service operators . Create register for management of accredited personnel.	Jemena to contact existing hydrogen/oxygen industries (industrial gases) to further understand specific risks and risk management. Create procedure for management of spare parts specific for hydrogen and oxygen service. Ensure field auditing of procedural activities occurs for the new facility. More intensively during initial operation.	3	AW		
H-30	**Whole site**	THIRD PARTY HAZARDS	Malicious damage; theft etc. (this has happened before at this location)	Damage	Secure location, away from the roadside, on an existing industrial facility. Signposting will not draw unwanted attention to the facility. Facility will be fenced and locked with authorised personnel entry only signage. Jemena is carrying out an action to review designs from a site security perspective.					

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Node		Problem Description			Safeguards and Controls		Action			
ID	**System / Plant**	**Guideword**	**Cause**	**Consequence**	**Existing Proposed Safeguards**	**New Proposed Safeguards**	**Priority**	**Responsible**	**Complete Yes/No**	**Comments / Notes**
H-31	**Whole site**	CHEMICAL ENERGY	Air ingress during commissioning, start up after maintenance	Explosion within piping	HAZOP action 1-22 Strict use of nitrogen purging after maintenance to be enforced in hydrogen service, and included in all start-up/re-commissioning operating procedures. HAZOP action 1-23 Develop competency based training module for the new facility. Make competency based training a requirement for hydrogen service operators . Create register for management of accredited personnel.					
H-32	**Whole site**	KINETIC ENERGY	Distortion of soft components in hydrogen service e.g. gaskets, Swagelok, treads, valve internals	Loss of containment.	Design and liaison with material vendors. Leak detection					
H-33	**Whole site**	THIRD PARTY HAZARDS	Aircraft crash / false landing. This site is in vicinity of training area with light aircraft.	Damage, loss of containment, fire.	General aircraft safety regulations make the event of a crash unlikely. The plant has a relatively small footprint making it unlikely to be hit in the event of a crash.					
H-34	**Whole site**	HARM TO HUMANS / BIOLOGY	Cooling water system - legionnaires?		Cooling uses refrigerant, no cooling tower (Hydrogenics to confirm) .					
H-35	**Whole site**	HARM TO ENVIRONMENT	Prospect reservoir - 1km away. Drains to creek. Only potential effluent is Brine.	Contamination of water ways		Water treatment and disposal options to be reviewed and specified. Consider EPA regulations and minimising harm to the environment.	1	SH		
H-36	**Whole site**	HARM TO ENVIRONMENT	NG venting through instrument gas system.	negligible contribution						
H-37	**Whole site**	HARM TO PUBLIC / COMMUNITY	Potential push-back from the consumer community on increased hydrogen in the product.		Jemena public affairs to develop engagement program with the local community and broader consumers.					
H-38	**Whole site**	HARM TO ADJACENT PROPERTY	Harm to aircraft flying overhead due to released flammable gas cloud during venting of storage pipeline.	Aircraft disturbance		Determine if the facility is directly under any new flight paths and potential consequences. Lease with relevant authorities.	2	AW		
H-39	**Whole site**	DOWNSTREAM / UPSTREAM EFFECTS	Electrical generation - synchronisation system	Generator supplies to the grid	Design is compatible with grid supply.					

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	Problem Description			Safeguards and Controls		Action			
ID	**Guideword**	**Cause**	**Consequence**	**Existing safeguard**	**Action required**	**Priority**	**Responsible**	**Complete Yes/No**	**Close-out Comments and References**
O-1	TOXICITY	Nitrogen leak within electrolyser enclosure.	Nitrogen is an asphyxiant. There is potential to create low oxygen atmosphere.	Continuous ventilation of the enclosure. Ventilation flow meter will stop unit if the ventilation is not working. Nitrogen bottles are located outside the container. Personnel use of low-oxygen gas detectors.	Develop procedures for entering enclosure when the system is shut-down. Consider use of low-oxygen alarm on atmosphere in the electrolyser container.	1 1	AW AW		
O-2	SERVICES REQUIRED	Low light inside enclosure on power failure.	Slip, trip or fall.	Night work not required.	Egress lighting from enclosure supplied from UPS to be provided.	1	AP		
O-3	SERVICES REQUIRED	Only instrument air users in current balance of plant scope are two small actuated shutoff valves.	Including a balance of plant air compressor may be an unnecessary expense		Facility instrument air to tie into electrolyser instrument air system.	1	AP / SH		
O-4	MATERIALS OF CONSTRUCTION	Underground pipeline is CS pipe, which is susceptible to hydrogen embrittlement.	Loss of containment.	Carbon steel pipeline designed with low design factor and relatively low-strength grade (X52) material to ensure low stress conditions protecting against rupture due to H2 embrittlement. Facility piping is stainless steel, which is less susceptible than carbon steel to H2 embrittlement, and is also operating under low stress conditions which will prevent a rupture.	Review requirements relating to hydrogen-assisted fatigue crack growth (HA-FCG), relating to defect inspection, weld defect tolerances, and monitoring etc.	1	NK		
O-5	MATERIALS OF CONSTRUCTION	Buried piping.		Use of coating and cathodic protection	Determine requirements for cathodic protection (sacrificial anode or cross-bonding to existing lines, TBC)	1	NK		
O-6	MATERIALS OF CONSTRUCTION	Degradation of soft materials e.g. Swagelok fittings, gaskets, instrumentation from exposure to hydrogen.	Loss of containment.		Confirm compatibility of soft components in hydrogen service (hot-tap O-rings, insulation joints, instrument seals etc.)	1	NK / SD		
O-7	COMMISSIONING	Contaminated pipeline.	Unable to achieve specified hydrogen purity (particularly for future scope items - fuel cells - where high purity is required).	Initial lower-spec hydrogen can be directed into the natural gas network (due to lower purity requirement).	Prepare commissioning plan for quality, with focus on pipeline cleanliness and dryness.	1	NK		
O-8	BREAKDOWN	Loss of power.	Site communications turn off and cannot identify the condition / status of the station. Note that hydrogen supply is not critical; interruption to hydrogen supply is not a contractual loss of supply problem. Demonstration plant only.	0.5 hour uninterruptible power supply (UPS) used in electrolyser for control/communications and will return instruments to a safe condition so that monitoring of parameters can continue while site is shut down.	Install UPS for balance of plant with 2 to 3 h backup time. Include backup power supply to lighting of exit signs in enclosures.	1 1	SD AP		

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ID	Guideword	Cause	Consequence	Existing safeguard	Action required	Priority	Responsible	Complete Yes/No	Close-out Comments and References
	Problem Description			Safeguards and Controls		Action			
O-9	STARTUP / SHUTDOWN	Start-up and shutdown are critical. One of the critical concerns is purging of piping; managing potential for air ingress during maintenance.	Explosion in piping/equipment.		Create competency based training for operators/maintainers and include risks of air ingress during start-up/shutdown. Create start-up and shutdown procedures and include air freeing/nitrogen purging of equipment prior to start-up.	3	AW		
O-10	EFFLUENT	Effluent includes Reject water from water treatment plant, Hydrogen and oxygen gasses.	Environmental pollution	Environmental approval plan required to be submitted and approved for the operation.	HAZOP action 3.1: design pre-filtration system to reduce waste water production rate from RO system from 30% to target 1% Sizing basis for on-site water inventory is 5m3 currently. Preferred sizing basis is the duration between load-out and size of load-out truck (e.g. 18 m3). Finalise sizing requirements for input into Environmental Impact Statement. Look at options to reduce water consumption and waste; on-site use optional.	1	SH		
O-11	NOISE / VIBRATION	Pumps, vents etc.	Neighbourhood disturbances.	Noise study planned for the site.					
O-12	FIRE / EXPLOSION	Hydrogen, oxygen, bushfire, and knock-on effects from adjacent facilities (this plant is within radiation contour of adjacent facilities).	Hydrogen facility potentially harmed if a pipeline incident occurs, but will not cause escalation beyond the existing risk.	Consequence modelling and risk assessment to be completed. Note: no gas or fire detection currently provided in the facility. HAZOP action	Determine if fire detection is required for the site e.g. fusible loops as a result of risk assessment.	1	SH		
O-13	FIRE / EXPLOSION	Loss of containment within electrolyser enclosure.	Fire within enclosure.	Hydrogen detector in the electrolyser enclosure, with control functionality to increase the fan speed for ventilation on low levels of H2 and shutdown on high levels.	Shutdown balance of plant when electrolyser shuts down on safety function (e.g. high hydrogen). Determine if fire detection is required within the electrolyser enclosure.	1 1	SD AP		
O-14	SAFETY EQUIPMENT	Loss of containment.	Operator approaches plant without knowing there's a leak, potentially introducing an ignition source.	Hydrogen detectors installed in the electrolyser building and planned for the BOP gas panel. Operators to wear personal hydrogen detectors. Control of ignition sources on the site though Jemena's existing management procedures such as hot work permits, antistatic clothing etc. Competency based training for operators.	Install an alarm/beacon at the site entrance gate to alarm on hydrogen detection so that operators do not approach faulted equipment. Determine if any modifications to Jemena's ignition control management procedures are required such as hot work permit system, antistatic clothing requirements, non-sparking tooling.	1 2	SD AW		

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	Problem Description			Safeguards and Controls		Action			
ID	**Guideword**	**Cause**	**Consequence**	**Existing safeguard**	**Action required**	**Priority**	**Responsible**	**Complete Yes/No**	**Close-out Comments and References**
O-15	QUALITY AND CONSISTENCY	*Leak due to material defect or human error during construction or maintenance.*	Loss of containment.	Jemena's Existing test and tag systems. Commissioning procedures					
O-16	OUTPUT – RELIABILITY AND BOTTLENECKS	*Demonstration plant only.* *Provision for future rate increase is included.*							
O-17	EFFICIENCY	*No Causes identified.*							
O-18	SIMPLICITY	*No Causes identified.*							
O-19	MOBILE EQUIPMENT / PLANT MOVEMENT	Buried services supplying Eastern Gas Pipeline (EGP) site are located in the area of the vehicle turnaround.	Access to buried equipment restricted by new development.		Review layout against buried services. Determine optimum locations for vehicle access to the site. Jemena to provide buried services drawing. Provide vehicle turnaround access for water storage tank load-out. Provide for laydown requirements for construction in development of layout.	1 1 1	AW / NK NK NK		
O-20	MOBILE EQUIPMENT / PLANT MOVEMENT	construction traffic	Compromise to existing operations	Construction phase - access to the EGP site required to be maintained during construction.	Include in commissioning plan access plans, laydown areas etc. so as not to disrupt access to existing facilities.	2	MR		
O-21	PROCESS PLANT NORMAL / ABNORMAL MAINTENANCE	Presence of oxygen causes high flammability of materials.	Unexpected ignition/fire	Specific oxygen-service grease provided by Hydrogenics.	Competency-based training to be reviewed for operators for equipment in oxygen service. Jemena to create management plan for consumables and critical spares - in oxygen and hydrogen service.	1 1	AW AW		
O-22	PROCESS PLANT PROCESS FUNCTIONALITY		Value in keeping spares separate to natural gas equipment.		Determine suitable location for spares. Review potential to store spares in site control hut, or existing facility sheds - separate room?	1	AW		
O-23	ERGONOMICS	Electrolyser has a number of filter packages and nitrogen bottles that need to be changed out routinely.			Ensure ease of access and manual handling requirements are accommodated.	1	NK		
O-24	GUARDING				Demarcate boundary of hazardous area for pipeline flanges (e.g. with Bollards).	1	NK		
O-25	WARNINGS	*Unauthorised access to site*	introduction of ignition sources.	Fencing and signage will be provided.					
O-26	VULNERABILITY	*Unauthorised access to site* *Demonstration plant has government & media interest.*	introduction of ignition sources.	Access to be managed through permit system.					
O-27	3RD PARTY INTERFERENCE	*Unauthorised access to site* *Demonstration plant has government & media interest.*	Theft, plant damage, introduction of ignition sources.	Site security includes line of sight detectors, gate alarms, CCTV (recently upgraded) etc. A separate security assessment will be completed for the site.	Complete site security review	2	AW		

HAZOP Minutes - Overview

	Problem Description			Safeguards and Controls		Action			
ID	**Guideword**	**Cause**	**Consequence**	**Existing safeguard**	**Action required**	**Priority**	**Responsible**	**Complete Yes/No**	**Close-out Comments and References**
O-28	GUARDING	ELECTRICAL: Electrical supply. Electrical equipment is high current.	Jemena technicians for the site are not familiar with electrolyser electrical equipment. Is there potential that stray currents will compromise CP function?		Confirm electrical maintenance requirements w. Hydrogenics/ANT. Determine if additional training is required for electricians. Confirm potential for stray currents to compromise CP system.	1 2 1	AP AW NK		
O-29	NATURAL EVENTS	Heavy rains	flooding	Site located at high point. There is a stormwater gully between facility and fence.					
O-30	NATURAL EVENTS	Bushfire	Plant damage	A bushfire assessment will be completed for the Environmental Impact Statement EIS					
O-31	NATURAL EVENTS	Wind	Debris, hail, branches coming down…		Operators to monitor trees to control risk of branches falling off.	3	AW		
O-32	NATURAL EVENTS	Lightning	Plant damage		Lightning review in accordance with AS 1768. Hydrogenics to advise of any lightning protection requirements	1 1	SD AP		

APPENDIX 3 ELECTROLYSER HAZOP

Project: P195947 JEMENA
HAZOP: Hydrogen Plant
Date: 9/09/2019

BOUNDARY HAZOP

Rev.	Date	By	Description
00	9/09/2019	RDA	Create project specific document derived from HYGS standard file

Project: P195947 JEMENA
HAZOP: Hydrogen Plant
Date: 9/09/2019

Source document: HYG-JEM-PRO-F02_PFD_Rev.00

Node No.	Description	Remarks	Drawing Reference
1.1	Electrolyser H2 vent		HYG-JEM-PRO-F03
1.2	Electrolyser outlet		HYG-JEM-PRO-F03
2.1	Electrolyser O2 vent		HYG-JEM-PRO-F03
3.2	N_2 to PEM		HYG-JEM-PRO-F03
4.1	AC power MV in		HYG-JEM-ELE-E01
5.1	Tap Water IN		HYG-JEM-PRO-F03
5.2	Drain Water Out		HYG-JEM-PRO-F03

HAZOP Worksheet

Node 1.1
Description: Electrolyser H2 vent
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
High Flow	1.1.1	Producing more than 200Nm3/hr hydrogen while venting to atmosphere		Hazardous area zone 1 balloon increases around vent stack	N/A	Failure of the DC current measurement	3	N/A	Design conditions consider hazardous area zoning of up to 15,000Nm3/hr.	100	N/A	N/A	N/A
Low Flow	1.1.2	Blockage (partial) of vent stack		System unable to vent or relief pressure, safety relief valves don't work propperly	B	Freezing of condensate	3	II	Vent stack designed to avoid blockage (no water pockets), heat tracing provided when ambient temperatures < -20°C	100	N/A	N/A	N/A
Reverse Flow	1.1.3	Electrolyser at atmospheric pressure in cooling cycle will end up with under pressure within the system.		Vacuum drawn and air ingress into system creating an explosive mixture.	B	Any de-pressurising shut down situation.	5	I	- Design pressure of system is 38barg meaning equipment can contain an explosion. Max explosion pressure 17.0barg. - If system pressure drops below 0.2barg then safety system prevents the production of hydrogen. This system also checks that the purge was successful. - Nitrogen purge of system once pressure drops below 0.2barg which purges Oxygen out of system. Minimum amount of N2 required to be passed through the system before re-start.	100 10 100	 1 2	N/A	N/A
High Pressure	1.1.4	Blockage of vent - Ice build up.		Rupture of vent stack	N/A	N/A	N/A	N/A	Vent stack is designed to 38barg which is design pressure of system. Stack will not rupture.	N/A	N/A	N/A	N/A
Low Pressure	1.1.5	No low pressure case possible.		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
High Temperature	1.1.6	Failure of cooling system in electrolyser		Vent stack over temperature. Degradation of stack.	N/A	N/A	N/A	N/A	Temperature switch on electrolysis cell. If high temperature sensed then production stops and shut down to standby. Pressure remains in system.	N/A	N/A	N/A	N/A
Low Temperature	1.1.7	Generation of ice in winter seasons. For safeguards please refer item 1.1.2 and 1.1.4 above.		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
High Level	1.1.8	No high level case possible		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low Level	1.1.9	No low level case possible		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Composition Change	1.1.10	Possibility to vent Nitrogen through stack.		None	N/A	When purging system	3	N/A	N/A	N/A	N/A	N/A	N/A

HAZOP Worksheet

Node 1.1
Description: Electrolyser H2 vent
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
Impurities / contamination	1.1.11	A fraction of Oxygen in Hydrogen.		An explosive mixture.	B	Failure of components inside stack. If there is a rupture of the membrane.	3	II	-Considered in basis of design so that mixture can not occur. -Gas analyser in place. Oxygen concentration is measured. Instrument ATZ-1520.	10 10	1	N/A	N/A
Start up	1.1.12	Air in stack and venting hydrogen.		Explosive atmosphere within the stack.	C	On start up.	3	III	Correct vent stack design basis. Standard CGA 5.5 as guidance	10	N/A	N/A	N/A
Shut down	1.1.13	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Climactic conditions	1.1.14	Seismic event or storm causing stack to physically fail.		Stack failure (bending...), hydrogen venting in non classified area	B	Earthquake event / storm	3		All pipe work and stacks designed to accommodate site seismic accelerations and wind speeds accordingly.	100	N/A	N/A	N/A
Maintenance	1.1.15	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

HAZOP Worksheet

Node 1.2
Description: Electrolyser outlet
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
High Flow	1.2.1	High flow as a result of line rupture (physical impact from forklift or similar)		Hydrogen leak and thus explosive atmosphere at rupture zone.	B	Possible during Nitrogen bank replacement and other maintenance activities.	3	II	Physical barrier required to prevent moving machinery to travel between containers.	100		Collision protection must be provided to protect hydrogen user line	Customer
Low Flow	1.2.3	Low flow as a result of physical impact reducing bore size of the line.		Larger pressure drop in line. Low inlet pressure at user.	D	Possible during Nitrogen bank replacement and other maintenance activities.	3	IV	N/A	N/A	N/A	N/A	N/A
Reverse Flow	1.2.4	If the hydrogen user is a compressor; High pressure side of compressor breaking through into low pressure side. Internal leakages within the compressor. Potentially through non return valves.		Design pressure of the line would be exceeded. Potential rupture of line.	B	Possible if there is a failure of the internals of the compressor.	3	II	-PRV on inlet of compressor shall protect against over pressure of this line. This would vent gas and protect all equipment up stream.	100	N/A	N/A	N/A
High Pressure	1.2.5	Pressure control system failure of electrolyser		Exceeding design pressure of the line. Potential rupture.	B	As and when purging.	3	II	PRV on all vessels in electrolyser	100	N/A	N/A	N/A
High Pressure	1.2.6	High pressure as a result of elevated ambient temperature whilst plant is shut down.		Exceeding design pressure of the line. Potential rupture.	B	During plant shut downs.	3	II	Design pressure of line shall be higher than the highest pressure that can be expected as a result of elevated T.	100		Customer to select piping material with design pressure taken into acount pressure rise caused by temperature swing.	Customer
Low Pressure	1.2.7	Startup after maintencance		Vacuum drawn and air ingress into system creating an explosive mixture.	B	Any de-pressurising shut down situation.	5	I	- Design pressure of system is 38barg meaning equipment can contain an explosion. Max explosion pressure 17.0barg. - If system pressure drops below 0.2barg then safety system prevents the production of hydrogen. This system also checks that the purge was successful. -Nitrogen purge of system once pressure drops below 0.2barg which purges Oxygen out of system. Minimum amount of N2 required to be passed through the system before re-start.	100 10 100	 1 2	N/A	N/A

HAZOP Worksheet

Node 1.2
Description: Electrolyser outlet
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes		Consequences		Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
High Temperature	1.2.8	Error (heating element used for drying mole sieve beds stays on) in Hydrogen Purification System resulting in elevated temperatures outside of operating range 5-80degC.		Gas going to outlet will be at elevated temperature. Outside of design basis. Weaken line and create leak. Creates ignition. Could damage compressor.	B	Output flow would have to be very low and heating element would need to fail.	3	II	-TTZ-1160 temperature transmitter downstream to protect against high temperature. -TTZ-1123 / 1133 temperature transmitters on both driers (DA-H, DB-H) to protect against high temperature from vessels. -H-DA and H-DB heating elements: Current of both elements are measured. When there is current feedback and no requirement for element to be operational the PLC will stop hydrogen production.	10 10	I I		
Low Temperature	1.2.9	Low ambient temperature < 0°C		Line blockage	D		5	I	Dewpoint of H2 is -75°C, freezing is not possible since ambient temperature will not get this low.	100	N/A		
High Level	1.2.10	No level to consider.											
Low Level	1.2.11	No level to consider.											
Composition Change	1.2.12	H2 purge after N2 purge not propperly done --> high N2 content in H2		? --> depends on application		Automatic H2 purge procedure after N2 purge forced by software	3					Check application's tolerance to 100% nitrogen.	Customer
Impurities / contamination	1.2.13	A fraction of Oxygen in Hydrogen.		An explosive mixture.	B	Failure of components inside stack. If there is a rupture of the membrane.	3	II	- HPS deoxo vessel reaction - Gas analysers in place. Oxygen concentration is measured. . Instrument ATZ-1520 Instrument ATZ-1720. If gas is out of spec, it will be sent to vent stack.	10 10 10		Check application's tolerance to oxygen contamination	Customer
Start up	1.2.14	Refer O&M manual for maintenance requirements.		Explosive mixture - user line filled with air					At first start up Nitrogen shall be manually purged through the lines.				
Shut down	1.2.15	Refer O&M manual for maintenance requirements.							At shut down, Nitrogen shall be manually purged through lines to remove hydrogen from the system.				
Climactic conditions	1.2.16	Seismic event causing line rupture at rigid fixings.		Line failure. Potential explosive atmosphere	B	Earthquake event	3	II	All pipe work and stacks to be designed accommodate site seismic accelerations accordingly. Design with expansion loops and/or flexible hoses.				

HAZOP Worksheet

Node 1.2
Description: Electrolyser outlet
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
Maintenance	1.2.17	Refer O&M manual for maintenance requirements. (reverse flow case !)							use tag and lock out procedures on valves before starting maintenance works				

HAZOP Worksheet

Node 2,1
Description: Electrolyser O2 vent
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
High Flow	2.1.1	Producing more than 100Nm3/hr Oxygen and plant dump required.		N/A	N/A	Failure of the DC current measurement	3	N/A	Design conditions consider maximum flow rate of up to 3,600Nm3/hr in a dumping condition.	N/A	N/A	N/A	N/A
Low Flow	2.1.2	Blockage (partial) of vent stack		System unable to vent or relief pressure, safety relief valves don't work propperly	B	Freezing of condensate	3	II	Vent stack designed to avoid blockage (no water pockets), heat tracing provided when ambient temperatures < -20°C	100	N/A	N/A	N/A
Reverse Flow	2.1.3	System at atmospheric pressure in cooling cycle will end up with under pressure within the system.		Vacuum drawn and air ingress into system creating a mixture of Oxygen and air.	N/A	Any de-pressurising shut down situation.	5	N/A	N/A	N/A	N/A	N/A	N/A
High Pressure	2.1.4	Blockage of vent - Ice build up.		Rupture of vent stack	N/A	N/A	N/A	N/A	Vent stack is designed to 38barg which is design pressure of system. Stack will not rupture.	N/A	N/A	N/A	N/A
Low Pressure	2.1.5	No low pressure case possible		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
High Temperature	2.1.6	Failure of cooling system in electrolyser		Vent stack over temperature. Degradation of stack.	N/A	N/A	N/A	N/A	Temperature switch on electrolysis cell. If high temperature sensed then production shall stop and shut down to standby. Pressure remains in system.	N/A	N/A	N/A	N/A
Low Temperature	2.1.7	Generation of ice in winter seasons. For safeguards please refer item 1.1.2 and 1.1.4 above.		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
High Level	2.1.8	No high level case possible		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low Level	2.1.9	No low level case possible		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Composition Change	2.1.10	Possibility to vent air (instead of Oxygen) through the stack.		Nil	Nil	When purging system	3	N/A	Nil	N/A	N/A	N/A	N/A
Impurities / contamination	2.1.11	A fraction of Hydrogen in Oxygen.		An explosive mixture.	B	Failure of components inside stack. If there is a rupture of the membrane.	3	II	Stack design to 38barg which is greater then any explosion pressure. 'Hydrogen in Oxygen analyser ATZ-1620 detects Hydrogen in the Oxygen stream. Threshold is set at 1.85%. If this is exceeded then the plant will stop and de-pressurize.	10 10	 1	N/A	N/A
Start up	2.1.12	Air in stack and venting Oxygen.				On start up.	3		N/A	N/A	N/A	N/A	N/A
Shut down	2.1.13	Nil		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Climactic conditions	2.1.14	Seismic event causing stack to physically fail.		Stack failure.		Earthquake event	N/A	N/A	All pipe work and stacks to be designed accommodate site seismic accelerations accordingly.	N/A	N/A	N/A	N/A
Maintenance	2.1.15	Nil		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

HAZOP Worksheet

Node 3.2
Description: N2 to PEM
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes		Consequences		Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
High Flow	3.2.1	Nitrogen supply line rupture. Forklift collision with overhead line.		Nitrogen leak (outside of containers). Personnel injury.	D	Possible during Nitrogen bank replacement and other maintenance activities.	3	IV	Physical barrier required to prevent moving machinery to travel between containers.	100		Customer to ensure nitrogen lines and system is protected from damage by collisions etc...	Customer
Low Flow	3.2.2	Low flow as a result of physical impact reducing bore size of the line.		Nitrogen purge will not work as flow switch will not feedback sufficient flow rate and thus purge = fail.	B	Possible during Nitrogen bank replacement and other maintenance activities.	3	IV	Two flow switches are in place FIZS-0125 / 0126.	100	II	N/A	N/A
Reverse Flow	3.2.3	Reverse flow of hydrogen back to Nitrogen system. Hydrogen system pressure 30barg vs Nitrogen bottle pressure of 10barg.		No Nitrogen being sent to purge. Rupture of 10barg system due to ingress of 30barg. Hydrogen purging system as oppose to Nitrogen.	B	When ever the electrolyser pressure is running.	5	I	Pressure transmitters PTZ-1107 (HPS) and PTZ-0303 (GGS) detect low system pressure equal to or lower than 0.2barg which feeds back the signal that the plant requires to be purged. Only then does instrument air feed supply double block and bleed solenoids valves to open the DBB to purge the system. Block valves are fail close and vent valve is fail open. DBB is de-energized in the closed position, thus cannot be opened in operation.	100 100		N/A	N/A
High Pressure	3.2.4	Malfunction of regulators on Nitrogen bottles and introduce 200barg pressure to the system.		Line over pressurization and line rupture.	B		3	II	PRV on Nitrogen panel shall safe guard against over pressurization of the system.	100		N/A	N/A
Low Pressure	3.2.5	Both cylinders run empty. Human error of not replacing.		Nitrogen purge will not work as flow switch will not feedback sufficient flow rate and thus purge = fail.	B	Possible during Nitrogen bank replacement and other maintenance activities.	3	IV	Two flow switches are in place FIZS-0125 / 0126.	100	II	N/A	N/A
High Temperature	3.2.6	Not possible to reach 80°C by ambient temperature.		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low Temperature	3.2.7	Not an issue provided ambient does not fall below -40degC		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
High Level	3.2.8	No high level case possible		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low Level	3.2.9	No low level case possible		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Composition Change	3.2.10	Incorrect supply of Nitrogen (supplies Oxygen for example)		Damage of cell stack sensor.	N/A	N/A	N/A	N/A	Ensure standard operating procedures cover the checking of bottles before connection made. Oxygen detection will read very high and alarm.	N/A	N/A	Confirm connection of Nitrogen bottles.	Customer

HAZOP Worksheet

Node 3.2
Description: N2 to PEM
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
Impurities / contamination	3.2.11	Incorrect supply of Nitrogen purity. It needs to be 99.996%.		Damage of cell stack.	N/A	N/A	N/A	N/A	Ensure standard operating procedures cover the checking of bottles before connection made. Appropriate procurement processes in place.	N/A	N/A	Check available Nitrogen purity range that is available locally	Customer
Start up	3.2.12	Refer standard O&M for start up.		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Shut down	3.2.13	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Maintenance	3.2.14	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

HAZOP Worksheet

Node 4.1
Description: AC power MV in
Drawings: HYG-JEM-ELE-E01

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
Low Voltage	4.1.1	Voltage dip on 400V network		Hydrogen production will be compromised (low).					System shall trip if voltage drop is below 90% of nominal voltage.				
High Voltage	4.1.2	Voltage swell on 400V network.		Hydrogen generation will stop. Plant will trip.					System shall trip if voltage drop is above 110% of nominal voltage.				
Loss of power	4.1.3	Black out Tripped breaker Blown fuse		No 400V supply to Hydrogen plant.					System shall trip if voltage drop is below 90% of nominal voltage.				
Loss of power	4.1.4			Damaged cell stack if it freezes outside.					Back up power to be connected to enable cell stack heaters to operate. Automatic switching of back up line in a power loss situation.			Provide 400V backup power supply line for heaters	Customer
Lightning Strike	4.1.5	Lightning strike.		Direct hit on container resulting in controls failure.					Primary safeguard is lightning poles and appropriate connection to site earth grid.			Provide site lightning protection equipment	Customer

HAZOP Worksheet

Node 5.1
Description: Tap Water IN
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
High Flow	5.1.1	Line rupture / physical damage. Loss of water.		Plant will not get water. Hydrogen generation will stop.	D	Vehicle movements. Earthquake.	3	IV	Physical barrier to protect the line. Adequate pipe supports. General maintenance inspections.	N/A	N/A	Provide physical barrier to protect the line	Customer
Low Flow	5.1.2	Line rupture / physical damage. Loss of water. Line restriction. Comms failure between buffer tank Level transmitter to supply pump.		Plant will not get water. Hydrogen generation will stop.	D	Vehicle movements. Earthquake.	3	IV	Physical barrier to protect the line. Adequate pipe supports. General maintenance inspections. Pressure switch PS-1212 on plant water line shall indicate low pressure and will shut plant down if low pressure indicated.	N/A	N/A	N/A	N/A
Reverse Flow	5.1.3	No reverse flow case possible. Water injected to intermediate buffer tank at atmospheric pressure.		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
High Pressure	5.1.4	?		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Incoming line to be protected via instrumentation and mechanically (relief valve) to restrict pressure to maximum 6barg.	Customer
Low Pressure	5.1.5	Ruptured incoming line line or other cause.		Plant will not get water. Hydrogen generation will stop.	D	Vehicle movements.	3	IV	Physical barrier to protect the line. Adequate pipe supports. General maintenance inspections. Pressure switch PS-1212 on plant water line shall indicate low pressure and will shut plant down if low pressure indicated.	N/A	N/A	N/A	N/A
High Temperature	5.1.6	Elevated temperature of water in lines due to thermal radiation on any exposed lines or buffer tank.		Slow degradation of RO membranes.	N/A	Possible on start up in summer months	N/A	N/A	All pipe shall be routed underground	N/A	N/A	All incoming water pipes should run underground or should be protected from heating up by solar irradiation	Customer
Low Temperature	5.1.7	Freezing of water filled lines.		Plant will not start as water will not flow. Rupture of lines.		35days/yr.	5		Pipe work is buried. Pressure transmitter on supply line shall protect pump and supply line.	N/A	N/A	Consideration of heat tracing above ground pipe work from pump to electrolyser container to be reviewed.	Customer
High Level	5.1.8	No high level case		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Low Level	5.1.9	No low level case		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Composition Change	5.1.10	No composition change case		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Impurities / contamination	5.1.11	Variances from required composition required for RO plant inlet. Formation of bacteria / algae.		Degradation of cell stack lifetime Degradation of RO membranes.	C	NA	3	NA	Conductivity transmitter (CT-1211) on water inlet. Conductivity transmitter (CT-1234) on outlet of RO membrane bank. Conductivity transmitter (CT-1271) on the outlet of mixed bed ion exchange process.	100	N/A	NA	NA

HAZOP Worksheet

Node 5.1
Description: Tap Water IN
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
Start up	5.1.12	Commissioning start up: Air in line, contaminants in line.		Degradation of filters and RO membranes.	NA	NA	NA	NA	Double block and bleed valve on plant inlet shall be used to flush the line before putting water into the plant.	NA	NA	NA	NA
Shut down	5.1.13			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Climactic conditions	5.1.14	Earthquake damaging rigid pipe.		NA	NA	NA	NA	NA	Material selection - flexible pipe work.			Use non rigid pipe for water connection	Customer
Maintenance	5.1.15	Refer O&M for general maintenance.		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

HAZOP Worksheet

Node 5.2
Description: Drain Water Out
Drawings: HYG-JEM-PRO-F03

Deviation / Guideword	#	Causes	Consequences			Frequency		Class	Safeguards			Recommendations / actions	Who
		description		description	rank	Description	rank		description	Risk reduction	SIL		
High Flow	5.2.1	No high flow case.							Drain can handle maximum inlet flow case.				
Low Flow	5.2.2	Blockage of drain. Birds nest, animal, ice.		Plant will shut down. No hydrogen generation	E	During plant shut down periods.	3	IV	Drain to be closed loop until the outfall. Mesh cap on outfall end. Conductivity transmitter CT-1271 to shut plant down when water composition constraints is not met.				
Reverse Flow	5.2.3	No reverse flow case possible.											
High Pressure	5.2.4	Blockage of drain. Birds nest, animal, ice.		Plant will shut down. No hydrogen generation	E	During plant shut down periods.	3	IV	Drain to be closed loop until the outfall. Mesh cap on outfall end. Conductivity transmitter CT-1271 to shut plant down when water composition constraints is not met.				
Low Pressure	5.2.5	No low pressure case											
High Temperature	5.2.6	No high temperature case											
Low Temperature	5.2.7	Freezing of water filled lines.		Plant will shut down. No hydrogen generation	E	During plant shut down periods.	3	IV	Drain to be closed loop until the outfall. Mesh cap on outfall end. Conductivity transmitter CT-1271 to shut plant down when water composition constraints is not met.				
High Level	5.2.8	No high level case											
Low Level	5.2.9	No low level case											
Composition Change	5.2.10	No composition change case											
Impurities / contamination	5.2.11	No impurities / contamination case.											
Start up	5.2.12	No start up issues.											
Shut down	5.2.13	No shut down issues.											
Climactic conditions	5.2.14	Earthquake damaging rigid pipe.							Material selection - non rigid pipe work. Provides flexibility.				
Maintenance	5.2.15	Refer O&M for general maintenance.											

APPENDIX 4 EVENT TREE FREQUENCY CALCULATIONS

APPENDIX 4A FATALITY FREQUENCY USING HYRAM FAILURE RATES

18667 WSGGT Event Tree Frequency Estimations - using HyRAM leak frequency data

Equipment	Plant Location	Frequency Data Used	Leak Frequency Units y -1	Parts Count	Cumulative Leak Frequency	Modelling Scenario	Substance	Leak Detected and Isolated? 80% Yes 20% No	Continuous leak rate kg/s	Ignition Probability	% of Jets Directed toward site boundary	Delayed Ignition Probability	Jet Fire Frequency (Directed Offsite)	Flash Fire Frequency	Total Frequency for Potential offsite fatal consequences	Comments
High Pressure Storage - 100% Leak																
Pressure Vessels	Refueller high pressure storage	100%	2.90E-07	7	2.03E-06	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	2.80E-08	4.9E-08	4.87E-08	Only the flash fire consequence exceeds the boundary
Steel Process Pipe	Refueller high pressure storage	100%	6.43E-07	20	1.29E-05	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	1.77E-07	3.1E-07	3.09E-07	Only the flash fire consequence exceeds the boundary
Flanges 25 NB	Refueller high pressure storage	100%	1.55E-05	79	1.22E-03	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	1.69E-05	2.9E-05	2.94E-05	Only the flash fire consequence exceeds the boundary
Compressor	Refueller high pressure storage	100%	3.04E-04	1	3.04E-04	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	4.20E-06	7.3E-06	7.30E-06	Only the flash fire consequence exceeds the boundary
Valves	Refueller high pressure storage	100%	1.49E-05	36	5.36E-04	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	7.40E-06	1.3E-05	1.29E-05	Only the flash fire consequence exceeds the boundary
Instruments	Refueller high pressure storage	100%	1.11E-04	11	1.22E-03	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	1.68E-05	2.9E-05	2.93E-05	Only the flash fire consequence exceeds the boundary
Total Frequency for HPS 100% Leak															**7.92E-05**	
Refueller - Dispenser																
Loadout flexible hose	Refueller load out	10%	1.60E-04	1	1.60E-04	6a	Hydrogen	0.2	1.46	0.063	0.3	0.027	6.05E-07	4.3E-06	4.32E-06	Only the flash fire consequence exceeds the boundary
Loadout flexible hose (random failures)	Refueller load out	100%	7.47E-05	1	7.47E-05	6b	Hydrogen	0.2	3.3	0.063	0.3	0.027	2.82E-07	2.0E-06	2.02E-06	Only the flash fire consequence exceeds the boundary
Loadout flexible hose (per use failures)	Refueller load out	100%	5.50E-09	1050	5.78E-06	6b	Hydrogen	0.2	3.3	0.063	0.3	0.027	2.18E-08	1.6E-07	1.56E-07	
Total Refueller															**8.35E-06**	
Total Potential Fatal Frequency for the site															**8.76E-05**	

APPENDIX 4B FATALITY FREQUENCY USING UK HSE AND HYRAM FAILURE RATES

18667 WSGGT Event Tree Frequency Estimations - using UK HSE and HyRAM leak frequency data

Equipment	Plant Location	Frequency Data Used	Leak Frequency Units y -1	Parts Count	Cumulative Leak Frequency	Modelling Scenario	Substance	Leak Detected and Isolated? 80% Yes 20% No	Continuous leak rate kg/s	Ignition Probability	% of Jets Directed toward site boundary	Delayed Ignition Probability	Jet Fire Frequency (Directed Offsite)	Flash Fire Frequency	Total Frequency for Potential offsite fatal consequences	Comments
High Pressure Storage - 100% Leak																
Pressure Vessels	Refueller high pressure storage	100%	4.00E-06	7	2.80E-05	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	3.86E-07	6.7E-07	6.72E-07	Only the flash fire consequence exceeds the boundary
Steel Process Pipe	Refueller high pressure storage	100%	6.43E-07	20	1.29E-05	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	1.77E-07	3.1E-07	3.09E-07	Only the flash fire consequence exceeds the boundary
Flanges 25 NB	Refueller high pressure storage	100%	1.55E-05	79	1.22E-03	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	1.69E-05	2.9E-05	2.94E-05	Only the flash fire consequence exceeds the boundary
Compressor	Refueller high pressure storage	100%	3.04E-04	1	3.04E-04	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	4.20E-06	7.3E-06	7.30E-06	Only the flash fire consequence exceeds the boundary
Valves	Refueller high pressure storage	100%	1.49E-05	36	5.36E-04	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	7.40E-06	1.3E-05	1.29E-05	Only the flash fire consequence exceeds the boundary
Instruments	Refueller high pressure storage	100%	1.11E-04	11	1.22E-03	5b	Hydrogen	0.2	7.51	0.23	0.3	0.120	1.68E-05	2.9E-05	2.93E-05	Only the flash fire consequence exceeds the boundary
Total Frequency for HPS 100% Leak															**7.98E-05**	

Refueller - Dispenser - using HSE Data comparison

Equipment	Plant Location	Frequency Data Used	Leak Frequency Units y -1	Parts Count	Cumulative Leak Frequency	Modelling Scenario	Substance	Leak Detected and Isolated? 80% Yes 20% No	Continuous leak rate kg/s	Ignition Probability	% of Jets Directed toward site boundary	Delayed Ignition Probability	Jet Fire Frequency (Directed Offsite)	Flash Fire Frequency	Total Frequency for Potential offsite fatal consequences	Comments
Loadout flexible hose	Refueller load out	15 mm	4.00E-07	1050	4.20E-04	6a	Hydrogen	0.2	1.46	0.063	0.3	0.027	1.59E-06	1.1E-05	1.13E-05	Only the flash fire consequence exceeds the boundary
Loadout flexible hose	Refueller load out	Guillotine	2.00E-07	1050	2.10E-04	6b	Hydrogen	0.2	3.3	0.063	0.3	0.027	7.94E-07	5.7E-06	5.67E-06	Only the flash fire consequence exceeds the boundary
Total Refueller															**1.70E-05**	

Total Potential Fatal Frequency for the site	**1.34E-04**

Denotes where UK HSE Frequencies have been used.

APPENDIX 4C INJURY FREQUENCY

18667 WSGGT Event Tree Frequency Estimations

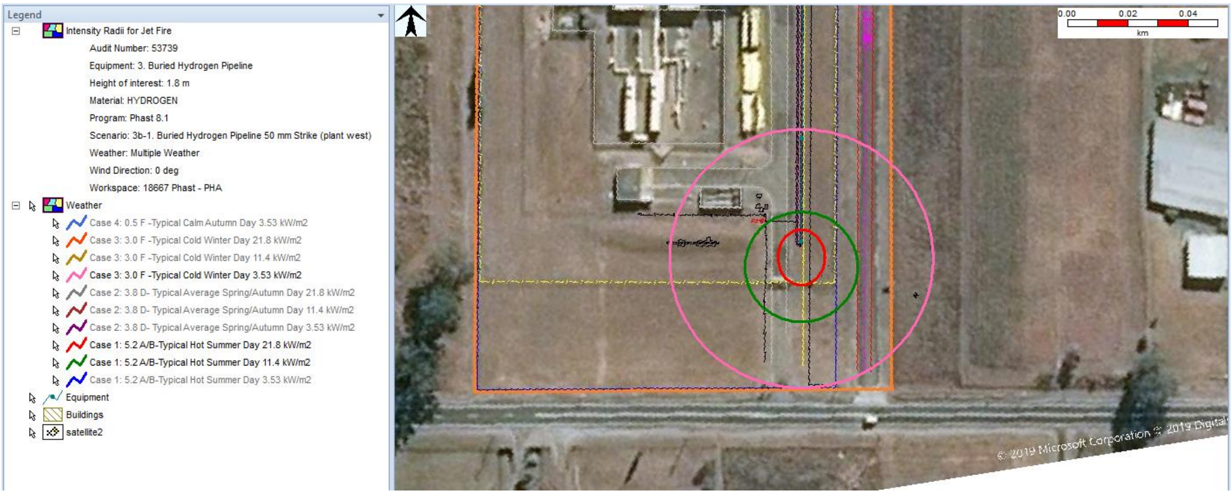
Equipment	Plant Location	Frequency Data Used	Leak Frequency Units y -1	Parts Count	Cumulative Leak Frequency	Modelling Scenario	Substance	Leak Detected and Isolated? 80% Yes 20% No	Continuous leak rate kg/s	Ignition Probability	% of Jets Directed toward site boundary	Delayed Ignition Probability	Jet Fire Frequency (Directed Offsite)	Flash Fire Frequency	Total Frequency for Potential offsite fatal consequences	Comments
Flanges 500 NB	Buffer Storage riser	78mm	1.00E-07	2	2.00E-07	3d	Hydrogen	0.2	1.46	0.063	0.3	0.027	7.56E-10	5.4E-09	7.56E-10	Only the Jet Fire can cause radiation injury
Loadout flexible hose (random failures)	Refueller load out	Guillotine	7.47E-05	1	7.47E-05	6b	Hydrogen	0.2	3.3	0.063	0.3	0.027	2.82E-07	2.0E-06	2.82E-07	Only the Jet Fire can cause radiation injury
Loadout flexible hose (per use failures)	Refueller load out	Guillotine	5.50E-09	1050	5.78E-06	6b	Hydrogen	0.2	3.3	0.063	0.3	0.027	2.18E-08	1.6E-07	2.18E-08	Only the Jet Fire can cause radiation injury

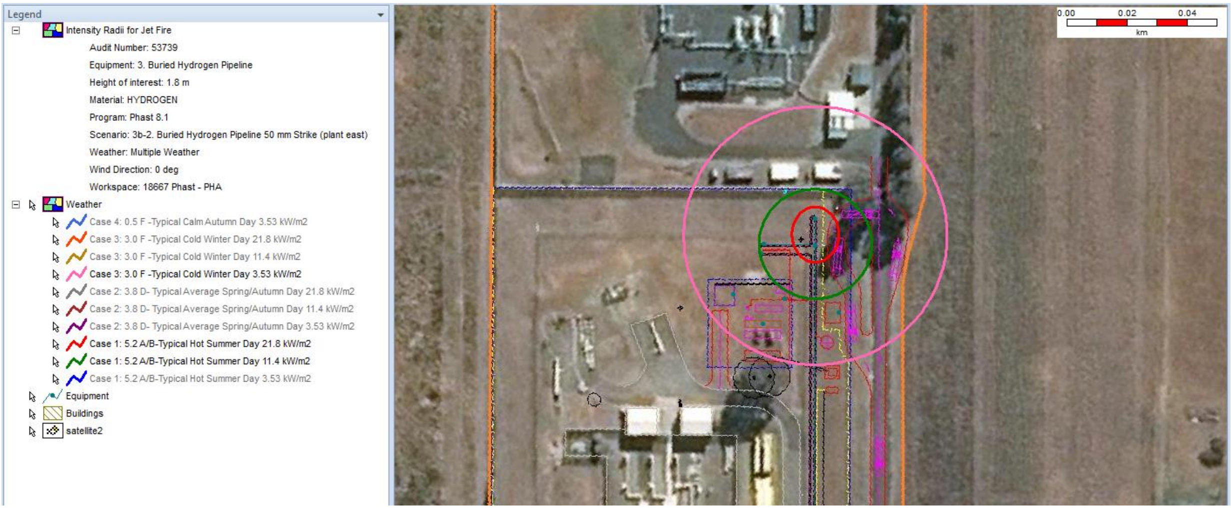
Total Potential Injury Frequency for the site	**3.05E-07**

APPENDIX 5 PHAST CONTOURS

APPENDIX 5A CASE 3B

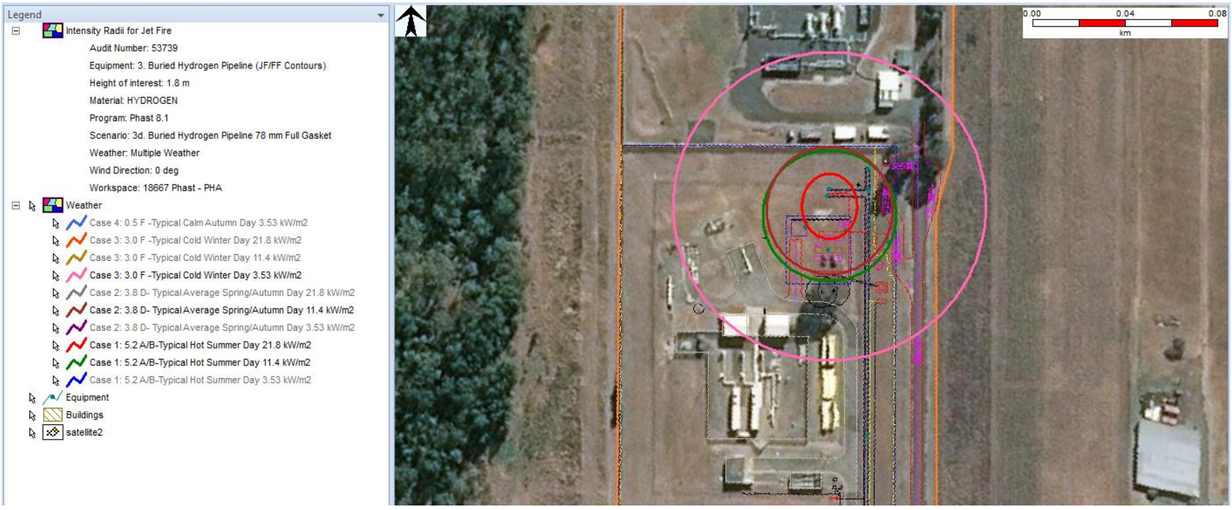
Jet Fire Radiation Contours





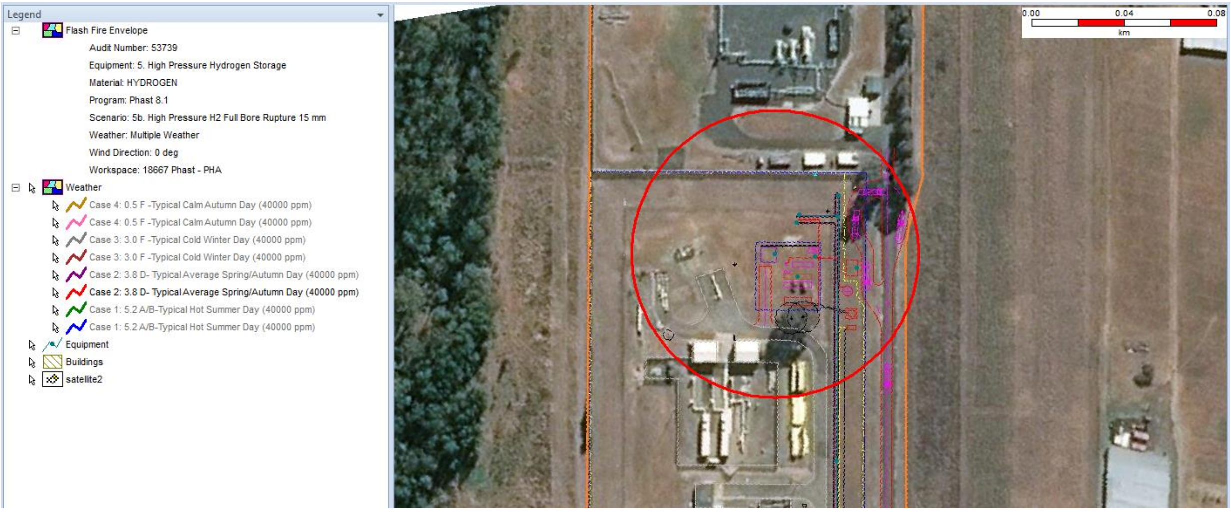
APPENDIX 5B CASE 3D

Jet Fire Radiation Contours



APPENDIX 5C CASE 5B

Flash Fire Contour



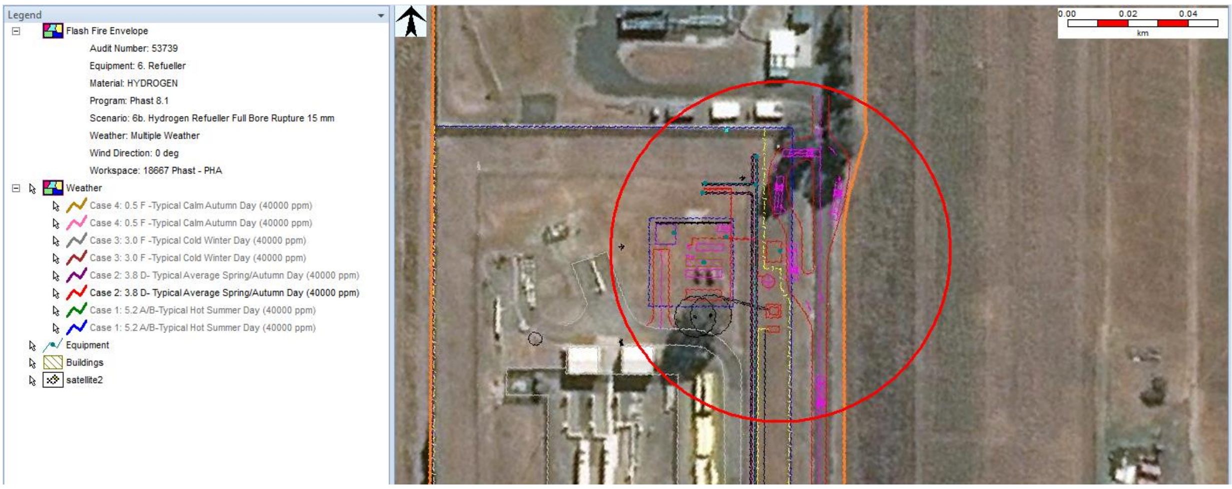
APPENDIX 5D CASE 6A

Flash Fire Contour

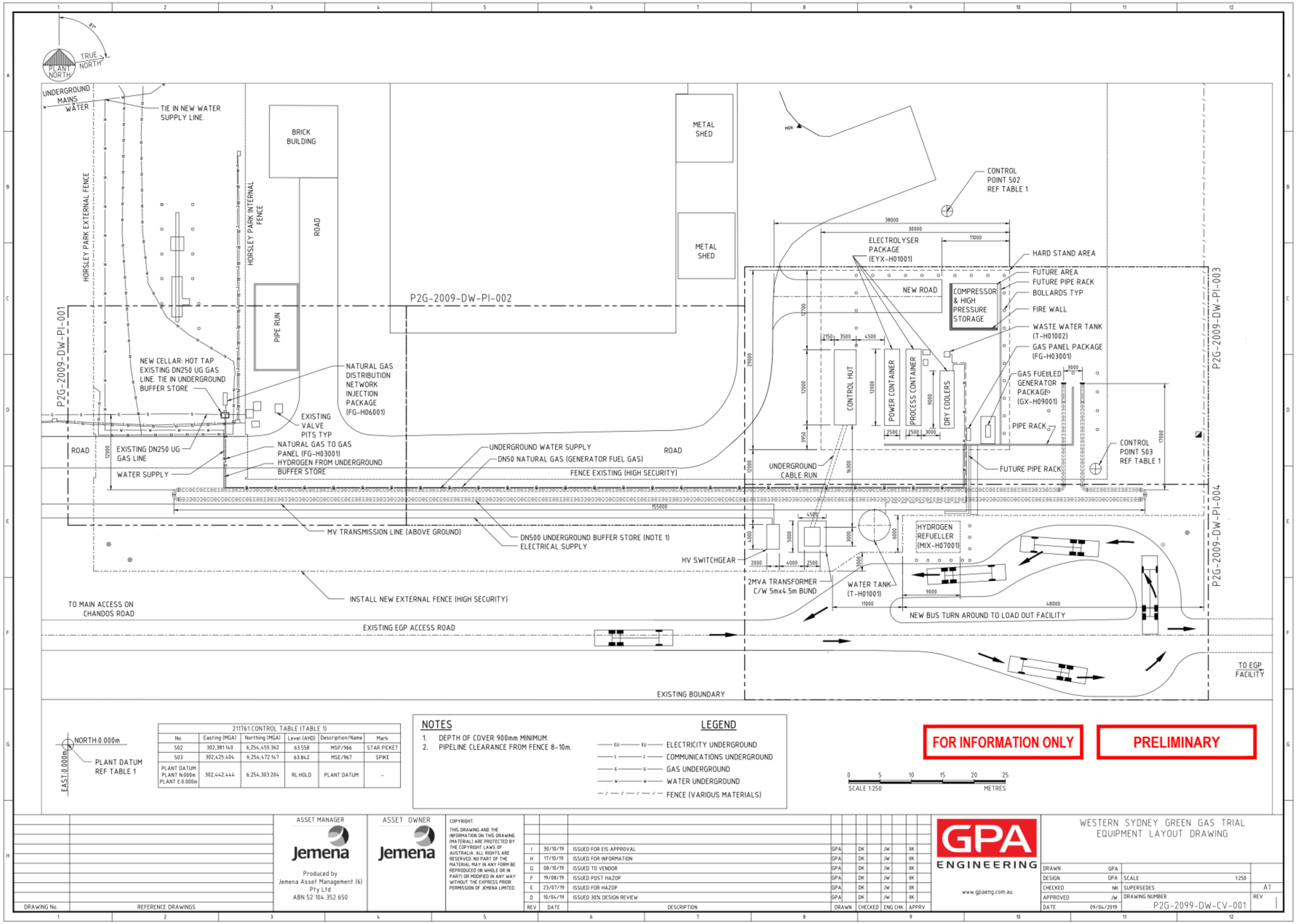
APPENDIX 5E CASE 6B

Jet Fire Radiation Contours

Flash Fire Contour



APPENDIX 6 EQUIPMENT LAYOUT DRAWING


TRUE NORTH
PLANT NORTH
UNDERGROUND MAINS WATER
TIE IN NEW WATER SUPPLY LINE.
BRICK BUILDING
METAL SHED
METAL SHED
HORSLEY PARK EXTERNAL FENCE
HORSLEY PARK INTERNAL FENCE
ROAD
PIPE RUN
P2G-2009-DW-PI-001
P2G-2009-DW-PI-002
P2G-2009-DW-PI-003
P2G-2009-DW-PI-004
CONTROL POINT 502 REF TABLE 1
ELECTROLYSER PACKAGE (EYX-H01001)
HARD STAND AREA
FUTURE AREA
FUTURE PIPE RACK
BOLLARDS TYP
FIRE WALL
WASTE WATER TANK (T-H01002)
GAS PANEL PACKAGE (FG-H03001)
GAS FUELLED GENERATOR PACKAGE (GX-H09001)
PIPE RACK
NEW ROAD
COMPRESSOR & HIGH PRESSURE STORAGE
CONTROL HUT
POWER CONTAINER
PROCESS CONTAINER
DRY COOLERS
NEW CELLAR: HOT TAP EXISTING DN250 UG GAS LINE. TIE IN UNDERGROUND BUFFER STORE
NATURAL GAS DISTRIBUTION NETWORK INJECTION PACKAGE (FG-H06001)
EXISTING VALVE PITS TYP
NATURAL GAS TO GAS PANEL (FG-H03001)
HYDROGEN FROM UNDERGROUND BUFFER STORE
EXISTING DN250 UG GAS LINE
WATER SUPPLY
UNDERGROUND WATER SUPPLY
DN50 NATURAL GAS (GENERATOR FUEL GAS)
FENCE EXISTING (HIGH SECURITY)
UNDERGROUND CABLE RUN
CONTROL POINT 503 REF TABLE 1
FUTURE PIPE RACK
MV TRANSMISSION LINE (ABOVE GROUND)
DN500 UNDERGROUND BUFFER STORE (NOTE 1)
ELECTRICAL SUPPLY
HV SWITCHGEAR
HYDROGEN REFUELLER (MIX-H07001)
2MVA TRANSFORMER C/W 5mx4.5m BUND
WATER TANK (T-H01001)
NEW BUS TURN AROUND TO LOAD OUT FACILITY
INSTALL NEW EXTERNAL FENCE (HIGH SECURITY)
TO MAIN ACCESS ON CHANDOS ROAD
EXISTING EGP ACCESS ROAD
EXISTING BOUNDARY
TO EGP FACILITY
NORTH:0.000m
EAST:0.000m
PLANT DATUM REF TABLE 1
211761 CONTROL TABLE (TABLE 1)
No. | Easting (MGA) | Northing (MGA) | Level (AHD) | Description/Name | Mark
502 | 302,381.140 | 6,254,455.362 | 63.558 | MSP/966 | STAR PICKET
503 | 302,425.404 | 6,254,472.147 | 63.842 | MSE/967 | SPIKE
PLANT DATUM PLANT N:000m PLANT E:0.000m | 302,442.444 | 6,254,303.204 | RL:HOLD | PLANT DATUM | -
NOTES
1. DEPTH OF COVER 900mm MINIMUM.
2. PIPELINE CLEARANCE FROM FENCE 8-10m.
LEGEND
ELECTRICITY UNDERGROUND
COMMUNICATIONS UNDERGROUND
GAS UNDERGROUND
WATER UNDERGROUND
FENCE (VARIOUS MATERIALS)
FOR INFORMATION ONLY
PRELIMINARY
SCALE 1:250
METRES
ASSET MANAGER
ASSET OWNER
Jemena
Produced by Jemena Asset Management (6) Pty Ltd ABN 52 104 352 650
I | 30/10/19 | ISSUED FOR EIS APPROVAL | GPA | DK | JW | IIK
H | 17/10/19 | ISSUED FOR INFORMATION | GPA | DK | JW | IIK
G | 08/10/19 | ISSUED TO VENDOR | GPA | DK | JW | IIK
F | 19/08/19 | ISSUED POST HAZOP | GPA | DK | JW | IIK
E | 23/07/19 | ISSUED FOR HAZOP | GPA | DK | JW | IIK
D | 10/04/19 | ISSUED 30% DESIGN REVIEW | GPA | DK | JW | IIK
REV | DATE | DESCRIPTION | DRAWN | CHECKED | ENG CHK | APPRV
GPA ENGINEERING
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WESTERN SYDNEY GREEN GAS TRIAL
EQUIPMENT LAYOUT DRAWING
DRAWN GPA
DESIGN GPA
CHECKED NK
APPROVED JW
DATE 09/04/2019
SCALE 1:250
SUPERSEDES
A1
DRAWING NUMBER P2G-2099-DW-CV-001
REV
DRAWING No.
REFERENCE DRAWINGS

Appendix D WSGG Project Stakeholder Management Plan

PLAN

WESTERN SYDNEY GREEN GAS PROJECT STAKEHOLDER MANAGEMENT PLAN

GAS-499-PA-CU-002

Revision Number: Rev A
Revision Date: 22/11/2019

AUTHORISATION

REVIEWED BY

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Approved by

Name	Job Title	Signature	Date
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INTERNAL

Jemena
bringing energy to life

DOCUMENT HISTORY

Revision	Date	Author	Description of Changes
A	14/02/2019	Gina Wilson	New document written – Western Sydney Green Gas Project
B	31/10/2019	Gina Wilson	Update Document

OWNING FUNCTIONAL GROUP & DEPARTMENT / TEAM

Asset Management : Projects : Western Sydney Green Gas Project

REVIEW DETAILS

Review Period:	Review Date + 6 months
Next Review Due:	May 2020

Contents

1. Introduction and Purpose

Jemena is one of Australia's leading and most experienced energy infrastructure companies owning approximately $11.5 billion worth of infrastructure assets around the country. Jemena, together with its related bodies corporate Jemena Eastern Gas Pipeline (1) Pty Ltd and Jemena Eastern Gas Pipeline (2) Pty Ltd, own the Horsley Park high pressure gas facility, at 194 - 202 Chandos Road in Horsley Park, NSW. This facility comprises the Jemena Gas Network as well as a number of pressure let down and pipeline pigging facilities, for the Eastern Gas Pipeline (EGP), Jemena Trunkline, Sydney Primary Loop and local secondary network. When referencing the Horsley Park site within this document, the site is referred to as the Jemena Horsley Park Facility.

Jemena proposes to undertake the Western Sydney Green Gas Project (WSGG Project), a power to gas (P2G) facility to transform renewable electrical energy into a combustible gas, hydrogen, which is either injected at up to 2% by volume into the Sydney secondary gas distribution network, supplied to a microturbine to generate electricity for export back to the grid, or potentially supplied to an adjacent hydrogen refuelling station (HRS) for bus refuelling. The P2G process will involve producing hydrogen from water using electrolysis, with a by-product from the electrolysis process being oxygen, which will be released directly into the atmosphere. Hydrogen is a renewable resource and is neither a hydrocarbon nor greenhouse gas.

Jemena recognises the importance of stakeholders and is committed to open, transparent and inclusive engagement throughout the Western Sydney Green Gas Project. Jemena is an immensely experienced energy infrastructure company with an excellent reputation, including for its outstanding stakeholder engagement, and will use the Western Sydney Green Gas Project to continue to advance that reputation.

Background

The uptake in renewable power generation, coupled with growing demand for decarbonising of energy sectors in Australia, presents a series of challenges and opportunities to the gas transmission and distribution network in NSW.

Jemena, as the sole owner of the network, seeks to understand and develop technologies that allow for a transition to a low or zero carbon gas network, whilst delivering a competitive and sustainable consumer product. Jemena believes that multiple technologies will be required, one of which is known as Power to Gas, or P2G.

P2G technology is an energy conversion system that transforms electrical energy from the power grid or directly powered into a combustible gas – hydrogen – which is fed directly into the gas network.

Jemena's Western Sydney Green Gas Project (WSGGP) involves designing and constructing a Power-to-Gas (P2G) facility which will convert renewably sourced electricity into hydrogen via electrolysis.

A portion of the hydrogen produced will be injected into the gas network, providing enough energy to meet the cooking, heating and hot-water requirements of approximately 250 homes. Another portion of the hydrogen will be stored in an underground buffer store which will feed a gas engine generator for electricity generation back to the grid.

Stakeholder Management Plan Purpose

This Stakeholder Management Plan (SMP) has been developed for Jemena's Western Sydney Green Gas Project. It is a dynamic document which will change and develop as the project progresses.

Its purpose is to define, for Jemena and the Western Sydney Green Gas Project teams, how stakeholder engagement is to be managed throughout all phases of the project.

The SMP, via the Stakeholder Register, sets out all of the stakeholders identified to date for the Western Sydney Green Gas Project, including which team member will be responsible for managing engagement and communications with those stakeholders, both at the organisational and individual level.

Stakeholders can be defined as individuals, groups or organisations which may affect, be effected by, or perceive themselves to be affected by the projects. Stakeholders can be internal or external to the organisation and exist across a range of sectors of society:

- Government, e.g. federal, state and local government agencies including environment, regulators, pipeline regulators, planning authorities and elected officials.
- Private, e.g. owners, developers, utility owners, industry participants and organisations, land tenure holders, staff and contractors.
- Community/Non-Government, e.g. media, the general public, NGOs, community, special interest and lobby groups
- Internal – company and contractor stakeholders

There is always significant overlap and interplay between stakeholder sectors, organisations and individuals and change inevitably occurs as project activities unfold and these normal changes occur in the internal and external environment over the life of any project.

This SMP attempts to paint the stakeholder landscape as it is now, both internally and externally, at the time of this version issue, but, of necessity, it will require revisiting and reviewing on a regular basis as the Western Sydney Green Gas Project progresses.

Implementation of this SMP and internal communication of its key elements are critical to the success of the project.

2. Plan Overview

Further revisions will occur during the planning, construction and operational phases of the Western Sydney Green Gas Project. The SMP is structured as follows:

- Section 3 provides a brief overview of the Western Sydney Green Gas Project and its objectives.
- Section 4 summarises Jemena's commitment to stakeholder engagement.
- Sections 5, 6 and 7 set out the Stakeholder Management Objectives, the Stakeholder Identification process and the Stakeholder Management process, respectively.
- Section 8 sets out the principles applied to Stakeholder Engagement.

- Section 9 sets out how Jemena will engage with stakeholders and the communication methods we'll use to do this.
- Section 10 provides guidance on how specific stakeholder groupings are to be managed and the responsible team member.
- Section 11 details Jemena's issues management strategy.
- Section 12 outlines the expected outcomes of successful stakeholder engagement.

Appendices are:

A-1 Severity Matrix

A-2 Stakeholder Engagement Plan

3. Project Overview and Objectives

Jemena proposes to undertake the Western Sydney Green Gas Project, a Power to Gas, or P2G, project, at the Horsley Park Site to transform renewable electrical energy from the power grid or directly powered into a combustible gas; hydrogen, which is injected into the Sydney secondary network at a small percentage or potentially supplied to an on-site hydrogen bus refuelling facility. The proposal is referred to as the Western Sydney Green Gas Project.

Jemena's Project Objectives include, but are not limited to:

- Demonstrate injection and storage of hydrogen, generated from renewable energy, into the gas distribution network;
- Establish a "green" or "renewable gas" market and demonstrate associated green gas certification
- Demonstrate gas and electricity network coupling, through the interconnection of both networks and markets;
- Demonstrate sector coupling through the implementation of hydrogen refuelling for transport;
- Evaluate all potential revenue streams to inform future hydrogen business cases including, but not limited to:
    - – Demand response;
    - – Network or ancillary services;
    - – Green gas (in the distribution network);
    - – Electricity generation; and
    - – Hydrogen for transport.

4. Commitment to Stakeholder Engagement

Jemena has invested a significant amount of time and resources into stakeholder engagement while undertaking a variety of projects in New South Wales, including multiple remediation projects, and intends to continue this effort as it progresses its Western Sydney Green Gas Project. Engagement for the Western Sydney Green Gas Project began in 2018 and Jemena will continue its commitment to stakeholder engagement during the early phases of the development and as we progress through the planning and construction phases and into operations.

Jemena recognises that, despite construction expected to take just three weeks and be of a small scale, the Western Sydney Green Gas Project will be visible in the community in which it will be constructed. Jemena is determined to leave a positive legacy within the communities in which we operate.

5. Stakeholder Management Objectives

The objectives of stakeholder management are:

1. To inform stakeholders of the project's progress.
2. To gather feedback and information from stakeholders to inform the site location and design.
3. To work with stakeholders constructively so as to successfully manage their varying interests in the project.
4. To avoid project delay or denial through stakeholder mismanagement.
5. To ensure any issues raised by stakeholders are considered and managed appropriately.
6. To protect and enhance Jemena's reputation in New South Wales and throughout Australia.

This will be achieved through:

1. The implementation of a strategic Stakeholder Management Plan (this document).
2. Clear and regular communication with stakeholders about the Project.
3. Coordinated and consistent messaging.

6. Stakeholder Identification

At October 2019 approximately 50 external stakeholders have been identified for the Western Sydney Green Gas Project.

The stakeholders include:

- Commonwealth and NSW ministers, agencies and departments, and local government
- Indigenous group representation and other interest groups and organisations
- Landholders and occupiers in the vicinity

For convenience, stakeholders are identified within four sectors:

1. Government
2. Organisation (industry/community)
3. Individual

Each of the stakeholder sectors is further compartmentalised into sub-sectors (or sub-categories) depending on the nature of the stakeholder organisations involved, e.g. level of government, interest type and so on.

Each of these sub-sectors is further distilled to identify each specific stakeholder organisation and then further to specific individual stakeholder representatives where this is possible.

Thus, the full identification of all project stakeholders is achieved and this information is used for good stakeholder management as set out further in this SMP.

7. Stakeholder Management

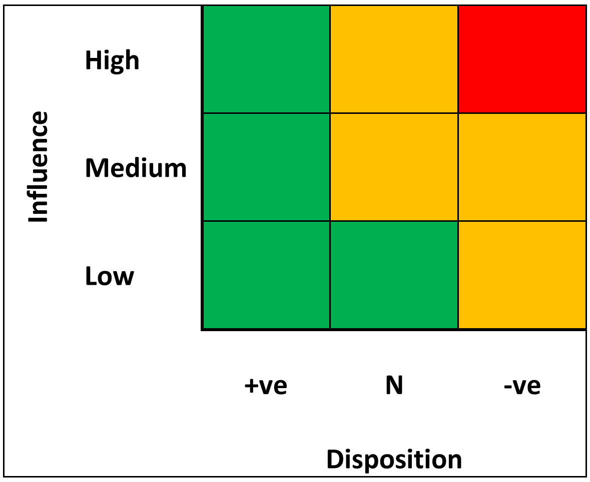
This section sets out how project stakeholders will be managed, firstly through analysing their influence on and disposition toward the project, the creation of specific engagement strategies for each stakeholder and the appointment of stakeholder managers at all levels and how Jemena will keep stakeholder records and manage data.

7.1 Stakeholder Analysis

When a stakeholder is identified, consideration is given to their interests and needs in association with the project, their potential influence on the project, i.e. low, medium or high, and also their likely disposition toward the project; positive, neutral or negative.

This allows for considered assessment of how each stakeholder organisation needs to be managed and gives an indication of the level of resources required for that engagement.

Stakeholders are mapped on a matrix as follows to provide an easy snapshot in time of the stakeholder landscape for the project.



Stakeholders are also ranked into three levels:

1. High level stakeholders are those who can directly and significantly (have a high) influence the project, e.g. deny or delay, whether of any disposition.
2. Medium level stakeholders are those who are important to the success of the project but have a lower influence. Those we need to bring along with support and information, e.g. the indigenous community, businesses, NGOs etc. and that Jemena will need to spend time engaging with.
3. Low level stakeholders are those who have a low influence on the project that we will need to spend less time on but keep informed, e.g. the broader community.

The stakeholder management effort is therefore directed toward working with and influencing stakeholders in a constructive and positive fashion toward the left of the matrix.

The Stakeholder Matrix for the Western Sydney Green Gas Project is shown above.

7.2 Determining Levels of Engagement

It is important to identify the appropriate level of engagement for each stakeholder. Jemena has considered the interest, influence and relevance of each stakeholder to determine the different levels of engagement which has informed the engagement strategies to be used.

Determining the level of engagement for each stakeholder then allows Jemena to determine the level of resourcing required and suitable methods of engagement – see Section 8.1 below.

7.3 Stakeholder Managers

Jemena will allocate each stakeholder a primary stakeholder manager, whose role it is to manage the interaction with that stakeholder.

This does not restrict interaction with any stakeholder by other project team members as this will be a necessity for efficient project implementation, however, for coordinated stakeholder interaction, a single stakeholder focal point is necessary.

To manage this flexible interaction effectively, any project team member who needs to communicate with external stakeholders must first contact the primary stakeholder manager to discuss the need and purpose for the interaction and how this will occur, e.g. written communication, a face to face meeting, the issues to be discussed and so on.

The primary stakeholder manager will advise on the best course of action.

Once the interaction has been undertaken a record is made. If contact is other than by the primary stakeholder manager, the contact must be provided to the primary stakeholder manager and to those involved in the matter being discussed.

As a general rule, the following levels of interaction should be observed:

Stakeholder Organisation Level	Jemena Primary Stakeholder Manager Level
Ministerial	Managing Director (MD)/Executive General Manager (EGM)/Government Relations Manager (GRM)
Other elected representatives	GRM/ Project Director (PD)
CEO and above	MD/EGM/SPM/Stakeholder and Approvals Manager (SAM)
Senior government department heads and officers	SAP/Senior Project Manager (SPM)
Officer level	Defined project team leaders or members

Departures from the above should be authorised by the Project Lead.

7.4 Record Keeping and Data Management

Good record keeping and data management is crucial to the success of SMP implementation and to that of the project. In particular where project approvals are being sought and where there are commercial and inter-cultural negotiations occurring within legal frameworks, clear historical records and evidence of interaction is necessary.

7.4.1 Contact Records

Contact records will be kept for all substantive interactions with stakeholders.

Substantive means anything where a stakeholder contacts us for information on the project, when we respond to a stakeholder or for any other contact except for arranging meetings.

Records can be in the form of:

1. Formal minutes of meetings with stakeholders.
2. Meeting contact records documented by the project team member.
3. Letters.
4. Email correspondence saved in pdf format.
5. Other evidence of interaction.

7.4.2 Stakeholder Records Management

The amount of data created in stakeholder engagement associated with projects like the Western Sydney Green Gas Project needs to be managed efficiently. Jemena is currently implementing a stakeholder database using Mipela's XIC software. XIC is currently being implemented across Jemena. Once implemented, selected project team members will have access to the file/database with varying user rights determined based upon individual requirements and needs.

In the meantime, Project Team members will keep good records using Excel or Word.

7.4.3 Post Construction Stakeholder Management

Once the Western Sydney Green Gas Project has been completed, management of stakeholders will become the responsibility of Jemena's operations team in NSW, or appropriate nominated person. All stakeholder records will be sent to the operations team.

8. Principles of Engagement

Throughout the Western Sydney Green Gas Project, Jemena will be guided by principles of best practice engagement to ensure the best possible outcome for stakeholders and for Jemena.

Communications and negotiations have and will continue to be approached at all times in a respectful and ethical manner and will provide the opportunity for stakeholders to participate and provide meaningful input into decision making processes, where possible.

As a member of the Australian Pipelines and Gas Association (APGA), Jemena is also aligned with the principles of stakeholder engagement outlined by APGA in its Code of Practice for Stakeholder Engagement[1]. Jemena believes successful communication and engagement is based on simple, practical principles which represent a combination of common sense, good business practice and ethical considerations.

These principles of stakeholder engagement include:

- <u>Communication:</u> open and effective engagement. Jemena will undertake open and effective engagement which will involve not only the provision of timely information but also hearing and listening to landholders, occupiers and other stakeholders. We encourage open and

[1] APGA Stakeholder Engagement Guidelines

two way communication and, at all times, will provide clear, accurate and relevant information in a timely fashion.

- Transparency: providing clear and accurate information. Jemena is committed to providing clear and accurate information to stakeholders at all stages throughout the Western Sydney Green Gas Project. As the project progress and additional information comes to hand, or as things change, Jemena will keep all stakeholders informed and up to date at all times.
- Collaboration: work collaboratively with stakeholders. Jemena will work collaboratively with stakeholders and provide opportunities for input into decisions which could affect their lives, their livelihood or the surrounding environment. Jemena will seek to achieve mutually beneficial outcomes.
- Inclusiveness: early and continued engagement. Jemena will continue to consult extensively with stakeholders throughout the Project to establish trusting and open working relationships.
- Integrity: Jemena will work in a manner which fosters mutual respect and trust.

8.1 Indigenous Engagement

Additionally, Jemena will give regard to the international best practice principles for engagement with Indigenous peoples published by the International Association for Impact Assessment[2]. These principles include:

- Equality: Traditional knowledge should be treated with the same respect and validity as Western scientific-based knowledge and Indigenous peoples are to be treated with the same respect as other stakeholders as they are experts in their own field.
- Uniqueness: Each Indigenous group is unique and holds different forms of traditional knowledge. Each Indigenous group also has its own participating, representing and decision-making models which must be respected.
- Rights: Indigenous peoples have rights to the natural resources on their traditional lands. In many instances these rights are protected by law. Respecting Indigenous rights to natural resources is essential.
- Sovereignty: Indigenous peoples define themselves as a sovereign group or self-governing entity. It is important for them to maintain this independence throughout the Economic and Social Impact Assessment process and participation in an impact assessment process does not in any way limit this sovereignty.
- Cultural Heritage: Indigenous peoples have the right to control intellectual property and other material items which relate specifically to their heritage, in order to preserve their culture.
- Free Prior Informed Consent: Intellectual property rights of Indigenous and local communities with respect to their traditional knowledge, innovations and practices, should be respected. Such knowledge should be used only with the prior informed consent of the owners of that traditional knowledge.

[2] Croal, P., Tetreault, C. and members of the IAIA IP Section. (2012) *Respecting Indigenous Peoples and Traditional Knowledge. Special Publication Series No. 9,* Fargo USA: International Association for Impact Assessment.

To the extent consistent with Australian law, Jemena has incorporated provisions into its arrangements with Indigenous representative bodies to respect the above principles.

Consistent with the above, and as further guiding principles, Jemena's approach is to strive to operate at a position which is a combination of the Involve and Collaborate parts of the IAP2 Public Participation Spectrum[3] (Fig 1).

IAP2'S PUBLIC PARTICIPATION SPECTRUM

The IAP2 Federation has developed the Spectrum to help groups define the public's role in any public participation process. The IAP2 Spectrum is quickly becoming an international standard.

INCREASING IMPACT ON THE DECISION →

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision. We will seek your feedback on drafts and proposals.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will work together with you to formulate solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Fig.1 IAP2 Public Participation Spectrum

This approach will inform the way in which Jemena approaches all consultations with stakeholders.

8.2 Codes of Conduct

Consultation with landholders and occupiers affected by the Western Sydney Green Gas Project will be undertaken having regard to the following codes of conduct:

- Australian Pipelines and Gas Association (APGA) Code of Practice for Stakeholder Engagement [4]
- Ministerial Council on Mineral and Petroleum Resources (MCMPR) Principles for Engagement with Communities and Stakeholders [5]

[3] IAP2's Public Participation Spectrum - International Association for Public Participation Australasia
[4] https://www.apga.org.au/sites/default/files/uploaded-content/website-content/stakeholder-engagement-guidelines.pdf
[5] http://energymining.sa.gov.au/__data/assets/pdf_file/0020/41735/mcmpr_principles_nov05.pdf

9. Proposed Engagement Strategy

Jemena proposes a multi-faceted approach to engaging with stakeholders which are directly and indirectly affected by the construction of the Western Sydney Green Gas Project. Jemena intends to build upon and leverage any positive relationships which exist with each of the key stakeholders and the broader public.

A detailed Stakeholder Engagement Action Plan has been developed for the Western Sydney Green Gas Project and is available at Appendix 1.

Communications with project stakeholders will be undertaken in a variety of ways as set out in 9.1 below and will be guided by Western Sydney Green Gas Project-specific Communications Strategy.

Stakeholder communications will be considered in the context of Jemena's Media Engagement Policy and Internal Communications Strategy, which detail the recommended external and internal communications approach to stakeholders and should eventually align with the Western Sydney Green Gas Project's community and business engagement requirements.

In order to ensure consistent and coordinated external messaging about the projects, specific Q&As have been developed and will be updated as the project progresses.

9.1 Communications Tools and Methods

A Western Sydney Green Gas Project, Communications and Advocacy Plan has been developed for the Project. All communications will be driven via this document. Communication and engagement frequency and method will vary throughout the project depending on the type of stakeholder and the level of interest or involvement each stakeholder has at that time of the specific project.

A Stakeholder Engagement Plan has been prepared for the Western Sydney Green Gas Project and is included at Appendix 1. This will be updated as the project progresses.

Consultation tools and methods with stakeholders will include the following:

9.1.2 Face to face discussions and meetings

The predominant form of communication and negotiation to be employed for the Western Sydney Green Gas Project includes meeting directly with landholders, occupiers and stakeholders, listening and recording all discussions and feeding input from discussions back to the project team to support project design, planning, construction, operations and issues management.

9.1.3 Letters, emails, phone calls and text messages

Phone calls will be vital for communicating with all stakeholders. Useful for communicating project updates to landholders, occupiers and stakeholders, letters will mostly be sent via email (where approved and available).

9.1.4 Webpage

Jemena has established a dedicated web page on its corporate website (www.jemena.com.au) which includes project information and contact details for the Western Sydney Green Gas Project.

The web page (https://jemena.com.au/about/what-we-own/our-assets Western Sydney Green Gas Project) will provide information about the Western Sydney Green Gas Project, information about consultation processes, project updates and contact details.

9.1.5 Community Meetings

As a part of Jemena's community engagement program, community meetings will be held. These are an effective way of disseminating information about the Project and engaging directly with stakeholders. The first of these will occur in the first half of 2019, during the EIS exhibition period.

9.1.6 1300 Community Feedback Line

A 1300 community feedback line has been established to allow members of the public to contact Jemena.
The Community Feedback Line for Jemena's Major Projects is 1300 081 989 and will be used for the Western Sydney Green Gas Project.
The phone is managed by the Community Relations Manager from within the Approvals and Stakeholder Management Team. A small number of approved project personnel will have access to information within. Overall management of the Community Feedback Line will be the responsibility of the Community Relations Manager.

Phone calls will be managed in accordance with the Western Sydney Green Gas Project Community Feedback Line and Email Procedure (to be developed), with emails forwarded to the correct primary stakeholder manager, as appropriate. Any issues arising from calls or emails are managed as per Section 11 Issues Management Protocols.

9.1.7 Fact Sheets

Fact sheets will be developed to cover key areas of the Western Sydney Green Gas Project, including project overview. These will be available on Jemena's Western Sydney Green Gas Project webpage, located within the Jemena website (www.jemena.com.au).

9.1.8 Media

As required, Jemena will use media as a method of communicating key project milestones and relevant information. As appropriate, Jemena will regularly use either good news stories or paid advertising to communicate. As noted below, overall management of media will be undertaken by Jemena's Manager, Media and External Affairs and will be carried out in line with Jemena's Media Engagement Policy.

10 Stakeholder Group Management

This section sets out how specific stakeholder groups will be managed.

10.1 Landholders & Occupiers

Maintaining positive, constructive and respectful relationships with landholders and occupiers is of key importance to Jemena.

All interactions and relationships with landholders and occupiers are to be managed by the Senior Approvals and Stakeholder Manager.

As the Western Sydney Green Gas Project is being developed on land occupied by Jemena, there are limited other landholders and occupiers.

The key group is the Local Aboriginal Land Council, referred to in 10.5 below.

10.2 Government/Regulatory

Relationships with governments in relation to approvals are managed by the Senior Approvals and Stakeholder Manager.

Relationships with governments at the political level are managed by the Government Relations Manager. Any divergences from the above are set out in the Stakeholder Register.

10.3 Media

In accordance with Jemena's Media Engagement Policy and Employee Code of Conduct, unless specifically authorised by the General Manager Corporate Affairs, personnel cannot comment to media. Employees who have been approached by media for comment are responsible for forwarding the enquiry.

Jemena's Manager, Media and External Affairs holds full responsibility to ensure messages are managed externally.
All media enquiries are to be referred to:

- Jemena's Manager, Media and External Affairs

10.4 Business Community & Suppliers

Jemena's Western Sydney Green Gas Project is a project of small size and scope however there will still be some opportunities for the NSW business and supplier community.
Potential supplier opportunities will be listed via Jemena's eprocure online portal:
https://www.eprocure.com.au/jemena/

Key responsibility for business community and supplier engagement will be determined in conjunction with Jemena's Commercial Specialist but ultimately would rest with the Senior Project Manager, in collaboration with Jemena's Major Projects commercial and procurement departments.

10.5 Aboriginal Parties

Communications with Aboriginal parties will be undertaken via the Local Aboriginal Land Council.

This engagement is the responsibility of the Senior Approvals and Stakeholder Manager.

10.6 Environmental Non-Government Organisations

Environment NGO communications are to be considered in respect of acknowledgement of specific agendas each interest group may hold.

While the engagement with Environment NGOs is the responsibility of the stakeholder manager as per the Stakeholder Register. Jemena's Media and External Affairs Manager holds full responsibility to ensure messages are managed externally.

10.7 General Public

'General Public' encompasses public, private and community groups not specifically referenced above. Jemena's Community Relations Manager will manage this group, although stakeholder 'managers' will be assigned as per the Stakeholder Register and, in the first instance, all clarifications can be sought from a member of the Western Sydney Green Gas Project team.

General public can contact Jemena via our Major Projects Community Feedback Line on 1300 081 989.

In addition Jemena's website will have dedicated pages with information on the Western Sydney Green Gas Project, with links to all public communication documents and will be regularly updated as appropriate.

11 Issues Management Protocols

Jemena recognises that during the planning, construction and commissioning of construction projects, from time to time, issues may arise with stakeholders. Jemena has well-established issues management protocols in place and will work with affected stakeholders to understand, manage and find resolutions to issues.

Any significant issues which are identified will be immediately reported to the Senior Project Manager, the General Manager Corporate Affairs or the Manager, Media and External Affairs.

Specific procedures are in place to manage inquiries via a dedicated 1300 Community Feedback Line, as outlined in 9.1.6 above.

12 Outcomes of Stakeholder Engagement

Meaningful, effective and thorough stakeholder engagement throughout the planning and development phases of the Western Sydney Green Gas Project should enable the project to achieve the following objectives:

- Create a shared understanding of issues and concerns.
- Consultation and cooperation with stakeholders to resolve issues and help Jemena improve its decision making process in achieving mutually beneficial management outcomes for specific aspects of the Project.

- Assist in obtaining the necessary regulatory approvals as well as demonstrating Jemena’s application and adherence to its stated commitments.
- Enhanced reputation for Jemena and its contractors within the affected communities, local, state and federal governments and the energy sector more broadly.
- Jemena recognises that stakeholder engagement does not necessarily produce solutions that are acceptable to all parties or that will resolve all differences of opinion, however effective stakeholder consultation does offer transparency and ensures that issues impacting stakeholders are thoroughly understood and appropriately responded to.

APPENDICES

APPENDIX 1: STAKEHOLDER ENGAGEMENT PLAN

Stakeholder	Primary Interest	Engagement method	Timing
Government/ Regulatory	• Project overview, timing and budget • Local job and business opportunities • Understand, obtain approvals and timeframes; compliance • Issues management • Good relationship with all stakeholders • Safety	F2F Let Web ME	• Monthly, or as required • As milestones are reached
Local councils etc	• Project overview • Local job and business opportunities • Roads and local infrastructure • Understand, obtain approvals and timeframes; compliance • Safety	F2F Let CM Web ME	• Regularly • As milestones are reached
Media	• Good news stories • Reactive media • Jemena's Western Sydney Green Gas Project brief is well understood • Jemena's lead role in hydrogen demonstration and commitment to decarbonisation of economy known/highlighted	Let Web CM	• Regularly • As milestones are reached • Updated when necessary
Business Community & Suppliers	• Project overview, timing, development • Local job and business opportunities	F2F CM Web ME	• Regularly, via peak body • Updated when necessary
Landholders/ Occupiers and Neighbours	• Project overview, timing, development • No or minimal disturbance • Safety	F2F Web ME CM	• As milestones are reached • Regularly, as necessary
Aboriginal Parties	• Project overview, timing, development • Land access agreements and compliance • Cultural heritage	F2F Let CM Web	• As milestones are reached • Regularly via representative bodies

	• Environment preservation	ME	
NGOs (Industry groups, economic committee etc)	• Project overview, timing, development • Local job and business opportunities • Environment • Key contact details	F2F BCM Web ME PU	• As milestones are reached • Regularly
General Public	• Project overview, timing, development • Local jobs and contracts • Environment • Safety	Web F2F CM ME CFL	• Updated when necessary • As milestones are reached

COMMUNICATIONS TOOLS KEY			
F2F	Face to face discussions and meetings (also utilised on need)	ME	Media (paid, free)
Web	Webpage	Let	Letters, emails, phone calls (not specifically referenced in matrix but utilised throughout)
FS	Fact Sheet	CFL	Community Feedback Line (not specifically referenced in matrix but utilised throughout)
CM	Community Meetings		

Appendix E WSGG Project Communications

The below outlines the WSGG Project communications as of the 16 October 2019.

- Total Audience Reach: 2,419,000
- Traditional media: 547,000
- New media: 1,872,000

MEDIA RELEASES

Date	Title	Coverage	Notes
22 October 2018	Renewable, Green Gas, Trial gets the Go Ahead	• Australian Financial Review • Sydney Morning Herald • Canberra Times • Energy Magazine • Mirage News • The 5th Estate • One step off the grid • Hot Copper • IT Wire • Renew Economy • Pipeline, Plant Offshore • Green Gas Congress • Gas Today	• Project launch • Coordinated with Energy Minister and ARENA • Project name Project H2GO
31 July 2019	Gearing up for a green gas future	• PV Magazine • Australian Pipeliner • Pipeline, Plant, Offshore • Renew Economy • Energy Source Distribution • Mirage News • Utility Magazine • Fuel Cell Works • Process Technology	Milestone: electrolyser procurement

MEDIA COVERAGE

Date	Title	Coverage	Notes
31 July 2019	Leading the Way in renewable energy	Sydney Morning Herald	Newspaper article in renewable feature.

ONLINE MEDIA

- Video (YouTube / Jemena website)
    - August 2019 - Greening the NSW gas network
    - March 2019 - Hydrogen Vehicles
    - October 2018 - Power to Gas explainer
- Jemena website
    - July 2019 - Media release posted (Gearing up for Green Gas future)
    - April 2019 - Thought Leadership (Hydrogen vehicles)
    - October 2018 - Thought Leadership (Project launch)

  - October 2018 - Media Release posted (Project launch)
  - October 2018 - Innovation Page update
  - August 2018 - Gas Vision 2050
- Twitter/LinkedIn/Facebook
  - October 2019 - Turbines
  - September 2019 - Young professionals
  - August 2019 - Why is greening the network significant
  - August 2019 - Customer told us they want green gas
  - July 2019 - Green Gas future (SMH)
  - July 2019 - Can homes use green gas?
  - May 2019 - Future Fuels CRC
  - April 2019 - Are hydrogen cars a myth?
  - April 2019 - Hydrogen vehicles
  - March 2019 - Hydrogen vehicles
  - March 2019 - Australian Domestic Gas outlook
  - February 2019 - Mark Butler MP
  - February 2019 - Committee for Economic Development of Australia
  - February 2019 - Hydrogen vehicles
  - January 2019 - National Hydrogen Strategy
  - December 2018 - Large Gas Users Forum
  - December 2018 - Hydrogen Mobility Australia (now called Australian Hydrogen Council)
  - October 2018 - Hyping up Hydrogen
  - October 2018 - Welcome to Project H2GO

CONFERENCES/PRESENTATIONS

Date	Conference	Presentation
September 2019	Young Pipeliners Forum	Mike Davies (Melbourne)
August 2019	Power Utilities Australia	Gabby Sycamore – on a panel with the owner of the electrolyser, (Melbourne)
July 2019	Grattan Institute	Peter Harcus spoke about how household appliances could still work with green gas, think tank (audience = academics, industry, multi-sector (Sydney)
March 2019	Australian Domestic Gas Outlook	Annual conference, Gabby Sycamore spoke on a panel re: hydrogen, Antoon spoke more general, industry audience (Sydney)
February 2019	Committee for Economic Development of Australia	Shaun Reardon spoke – general gas discussion with hydrogen discussed (significant chunk). 150+ participants including management consultants, economic groups, energy industry, membership of businesses, Mix of businesses, industry, regulators, Mark Butler (shadow energy minister) (Melbourne)

Date	Conference	Presentation
February 2019	Hydrogen vehicles	Jemena organised at Hyundai (hydrogen refueller on site in SYD), promoting the project as a whole, how can we provide the fuel – 30 pax, Hyundai, HMA and others (Sydney)
December 2018	Large Gas Users Forum	Large gas customers in JGN (Bluescope, Austral Brickworks, Homeart Pharmaceuticals) [~50 businesses] (Sydney)

Appendix F WSGG Project Fact Sheet

Fact Sheet
Western Sydney Green Gas Trial Project

Jemena
bringing energy to life

Jemena owns and operates a diverse portfolio of energy and water transportation assets across the east coast of Australia. We employ 3,000 Australians and supply millions of households and businesses with essential services every day.

Jemena has partnered with the Australian Renewable Energy Agency (ARENA) to develop and deliver the Western Sydney Green Gas Trial Project. The 'Power to Gas' trial is ARENA's largest investment in hydrogen technology to date.

Jemena's P2G trial is Australia's most comprehensive hydrogen fuel study to date and, over the next five years, will test how we develop affordable energy storage to complement renewable energy when the sun doesn't shine and the wind doesn't blow.

What is the Western Sydney Green Gas Trial Project?

The Western Sydney Green Gas Trial Project will help bring clean, green and renewable energy to Australian businesses and homes. It will accelerate Australia's hydrogen vehicle industry. It will use existing infrastructure to make renewable technology cheaper, faster, and more reliable.

How will you do this?

Jemena's Western Sydney Green Gas Trial Project will convert renewably sourced electricity into hydrogen via electrolysis.

A portion of the hydrogen produced will be injected into the gas network, providing enough energy to meet the cooking, heating and hot-water requirements of approximately 250 homes.

Another portion of the hydrogen will be stored underground supplying a gas engine generator which will provide electricity back to the grid.

The project includes an onsite Hydrogen Refuelling Station (HRS) for Fuel Cell Electric Buses.

What is hydrogen?

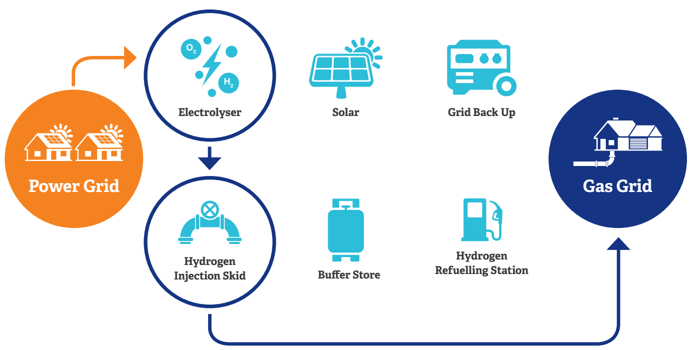
Hydrogen is the most common chemical in the universe. It can be produced as a gas or liquid, or made part of other materials, and has many uses such as fuel for transport or heating, a way to store electricity, or a raw material in industrial processes.

Hydrogen has zero carbon emissions.

Just like natural gas, hydrogen can be safely transported through existing infrastructure, like pipelines. It can be converted back to electricity or support the existing or international hydrogen market.

What is the process?

Through a process called 'power to gas,' renewable energy will be converted into hydrogen using an electrolyser – the first of its kind in New South Wales. The electrolyser will use power generated by wind and solar to split water into hydrogen and oxygen. The oxygen is released into the atmosphere; the hydrogen will be stored as renewable energy for weeks and months, making it more efficient than batteries which can only store excess renewable energy for minutes or hours.



Where will the trial take place?

The trial will take place at Jemena's existing Horsley Park site, in western Sydney.

Why is Jemena undertaking this trial?

Jemena aims to demonstrate that our gas network is ready to deliver clean, safe and sustainable green gas to customers.

In doing so, Jemena is supporting the decarbonisation of Australia's energy market by demonstrating a long term storage solution for renewable energy for when the sun doesn't shine and the wind doesn't blow.

When will the project be built?

Jemena is currently in the development phase of this project. Jemena expects the trial to be operational in 2020.

How do I find out more information?

You can view more information the project here: https://jemena.com.au/about/innovation/power-to-gas-trial

You can get in touch with our team in these ways:

- Call our Community Feedback Line on 1300 081 989
- Email our team danielm@ecoaus.com.au
- Visit our website at www.jemena.com.au
- You can view ARENA's work at its website: https://arena.gov.au/

Jemena
bringing energy to life

Appendix G Air Quality Impact Assessment (Benbow Environmental, 2019)

AIR QUALITY IMPACT ASSESSMENT
FOR
WESTERN SYDNEY GREEN GAS PROJECT
194-202 CHANDOS ROAD, HORSLEY PARK NSW

Prepared for: Daniel Magdi, Eco Logical Australia

Prepared by: Kate Barker, Environmental Scientist
R T Benbow, Principal Consultant

Report No: 191211_AQIA_Rev4
November 2019
(Released: 7 November 2019)

Benbow ENVIRONMENTAL

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EXECUTIVE SUMMARY

Jemena Gas Networks (Jemena) commissioned Benbow Environmental to conduct a qualitative assessment of the air quality impacts, including odour and greenhouse gases, of the proposed Power to Gas project '*Western Sydney Green Gas Project (WSGG Project)'* at 194-202 Chandos Road, Horsley Park NSW. The proposed project will transform electrical energy into a combustible gas, hydrogen, which will be injected into the Sydney secondary gas distribution network or supplied to an adjacent hydrogen bus refuelling facility.

The assessment determines the likely air quality impacts from the WSGG Project in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA 2016). It determines the proposed developments ability to comply with *Protection of the Environment Operations Act 1997* and *Protection of the Environment Operations (Clean Air) Regulation 2010*.

In addition, an assessment of the likely greenhouse gas (GHG) impacts of the project is made in accordance with AS ISO 14064.1-2019 *Greenhouse gases - Part 1 Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals, National Greenhouse Accounts (NGA) Factors, National Greenhouse and Energy Reporting (Measurement) Technical Guidelines* and *The Greenhouse Gas Protocol*. It determines the variation in GHG emissions that would result from Scope 1, 2 and 3 emissions, including natural gas and electricity consumption.

There are three sources of emissions to air in the current scope of the WSGG Project. These include a generator, electrolyser (500kW) and a buffer store blowdown vent. The future scope of the project includes and additional electrolyser and a hydrogen refuelling and dispensing station. The future scope is considered within this assessment.

The generator has minimal expected emissions of nitrogen oxides from the consumption of natural gas. The electrolysis process will be emitting oxygen to open air. This is not considered to be a significant risk to the surrounding health and environment. A pipeline blowdown is not expected for regular operation and is not considered a significant source of emissions. The existing Jemena gas facility uses odorant in the natural gas. There are no new sources of odour for the proposed development. The only occurrence of odour impacts from the odorant in the natural gas would be due to an abnormal incident and would not occur due to normal operations. Emissions from the future refuelling and dispensing station would be limited to fugitive emissions of hydrogen and are not considered significant. There are no sources of dust and particulates associated with the operation of the WSGG Project. Emissions to air may occur during the construction phase of the project and measures should be taken to reduce these.

Australia's total emissions in 2017 were estimated to be 534.7 Mt CO_2-e (Australian Government, DEE National Inventory Report 2017). In comparison, the estimated annual greenhouse emission for the Project is 0.000019 Mt CO_2-e. Therefore, the annual contribution of greenhouse emissions from the current project in comparison to the Australian greenhouse emissions in 2017 is approximately 0.000000004%.

In summary, the air quality impacts from the proposed Power to Gas project '*Western Sydney Green Gas Project (WSGG Project)'* are expected to be very low and will not cause a negative impact on the health and environment of the surrounding area.

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Tables Page

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Attachments

1. INTRODUCTION

Jemena Gas Networks (Jemena) commissioned Benbow Environmental to conduct a qualitative assessment of the air quality impacts, including odour and greenhouse gases (GHG), of the proposed Power to Gas project '*Western Sydney Green Gas Project (WSGG Project)'* at 194-202 Chandos Road, Horsley Park NSW. The proposed project will transform electrical energy into a combustible gas, hydrogen, which will be injected into the Sydney secondary gas distribution network or supplied to an adjacent hydrogen bus refuelling facility.

The assessment determines the likely air quality impacts from the WSGG Project in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA 2016). It determines the proposed developments ability to comply with *Protection of the Environment Operations Act 1997* and *Protection of the Environment Operations (Clean Air) Regulation 2010*.

In addition, an assessment of the likely greenhouse gas impacts of the project is made in accordance with AS ISO 14064.1-2019 *Greenhouse gases - Part 1 Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals, National Greenhouse Accounts (NGA) Factors, National Greenhouse and Energy Reporting (Measurement) Technical Guidelines* and *The Greenhouse Gas Protocol*. It determines the variation in GHG emissions that would result from Scope 1 and Scope 2 emissions, including natural gas and electricity consumption.

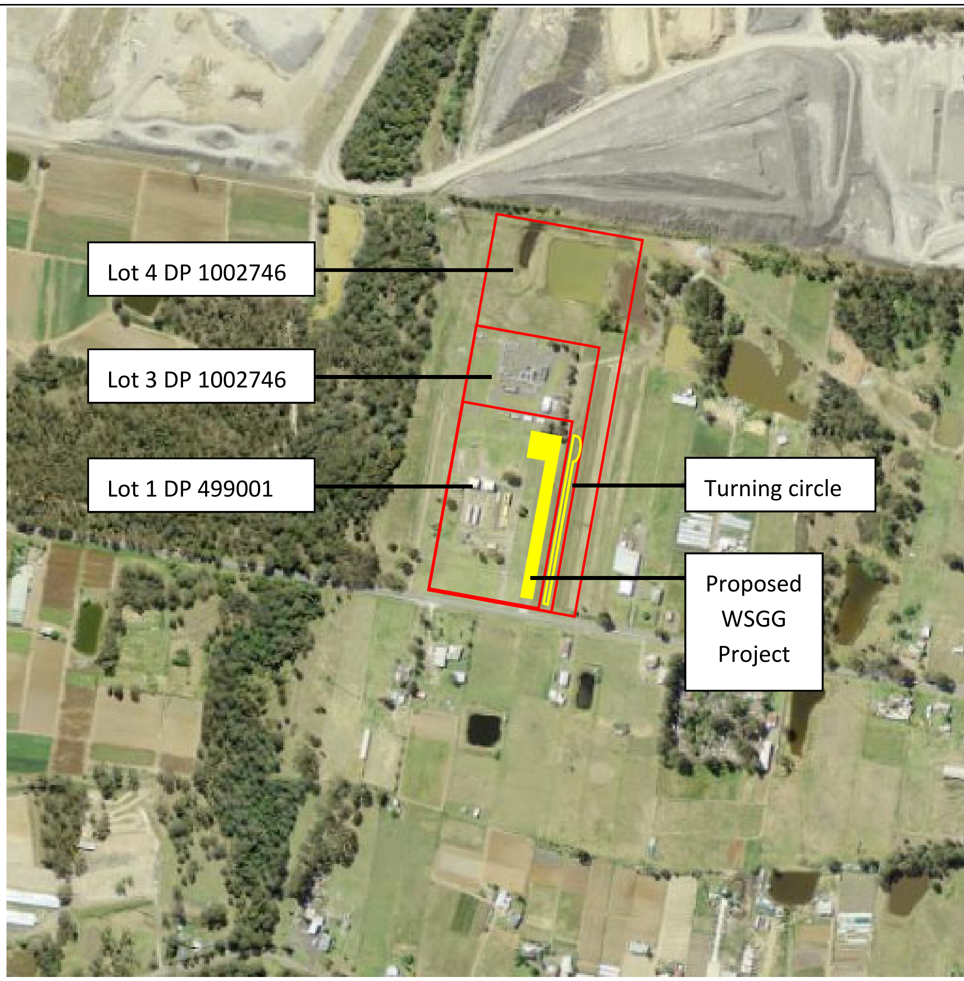
2. SITE INFORMATION

A brief description of the subject site and proposed operations has been provided below.

2.1 SITE LOCALITY

The proposed WSGG Project is located on land within the Western Sydney Parklands within the Fairfield City Council Area. The proposed WSGG Project includes a hydrogen dispenser and bus turning circle which would be located on land adjacent to the existing facility Jemena facility. The existing Jemena Horsley Park facility is located on Lot 1 DP 499001. The turning circle of the proposed development will extend across the narrow access route on Lot 3 DP 1002746 which is also owned by Jemena, as shown in Figure 2-1.

Figure 2-1: Site Location



Source: SIX Maps 2019

N
Not to scale

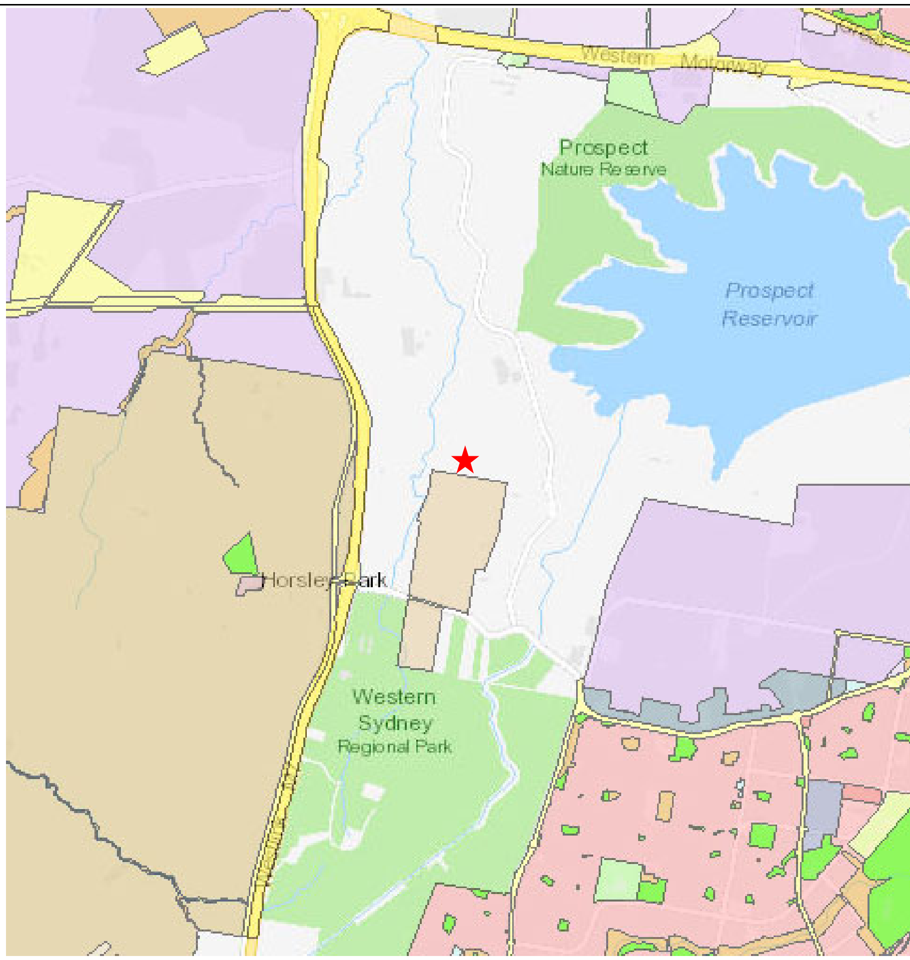
LEGEND:
Lot boundary
Proposed development

Benbow Environmental
25-27 Sherwood Street,
Northmead NSW 2152

2.2 Surrounding Land

The proposed WSGG Project is located approximately 0.2 km west of Eastern Creek, 1.2 km east of Upper Canal and 1.2 km south west of Prospect Reservoir. The surrounding land zoning is shown in Figure 2-2. The nearest residential zone is approximately 1.2 km west of the WSGG Project.

Figure 2-2: Site Location and Surrounding Land Zoning



Source: NSW Government ePlanning Spatial Viewer

↑N

Not to scale

LEGEND:

★ Proposed development

Land Zoning

Non Standard Zones

B1, B2, B3, B4, B5, B6, B7, B8, DM, E1, E2, E3, E4, IN1, IN2, IN3, IN4, R1, R2, R3, R4, R5, RE1, RE2, RU1, RU2, RU3, RU4, RU5, RU6, SP1, SP2, SP3, UD, UL, W1, W2, W3

Benbow Environmental
25-27 Sherwood Street,
Northmead NSW 2152

2.2.1 Nearest Sensitive Receptors

The subject site is surrounded by rural developments and a number of nearby residential dwellings. A list of the nearest sensitive receptors is presented in Table 2-1 and shown in Figure 2-3.

Table 2-1: Nearest Potentially Affected Receptors

Receptor	Description	Address	Distance	Direction
R1	Brickworks	780 Wallgrove Road, Horsley Park	870 m	NW
R2	Brickworks	780 Wallgrove Road, Horsley Park	690 m	NE
R3	Structure on rural land	168-174 Chandos Road, Horsley Park	190 m	E
R4	Structure on rural land	168-174 Chandos Road, Horsley Park	160 m	E
R5	Residence on rural land	150-154 Chandos Road, Horsley Park	330 m	E
R6	Residence on rural land	126-130 Chandos Road, Horsley Park	510 m	E
R7	Residence on rural land	105-119 Chandos Road, Horsley Park	610 m	E
R8	Residence on rural land	121-135 Chandos Road, Horsley Park	520 m	E
R9	Residence on rural land	137-153 Chandos Road, Horsley Park	430 m	SE
R10	Residence on rural land	171-185 Chandos Road, Horsley Park	280 m	SE
R11	Residence on rural land	187-201 Chandos Road, Horsley Park	230 m	SE
R12	Residence on rural land	203-209 Chandos Road, Horsley Park	250 m	S
R13	Residence on rural land	211-217 Chandos Road, Horsley Park	330 m	S
R14	Residence on rural land	109-125 Ferrers Road, Horsley Park	860 m	SE
R15	Residence on rural land	203-213 Redmayne Road, Horsley Park	630 m	S
R16	Residence on rural land	157-165 Redmayne Road, Horsley Park	600 m	S
R17	Residence on rural land	259-273 Chandos Road, Horsley Park	590 m	SW
R18	Residence near M7	650-664 Wallgrove Road, Horsley Park	850 m	SW
R19	Residence near M7	741-747 Wallgrove Road, Horsley Park	880 m	W
R20	Residence near M7	763-783 Wallgrove Road, Horsley Park	940 m	W

Figure 2-3: Location of the Nearest Sensitive Receptors

↑N Not to scale	LEGEND: S1 = Source R1-R9 = Receptors 1 to 9	Benbow Environmental 25-27 Sherwood Street, Northmead NSW 2152

2.3 Proposed Development

The production of hydrogen at the WSGG Project will be using the method of electrolysis. This method uses distilled water as a feedstock and uses electrical energy to separate the hydrogen ions through a membrane. The moisture and excess oxygen are removed from the produced hydrogen through the purification process. The hydrogen is transferred to the buffer storage where it can be used in refuelling, injected into the network or used in the gas generators. The facility is designed for an initial production of 9 kilograms of hydrogen per hour of with a future maximum production of 18-20 kilograms of hydrogen per hour and will be operated intermittently depending on the hydrogen demand.

Electricity from the main grid is used to power the electrolyser system. Mains water is used for the system and is treated through reverse osmosis to remove particles, ions and molecules to produce pure, demineralised water.

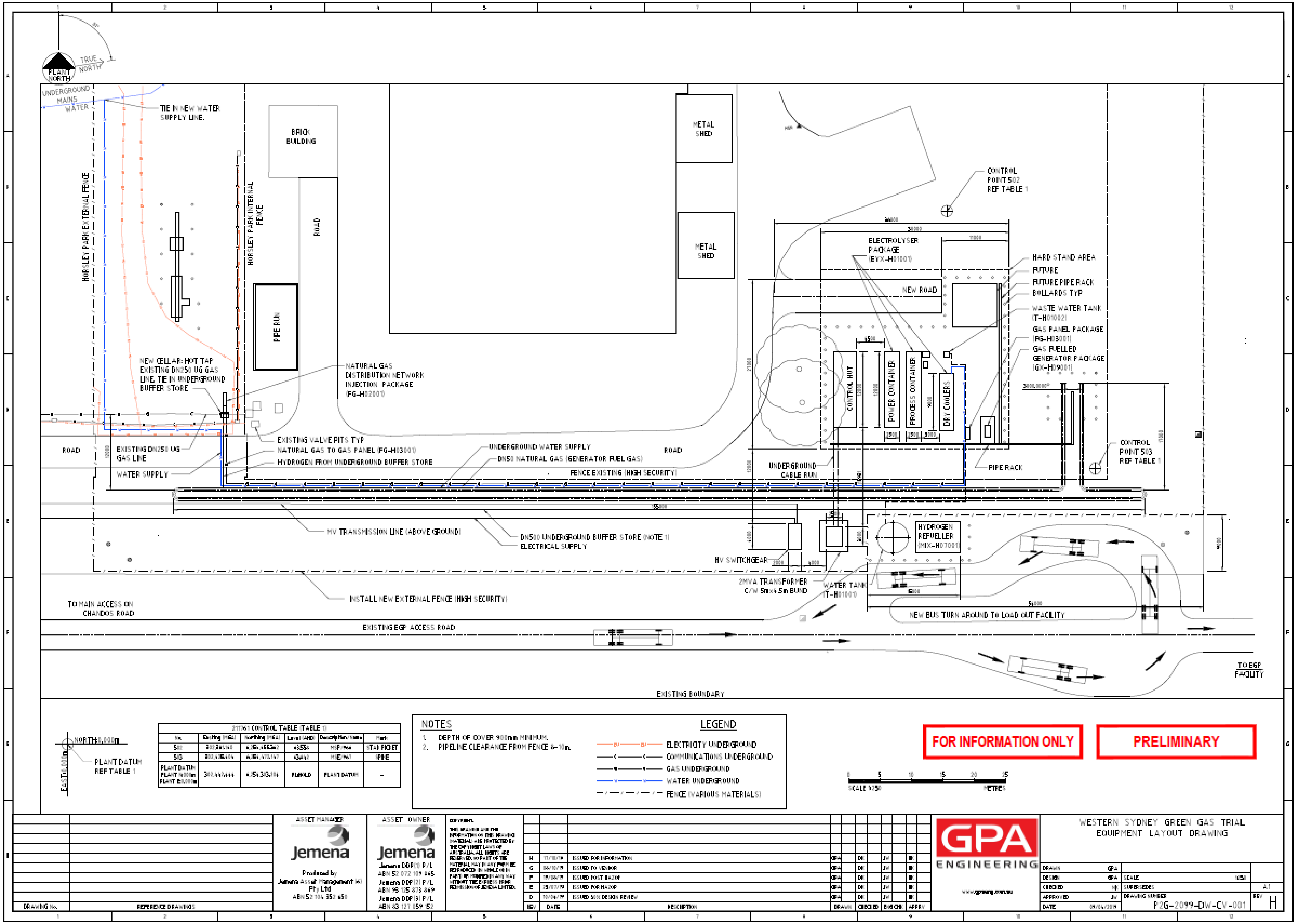
The physical connection of the hydrogen production facility to the network will be via a pressure reducing gas control panel, which will ensure the correct pressure and flow rate is maintained from the hydrogen pipeline blending into the natural gas secondary main. Further features on this panel will include an automatic isolation valve that interlocks with the existing facilities on site to ensure complete isolation from the network in the event of any parameters being outside those specified for the purposes of testing.

The WSGG Project facility will perform the following key functions:

- Convert tap water and grid electricity into hydrogen gas through an electrolyser package.
- Store hydrogen gas in an underground onsite pipeline for buffer storage and injection management.
- Control and safely manage hydrogen gas pressures, temperatures and flowrates for injection into Jemena's secondary network and connect to a hydrogen refuelling station.
- Metering and regulation for a hydrogen generator set to convert excess hydrogen back to electrical energy at times of peak energy demand.

The site layout is shown in Figure 2-4.

Figure 2-4: Site Layout



3. LEGISLATION, POLICY AND GUIDELINES

3.1 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) applies the following definitions relating to air pollution:

> *'**"Air pollution"** means the emission into the air of any air impurity.*
>
> *While "air impurity" includes smoke, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, mists odours, and radioactive substances'*

The following sections of this Act have most relevance to the site:

- *Section 124 Operation of Plant - other than domestic plant*

The occupier of any premises who operates any plant in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupier's failure:

(a) to maintain the plant in an efficient condition, or

(b) to operate the plant in a proper and efficient manner.

- *Section126 Dealing with Materials*

(1) The occupier of any premises who deals with materials in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupiers failure to deal with those materials in a proper and efficient manner.

(2) In this section:

***deal** with materials means process, handle, move, store or dispose of the materials.*

***materials** includes raw materials, materials in the process of manufacture, manufactured materials, by-products or waste materials.*

- *Section 127 Proof of causing pollution*

To prove that air pollution was caused from premises within the meaning of Sections 124 – 126, it is sufficient to prove that air pollution was caused on the premises, unless the defendant satisfies the court that the air pollution did not cause air pollution outside the premises.

- *Section 128 Standards of air impurities not to be exceeded*

  (1) The occupier of any premises must not carry on any activity, or operate any plant, in or on the premises in such a manner as to cause or permit the emission at any point specified in or determined in accordance with the regulations of air impurities in excess of:

  (a) The standard of concentration and the rate, or

  (b) The standard of concentration or the rate.

  Prescribed by the regulations in respect of any such activity or any such plant.

  (2) Where neither such a standard nor rate has been so prescribed, the occupier of any premises must carry on any activity, or operate any plant, in or on the premises by such practicable means as may be necessary to prevent or minimise air pollution.

The proposed development is required to comply with this Act.

3.2 PROTECTION OF ENVIRONMENT OPERATIONS (CLEAN AIR) REGULATION 2010

In accordance with Part 5 of the *Protection of the Environment Operations (Clean Air) Regulation 2010* (herein referred to as the Clean Air Regulation), the proposed WSGG Project would belong to Group C (Standards for non-scheduled premises) as the activity is to be "*commenced to be carried on, or to operate, on or after 1 September 2005 as a result of development consent granted pursuant to a development application made on or after 1 September 2005".*

Schedule 6 of the Clean Air Regulation provides standards of concentration for non-scheduled premises for any activity and plant as:

Solid Particles = 100 mg/m^3

The facility would be required to meet the above standard of concentration.

3.3 RELEVANT CRITERIA & NSW ENVIRONMENT PROTECTION AUTHORITY GUIDELINES

The *Approved Methods* (EPA 2016) provides guidance on methodology and thresholds that are to be used for the assessment of a proposed development. This assessment has been conducted in accordance with this guideline. Assessable pollutants (along with their corresponding limits) are summarised in Table 3-1. These criteria are applied at the nearest existing or likely future off-site sensitive receptor.

Table 3-1: Applicable Particulate Criteria at Sensitive Receptors from the NSW EPA Modelling Guidelines (*Approved Methods* 2016)

Pollutant	Averaging Period	Percentile	Concentration µg/m^3
Total Suspended Particulates (TSP)	Annual	100th	90
PM_{10}	24 Hours	100th	50
	Annual	100th	25
$PM_{2.5}$	24 Hours	100th	25
	Annual	100th	8
Nitrogen dioxide (NO_2)	24 Hours	100th	246
	Annual	100th	62

The *Approved Methods* has designed the impact assessment criteria for complex mixtures of odour to take in consideration the size of the affected population. Statistically, as the population density increases, the proportion of individuals particularly sensitive to odours is also likely to increase, indicating that more stringent criteria are necessary in these situations, as summarised in Table 3-2.

Table 3-2: Impact Assessment Criteria for Complex Mixtures of Odour

Population of affected community	Impact assessment criteria for complex mixtures of odorous air pollutants (OU)
Urban (Population ≥ ≈ 2000)	2.0 OU/m^3
Population ≈ 500	3.0 OU/m^3
Population ≈ 125	4.0 OU/m^3
Population ≈ 30	5.0 OU/m^3
Population ≈ 10	6.0 OU/m^3
Single residence (≤ ≈ 2)	7.0 OU/m^3

The *Approved Methods* provides the following formula to determine the appropriate impact assessment criteria for complex mixtures of odorous air pollutants:

- Impact Assessment Criteria (OU) = [$\log_{10}$ (population)-4.5]/-0.6

In Horsley Park NSW the average household size is 3.2 people according to the 2016 Census. There are 16 residences considered in the nearest sensitive receptors, which would equate to a population of approximately 52. Using the calculation provided above, this would result in an indicative criterion of 5 OU. The assessment criteria can be verified by the results of modelling and based on the population that falls within the 2 OU. Due to the rural nature and minimal emissions of the proposed development, modelling is not considered warranted.

4. EXISTING ENVIRONMENT

4.1 CLIMATE AND METEOROLOGY

Assessment of the climate and meteorological conditions around the proposed development is made using data collected from the nearest automatic weather station (AWS) with long-term historical climate records.

The nearest automatic weather monitoring station within proximity to the subject site is Horsley Park Equestrian Centre AWS 067119 (Latitude: 33.85 °S Longitude: 150.86 °E) operated by the Bureau of Meteorology (BoM). This monitoring station is located approximately 2.2 kilometres to the south of the subject site. This weather station is considered suitable to determine the most representative year and summarise the local weather conditions presented in this section.

4.1.1 Climate

Climate data is available online at the Australian Bureau of Meteorology website. The Horsley Park Equestrian Centre AWS has monthly statistics from 1997 - 2019 for minimum and maximum temperature and 2003-2019 for daily wind run. The monthly and annual statistics are summarised in Table 4-1.

The mean daily wind run was lowest in May and the highest in November. The mean maximum and minimum temperatures were lowest in July and highest in January. The mean rainfall was lowest for September and highest in February. The mean number of days of rain ≥ 1mm was lowest in August and highest in March

Table 4-1: Climate data from the Horsley Park Equestrian Centre AWS

Month	Mean Maximum Temperature (°C)	Mean Minimum Temperature (°C)	Daily Wind Run (km)	Mean Rainfall (mm)	Mean Number of Days of Rain ≥ 1mm
January	30.1	17.9	212	75.6	7.6
February	28.9	17.8	204	103.6	7.1
March	26.9	16.2	177	83.3	8.0
April	23.9	13.0	174	70.3	6.8
May	20.6	9.0	157	41.9	5.0
June	17.6	7.2	174	74.7	6.3
July	17.4	5.8	177	35.2	5.0
August	19.0	6.4	198	36.8	4.0
September	22.4	9.3	211	35.1	4.9
October	24.7	11.8	202	58.8	5.8
November	26.4	14.4	215	78.6	7.0
December	28.4	16.3	211	66.4	7.1
Annual	**23.9**	**12.1**	**193**	**757.3**	**74.6**

4.2 ATMOSPHERIC STABILITY

The "stability" of the atmosphere is a classification used to describe the structure of the atmosphere in terms of temperature, specifically, how temperature changes in the atmosphere with altitude. Classification is often done according to the Pasquill-Gifford classification system that consists of six stability class groups, shown in Table 4-2. The class "A" describes an atmosphere where the air is well-mixed and there is little hindrance of dispersion into the atmosphere. At the other end of the scale is class "F", which describes conditions under which temperature inversions would occur, where winds are calm or absent and air close to the earth's surface cannot rise into the atmosphere due to the presence of warmer air layers above. The classes in between A and F indicate changing degrees of stability due to variations in temperature in the atmosphere.

Table 4-2: Pasquill-Gifford Stability Class System

Stability Class	Description
A	Extremely Unstable
B	Unstable
C	Slightly Unstable
D	Neutral
E	Slightly Stable
F	Very Stable

BoM meteorological data for the years 2014-2018 from Horsley Park Equestrian Centre AWS was compared to select a representative year (attachment 2). The most representative year, 2015, was used to determine atmospheric stability classification for the site. Table 4-3 and Table 4-4 present the statistical information for the Horsley Park Equestrian Centre AWS meteorological data for 2015. There were 3.3% missing or incomplete data for this file which has been excluded. The annual average wind speed for 2015 was 1.97 m/s. The tables show that the primary wind directions were from the south west at 19.8% of the time. Winds were least likely to originate from the north east at 6.5% of the time.

Worst case dispersion conditions for emissions would occur during F-class stability conditions – generally associated with still/light winds and clear skies during the night time or early morning period (stable conditions). Analysis of the referenced site-specific meteorological data indicates the F-class dispersion conditions were present for approximately 11.5% of the time in the Horsley Park Equestrian Centre AWS 2015 meteorological data.

Looking at Table 4 3, it can be seen that stability class D is the most frequent, with an occurrence of 41.1%. Stability classes A, B, and C, which offer the best dispersion conditions, occur with frequencies of 13.2%, 7.2% and 15.1% respectively.

Table 4-3: Wind Direction/Stability Class Frequency Distribution (Count) for Referenced Meteorological Station Horsley Park Equestrian Centre AWS (BOM data for 2015)

Frequency Distribution (Count)							
Direction (Blowing From)	Stability Class						
	A	**B**	**C**	**D**	**E**	**F**	**Total**
N	219	101	196	543	152	304	1515
NE	185	62	50	202	64	28	591
E	113	69	183	305	66	33	769
SE	89	101	196	541	152	304	1383
S	219	57	206	496	127	81	1186
SW	89	73	210	1025	305	102	1804
W	142	108	164	286	141	113	954
NW	144	86	165	342	74	82	893
Total	1200	657	1370	3740	1081	1047	9095

Table 4-4: Wind Direction/Stability Class Frequency Distribution (Percentage) for Referenced Meteorological Station Horsley Park Equestrian Centre AWS (BOM data for 2015)

Frequency Distribution (Percentage %)							
Direction (Blowing From)	Stability Class						
	A	**B**	**C**	**D**	**E**	**F**	**Total**
N	2.4	1.1	2.2	6.0	1.7	3.3	16.7
NE	2.0	0.7	0.5	2.2	0.7	0.3	6.5
E	1.2	0.8	2.0	3.4	0.7	0.4	8.5
SE	1.0	1.1	2.2	5.9	1.7	3.3	15.2
S	2.4	0.6	2.3	5.5	1.4	0.9	13.0
SW	1.0	0.8	2.3	11.3	3.4	1.1	19.8
W	1.6	1.2	1.8	3.1	1.6	1.2	10.5
NW	1.6	0.9	1.8	3.8	0.8	0.9	9.8
Total	13.2	7.2	15.1	41.1	11.9	11.5	100.0

In addition, the wind speed frequency distribution across wind directions is shown in Table 4-5. There were 19% calms which will contribute to the stable conditions in E and F stability classes. The majority of wind speed lies between 0.5 – 3.6 m/s for 52.1% of the time. This is represented in the D stability class which is experienced 41.1% of the time as shown in Table 4-4.

Table 4-5: Wind Direction/Speed Frequency Distribution (Percentage) for Referenced Meteorological Station Horsley Park Equestrian Centre AWS (BOM data for 2015)

Frequency Distribution (Percentage %)								
Direction (Blowing From)	Wind speed (m/s)							**Total**
	<0.50	0.50 - 2.10	2.10 - 3.60	3.60 - 5.70	5.70 - 8.80	8.80 - 11.10	>= 11.10	
N	-	5.23	2.59	0.67	0.02	0	0	8.52
NE	-	3.3	2.0	0.4	0.0	0.0	0.0	5.7
E	-	2.4	2.7	2.8	0.2	0.0	0.0	8.0
SE	-	2.9	3.0	3.1	0.5	0.0	0.0	9.4
S	-	3.9	4.4	2.1	0.7	0.0	0.0	11.0
SW	-	6.8	9.2	2.7	0.3	0.0	0.0	18.9
W	-	5.4	1.9	1.0	0.1	0.0	0.0	8.4
NW	-	5.0	1.7	0.8	0.4	0.0	0.0	7.8
Calms	19.0	-	-	-	-	-	-	19.0
Incomplete	3.3	-	-	-	-	-	-	3.3
Total	22.3	34.9	27.2	13.5	2.1	0.0	0.0	100.0

4.3 Local Wind Trend and Rose Plots

Wind rose plots show the direction from which the wind is coming using triangles known as "petals". The petals of the plots in the figure summarise wind direction data into four compass directions i.e. north, east, south and west.

The length of the triangles, or "petals", indicates the frequency with which wind blows from the direction presented. Longer petals for a given direction indicate a higher frequency of wind from that direction. Each petal is divided into segments, with each segment representing one of the six wind speed classes.

The proportion of time for which wind speed is less than speeds in the first class (i.e. 0.5 m/s) when speed is negligible, is referred to as calm hours or "calms". Calms are not shown on a wind rose as they have no direction, but the proportion of calms for the period under consideration is noted under each wind rose.

The concentric circles in each wind rose are the axes that denote wind frequencies. In comparing the plots it should be noted that the axes vary between wind roses, although all wind roses are the same size. The frequencies shown in the first quadrant (top-right quarter) of each wind rose are stated beneath the diagram.

Wind rose plots of seasonal average for a five year period (2014-2018), generated from the Horsley Park Equestrian Centre AWS data, is shown in Figure 4-1.

4.3.1 Seasonal Wind Trends

Seasonal wind rose plots for this site using Horsley Park Equestrian Centre AWS (067119) have been included in Figure 4-1. Over the years of 2014-2018 the wind direction varies but they mostly arrive at the site from the south west, between 16-20% of the time. Wind blows from the other directions less than 12% of the time, with wind blowing from the east and north east less than 8% of time. The average wind speed over this period is 2.07 m/s and the calms frequency is 19.16%.

The average summer period had the 2nd highest wind speed of 2.24 m/s and a calms frequency of 17.86%. Unlike the overall year trend, wind during summer came mostly from the south east, east and south, with frequencies of approximately 18%, 15%, and 13% respectively. Winds from the west and north west were the lowest with frequencies below 4%.

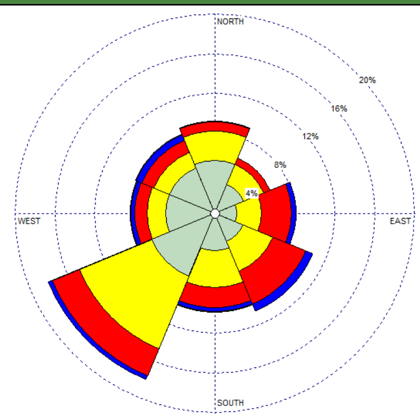
Autumn had an average speed of 1.87 m/s and dominant winds blew from the south west at a frequency of ~27%. The calms frequency was the highest during autumn, at 22.19%.

Winter winds blew from predominately westerly directions, from the south west, west, and north west at ~25%, ~15%, ~15% frequencies respectively. Wind from the north was less than 15% in frequency and at ~5% or below for all other directions. Average wind speed was 1.94 m/s and the calms frequency was 17.52%.

The spring period had the highest wind speed of 2.26m/s and saw winds blow from the south west approximately ~15% of the time, followed by south east at ~12% of time, and east, north and north west each at 8-12% of the time. Spring had a calms frequency of 17.85%.

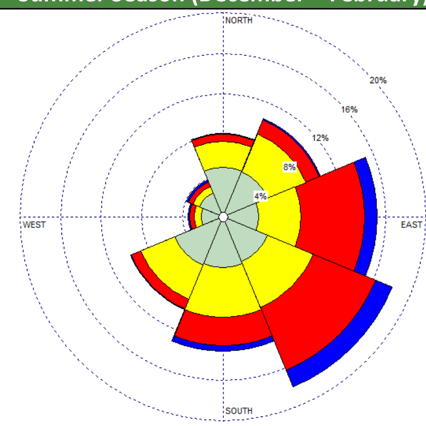
Figure 4-1: Wind Rose Plots for the Referenced Meteorological Station – Horsley Park, Bureau of Meteorology (2014-2018)

All Seasons



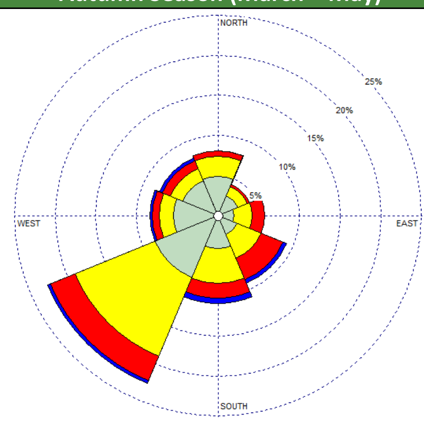
Average Wind Speed: 2.07 m/s
Calms Frequency: 19.16%
Axis Frequencies: 4%, 8%, 12%, 16%, 20%

Summer Season (December – February)



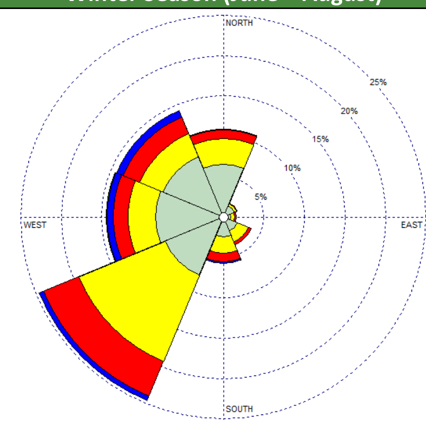
Average Wind Speed: 2.24 m/s
Calms Frequency: 17.88%
Axis Frequencies: 4%, 8%, 12%, 16% and 20%

Autumn Season (March – May)



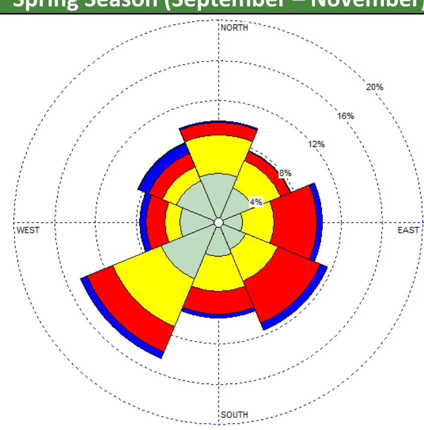
Average Wind Speed: 1.87 m/s
Calms Frequency: 22.99%
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Winter Season (June – August)



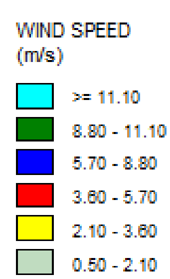
Average Wind Speed: 1.94 m/s
Calms Frequency: 17.52%
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Spring Season (September – November)



Average Wind Speed: 2.26 m/s
Calms Frequency: 17.85%
Axis Frequency: 4%, 8%, 12%, 16%, 20%

Legend

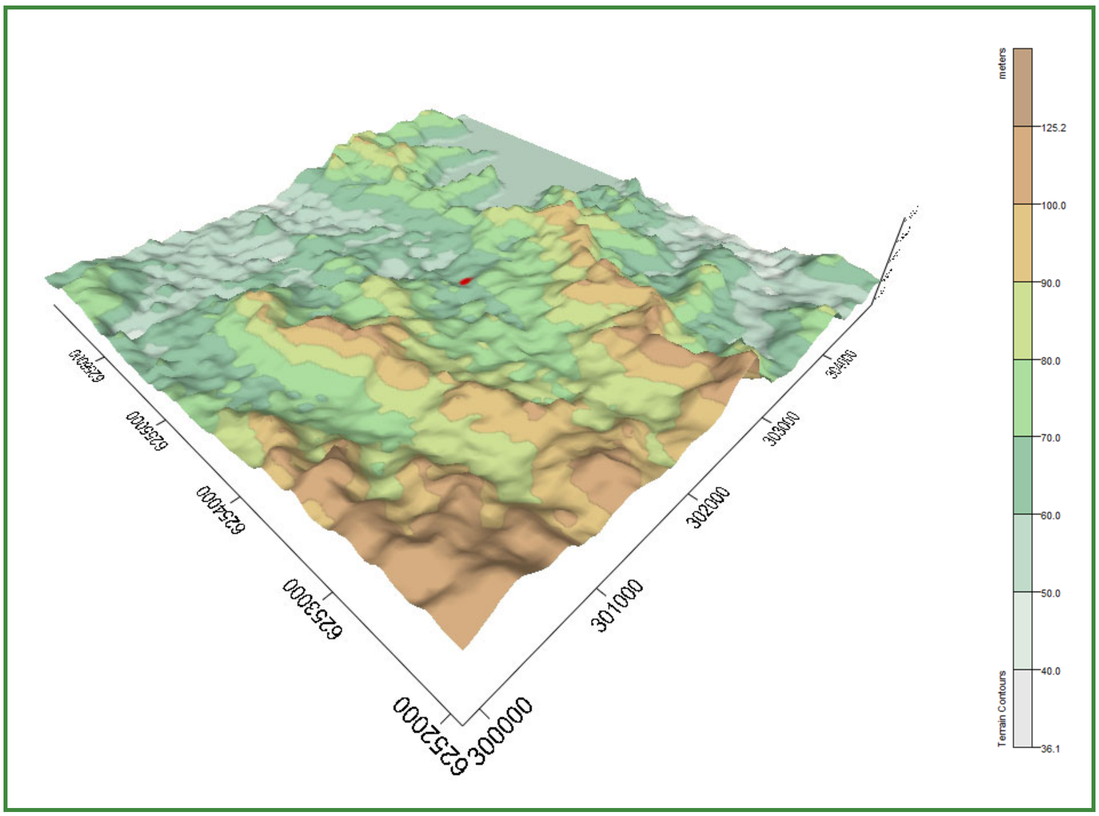


4.4 TERRAIN AND STRUCTURAL EFFECTS ON DISPERSION

The meteorological condition known as katabatic flow (or katabatic drift) is often identified as the condition under which maximum environmental impacts from primarily ground-based sources are likely to occur. Katabatic flow is simply the movement of cold air down a slope, generally under stable atmospheric conditions. Under such circumstances, dispersion of airborne pollutants is generally slow and the associated impacts can reach their peak.

Although there are small ridges to the west and east of the subject site, katabatic flow is unlikely to affect emissions as there is sufficient distance and northerly directions of the site are relatively flat. Figure 4-2 shows the terrain with the z-axis (i.e. vertical axis) exaggerated by a factor of 10 (i.e. a given distance on the x-axis or y-axis appears three times as great on the z-axis) in order to provide a clearer description of the topography. A coloured scale bar shows elevations corresponding to the colours used in the figures. It should be noted that these figures are an approximation of the actual terrain, based on terrain information that has been digitised from local contour terrain maps.

Figure 4-2: Local Topography of Site, factor of 10 vertical exaggeration



4.5 Local Air Quality

No air quality measurements have been undertaken specifically for this project. Instead, the nearest available air quality monitoring data was used to gain an understanding of what current pollutant levels may be around the site and to provide background air quality parameters for the assessment.

Ambient air quality data for NO_x, PM_{10}, and $PM_{2.5}$ from Prospect air quality monitoring station was used, as it is located in William Lawson Park, Myrtle Street, approximately 6 km south of the subject site, which is considered to be site-representative. The monitoring station was installed in 2006, and available data was obtained from the years 2007-2018. The relevant data is summarised in Table 4-6.

Table 4-6: Summary of Data for NO_x, PM_{10} and $PM_{2.5}$ from Prospect Air Quality Monitoring Station

Year	NO average mg/m³	NO_2 average (ppb)	PM_{10} average mg/m³	$PM_{2.5}$ average mg/m³
2007	NA	NA	0.018	NA
2008	NA	NA	0.018	NA
2009	NA	20.70	0.026	NA
2010	NA	22.58	0.015	NA
2011	NA	18.82	0.016	NA
2012	NA	18.82	0.017	NA
2013	NA	20.70	0.019	NA
2014	NA	18.82	0.018	NA
2015	NA	20.70	0.018	0.0082
2016	9.82	18.82	0.019	0.0087
2017	9.82	18.82	0.019	0.0077
2018	8.59	16.93	0.022	0.0085
2007-2018	9.45	19.57	0.019	0.0083

Using the worst-case particle size distribution data provided by the U.S. Environmental Protection Agency (USEPA) AP-42 Emissions Database, a PM_{10}-to-TSP ratio of 0.51 was used to estimate the TSP background concentration level of 0.03 mg/m^3 for the 2007-2018 average.

5. AIR QUALITY IMPACTS

There are three sources of emissions to air in the current scope of the WSGG Project. These include a generator, electrolyser and a buffer store blowdown vent. The future scope of the project includes an additional electrolyser and a hydrogen refuelling and dispensing station. There is also a waste water tank but it is not considered to be a source of emissions. The hydrogen production method uses distilled water as a feedstock and excess moisture is removed through the purification process, there are no emissions of concern or odour from this tank.

The generator is a capstone C65 Microturbine (high-pressure natural gas) Generator. There are expected emissions of nitrogen oxides from the consumption of natural gas by the generator. The manufacturer specifications of the generator state a maximum of 19 mg/m^3 of NO_x emissions at 15% O_2 as shown in attachment 1. This emission concentration is at the source and is expected to have minimal impacts at receptors. N_2O emissions have been considered in the GHG assessment. The generator is designed to be operated on 100% natural gas for the commencement of the project and expected to be converted to operating with 100% hydrogen after approximately 1 year of operation.

The products of the electrolysis process are hydrogen and oxygen. The hydrogen will be pumped into the buffer store for temporary on-site storage and distribution to gas injection and the oxygen will be emitted to open air. This is not considered to be a significant risk to the surrounding health and environment.

A pipeline blowdown is required for the system to vent natural gas within the pressure system when necessary. This is not expected to be used for regular operation and is not considered a significant source of emissions.

The existing Jemena gas facility uses odorant in the natural gas. There are no new sources of odour for the proposed development. The only occurrence of odour impacts from the odorant in the natural gas would be due to an abnormal event such as a leak, which is the purpose of adding the odorant. Odour emissions from fugitive emissions have been considered to be insignificant. Odour impacts from the proposed development would not occur due to normal operations.

Emissions from the planned refuelling and dispensing station would be limited to fugitive emissions of hydrogen and are not considered significant.

The sources of emissions to air of the WSGG Project are summarised in Table 5-1.

Table 5-1: Sources of Emissions to Air

Source	Scope	Emissions	Predicted Impacts
Capstone generator	Current	Nitrogen oxides, oxygen, carbon dioxide, water vapour, fugitive natural gas and odour	Low
Electrolyser (1)	Current	Oxygen and fugitive hydrogen	Very Low
Buffer store blowdown vent	Current	Fugitive hydrogen	Very Low
Electrolyser (2)	Future	Oxygen and fugitive hydrogen	Very Low
Hydrogen refuelling & dispensing station	Future	Fugitive hydrogen	Very Low
Capstone generator (after conversion to hydrogen fuel gas operation)	Future	Fugitive hydrogen and water	Very Low

There are no sources of dust and particulates associated with the operation of the WSGG Project. However, emissions to air may occur during the construction phase of the project.

It is recommended that during the construction phase, the following mitigation measures are utilised:

- Any stock piles of earth should be covered or sprayed down with water; and
- Movement of soil or dusty material should be ceased during high wind.

6. GREENHOUSE GASES (GHG)

The following standards, sources and guidelines have been used as part of this greenhouse gas (GHG) assessment:

- Australian Standard AS ISO 14064.1: 2018– "Greenhouse gases" – "Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals";
- Department of Climate Change and Energy Efficiency, August 2019. *Australian National Greenhouse Accounts – National Greenhouse Accounts Factors*;
- Department of Climate Change and Energy Efficiency, October 2017. *National Greenhouse and Energy Reporting System Measurement – Technical Guidelines*;
- Department of Climate Change and Energy Efficiency, 2019. *Australian National Greenhouse Accounts, Quarterly Update of Australia's National Greenhouse Gas Inventory, March Quarter 2019 and*
- Greenhouse Gas Protocol, revised edition 2015. *Corporate Accounting and Reporting Standard*.

6.1 DIRECT AND INDIRECT EMISSIONS

Emissions are commonly classified as direct or indirect emissions, which are defined by the GHG Protocol as:

- Direct GHG emissions are emissions from sources within the boundary of an organisation and as a result of that organisations activities;
- Indirect GHG emissions are emissions generated in the wider economy that are a consequence of the activities of the organisation, but occur at sources owned or controlled by another entity.

Direct and indirect emissions are further categorised into three broad scopes:

- Scope 1: All direct GHG emissions;
- Scope 2: Indirect emissions from consumption of purchased electricity, heat or steam;
- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.

The operation of electrolysers, generators and refuelling stations would generate direct and indirect emissions as described in the following sub-sections.

6.1.1 Direct Emissions

Direct greenhouse gas emissions from the proposed development would be generated from the consumption of natural gas in the micro turbine generator for production of electricity. This would contribute to Scope 1 emissions.

6.1.2 Indirect Emissions

Indirect emissions can be Scope 2 or Scope 3 emissions generated by the proposed development. These include:

- Consumption of generated electricity by electrolyser (Scope 2); and
- Other indirect emissions calculated for the purposes of this assessment, limited to upstream extraction and processing of raw materials required for producing the natural gas and electricity only (Scope 3).

6.2 Estimation of GHG Emissions

Operation of the electrolyser involves activities that require energy and fuel consumption; hence there would be greenhouse gas emissions. This assessment estimates all Scope 1 and 2 GHG emissions, and also some Scope 3 emissions with the given information.

The WSGG Project equipment is expected to operate 2 hours per day, 5 days per week. For the first year of operation the microturbine generator will operate on natural gas for 6 months and then hydrogen gas for the remaining 6 months. It is noted that the operation of the generator is planned to be converted to consumption of 100% hydrogen gas within one year of operation.

All electricity used for the WSGG Project will be GreenPower from an appropriate provider. Purchased GreenPower energy has no net greenhouse gas emissions.

The GHG assessment has been based on the following assumptions:

Source	Scope	Energy Source	GHG emissions
Capstone micorturbine generator	Current	Natural gas (6 months) Hydrogen gas (6 months)	Yes
Electrolyser (1)	Current	GreenPower electricity	No
Electrolyser (2)	Future	GreenPower electricity	No
Hydrogen refuelling & dispensing station	Future	GreenPower electricity	No
Capstone generator (after conversion to hydrogen fuel gas operation)	Future	Hydrogen gas	No

One Scenario was assessed:

- Scenario 1– GHG emissions for 1 x microturbine generator with 100% consumption of natural gas for 6 months and 1 x 500 kW electrolyser;

Methodology used and results are provided in the following sub-sections.

6.2.1 Scope 1 GHG Emissions

Scope 1 greenhouse gas emissions are produced as a result of gas consumption within the generator.

The National Greenhouse Accounts (NGA) Factors, August 2019 was used to estimate the Scope 1 GHG emissions. The following formula for fuel combustion emissions of gaseous fuels was adopted:

$$E = \frac{Q \ x \ EF}{1,000}$$

Where:
E is the amount of estimated greenhouse gas in tonnes CO_2-e
Q is the annual consumption quantity of natural gas in GJ
EF is the greenhouse gas emission factor specific to fuel type in kg CO_2-e/GJ

Calculation of these emissions is estimated based on the assumptions that natural gas will be used for 6 months (maximum of 180 days) with consumption of 291.6 GJ per annum. Table 6-1 details the annual Scope 1 GHG emissions for Scenario 1.

Table 6-1: Estimated Scope 1 (Direct) Greenhouse Gas Emissions – Scenario 1

Activity	Annual Consumption (GJ/year)	Emission Factor (kg CO_{2-e}/GJ)			Annual GHG Emissions (tonnes CO_{2-e})
		CO_2	CH_4	N_2O	
Consumption of Natural Gas by Generator	291.6	51.4	0.1	0.03	15*
Total Annual Scope 1 GHG Emissions for Scenario 1					15*

Note: * Results for GHG emissions are in 2 significant figures

6.2.2 Scope 2 GHG Emissions

Scope 2 GHG emissions are associated with the consumption of purchased electricity due to the use of fuels (e.g. coal) upstream at power generation plants. Electricity is used on site for the operation of the electrolysers, refueller, and Balance of Plant (BoP) electricity use by auxiliary equipment that allows the electrolyser to function. All electricity used for the WSGG Project will be GreenPower from an appropriate provider. Purchased GreenPower energy has no net greenhouse gas emissions. As such there are considered to be no Scope 2 emissions.

6.2.3 Scope 3 GHG Emissions

Scope 3 emissions encompass a wide range of potential sources. For this facility, only a few sources have been studied in this report due to availability of information. These are emissions from the a large number of processes and a range of often diffuse sources and production, distribution and consumption processes of natural gas, and the extraction/processing of fuels burned at electricity generation plants as well as indirect emissions due to transmission and distribution (T&D) losses.

Natural Gas Scope 3 emissions

The exploration, production, transmission and distribution of natural gas to site also have associated GHG emissions. A Scope 3 emissions factor of 12.8 kg CO_2-e/GJ is provided in the NGA Factors (2019). Using the same methodology as used for Scope 1, we find that natural gas Scope 3 emissions total 4 tCO_2-e. Refer to Table 6-2 below.

Electricity Scope 3 emissions

Further GHG emissions are produced upstream of the site, due to the extraction, processing and transport of fuels to electricity power plants, as well as indirect emissions associated with compensating for transmission and distribution losses in the electricity network. However, as all electricity used for the site will be GreenPower, there is no net greenhouse gas contribution from this energy source. There are considered to be no S cope 3 emissions for electricity. .

Table 6-2: Total Estimated Scope 3 (Other Indirect) Greenhouse Gas Emissions – Scenario 1

Energy Source	Annual Consumption	Emission Factor (kg CO_{2-e}/GJ)	Annual GHG Emissions (Tonnes CO_{2-e})
Natural Gas	291.6 GJ	12.8 CO_2-e/GJ	4*
		Total Annual Scope 3 GHG Emissions	**4***

Note: *Results are in 2 significant figures

6.2.4 Summary of GHG Emissions

A summary of the above-calculated GHG emissions is shown in **Error! Reference source not found.**.

Emission Type	Annual GHG Emissions (tonnes CO_{2-e})
	SCENARIO 1
Scope 1 – Natural gas consumption of generator	15*
Scope 2 – Electricity consumption	0*
Scope 3 – Natural gas scope 3 emissions	4*
Total (Scope 1 + 2 + 3)	**19***

Note: *Results are in 2 significant figures

The total amount of greenhouse gas emissions from the proposed development is approximately 19 tonnes CO_2-e per annum. This quantity is well below the reporting thresholds under the National Greenhouse and Energy Reporting Act 2007 (NGER Act).

The estimation of emissions has been conducted based on primary activities only which include the use of natural gas. The calculations have been made based on the 2019 NGA factors, stated assumptions and also figures provided by the proponent.

It is noted that not all potential future Scope 3 sources have been due to the undetermined demand for hydrogen gas and the refuelling station. Wider Scope 3 emissions are considered to be accounted for in the Scope 1 and 2 emissions of other organisations related to the project.

Australia's total emissions in 2017 were estimated to be 534.7 Mt CO_2-e (Australian Government, DEE National Inventory Report 2017). In comparison, the estimated annual greenhouse emission for the Project is 0.000019 Mt CO_2-e. Therefore, the annual contribution of greenhouse emissions from the project in comparison to the Australian greenhouse emissions in 2017 is approximately 0.000000004%.

6.3 Measures to Reduce Greenhouse Emissions

Opportunities to reduce greenhouse gas emissions need to be considered as an ongoing objective within the site's Environmental Management Plan. Due to the changing nature of the project due to demand for hydrogen, the understanding of where the greenhouse gas emissions are generated is the first step in determining ways to reduce emission per unit of material processed.

It is noted that the operation of the generator is planned to be converted to consumption of 100% hydrogen gas within one year of operation. This would help reduce the project's greenhouse gas emission impacts.

7. SUMMARY

There are three sources of emissions to air of the current scope of the WSGG Project. These include a generator, electrolyser and a buffer store blowdown vent. The future scope of the project includes an additional electrolyser and a hydrogen refuelling and dispensing station.

The generator has minimal expected emissions of nitrogen oxides from the consumption of natural gas. The electrolysis process will be emitting oxygen to open air. This is not considered to be a significant risk to the surrounding health and environment. A pipeline blowdown is not expected for regular operation and is not considered a significant source of emissions. The existing Jemena gas facility uses odorant in the natural gas. There are no new sources of odour for the proposed development. The only occurrence of odour impacts from the odorant in the natural gas would be due to an abnormal leakage and would not occur due to normal operations. Emissions from the future scope refuelling and dispensing station would be limited to fugitive emissions of hydrogen and are not considered significant. There are no sources of dust and particulates associated with the operation of the WSGG Project. Emissions to air may occur during the construction phase of the project and measures should be taken to reduce these.

Australia's total emissions in 2017 were estimated to be 534.7 Mt CO_2-e (Australian Government, DEE National Inventory Report 2017). In comparison, the estimated annual greenhouse emission for the Project is 0.000019 Mt CO_2-e for the current scope of the project. Therefore, the annual contribution of greenhouse emissions from the current project in comparison to the Australian greenhouse emissions in 2017 is approximately 0.00000004%.

8. CONCLUDING REMARKS

The air quality impacts from the proposed Power to Gas project '*Western Sydney Green Gas Project (WSGG Project)'* are expected to be very low and will not cause a negative impact on the health and environment of the surrounding area.

This concludes the report.

K Barker
Environmental Scientist

R T Benbow
Principal Consultant

9. LIMITATIONS

Our services for this project are carried out in accordance with our current professional standards for site assessment investigations. No guarantees are either expressed or implied.

This report has been prepared solely for the use of Eco Logical Australia Pty Ltd, as per our agreement for providing environmental services. Only Eco Logical Australia Pty Ltd is entitled to rely upon the findings in the report within the scope of work described in this report. Otherwise, no responsibility is accepted for the use of any part of the report by another in any other context or for any other purpose.

Although all due care has been taken in the preparation of this study, no warranty is given, nor liability accepted (except that otherwise required by law) in relation to any of the information contained within this document. We accept no responsibility for the accuracy of any data or information provided to us by Eco Logical Australia Pty Ltd for the purposes of preparing this report.

Any opinions and judgements expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal advice.

ATTACHMENTS

Attachment 1: Manufacturers Specifications for Generator

C65 Microturbine

High-pressure Natural Gas

Capstone

Achieve ultra-low emissions and reliable electrical generation from natural gas.

- Ultra-low emissions
- One moving part – minimal maintenance and downtime
- Patented air bearings – no lubricating oil or coolant
- Integrated utility synchronization – no external switchgear
- Compact modular design allows for easy, low-cost installation
- Multiple units easily combined – act as single generating source
- Remote monitoring and diagnostic capabilities
- Proven technology with tens of millions of operating hours
- Various Factory Protection Plans available

C65 Microturbine

Electrical Performance(1)

Electrical Power Output	65kW
Voltage	400/480 VAC
Electrical Service	3-Phase, 4 Wire Wye
Frequency	50/60 Hz
Electrical Efficiency LHV	29%

Fuel/Engine Characteristics(1)

Natural Gas HHV	30.7–47.5 MJ/m^3 (825–1,275 BTU/scf)
Inlet Pressure	517–551 kPa gauge (75–80 psig)
Fuel Flow HHV	888 MJ/hr (842,000 BTU/hr)
Net Heat Rate LHV	12.4 MJ/kWh (11,800 BTU/kWh)

Exhaust Characteristics(1)

NOx Emissions @ 15% O_2	< 9 ppmvd (19 mg/m^3)
Exhaust Mass Flow	0.49 kg/s (1.08 lbm/s)
Exhaust Gas Temperature	309°C (588°F)

Dimensions & Weight(2)

Width x Depth x Height(3)	0.76 x 1.95 x 1.91 m (30 x 77 x 75 in)
Weight - Grid Connect Model	758 kg (1,671 lb)
Weight - Dual Mode Model	1,121 kg (2,471 lb)

Minimum Clearance Requirements[4]

Horizontal Clearance	
Left & Right	0.76 m (30 in)
Front - Grid Connect Model	0.76 m (30 in)
Front - Dual Mode Model	1.65 m (65 in)
Rear	0.91 m (36 in)

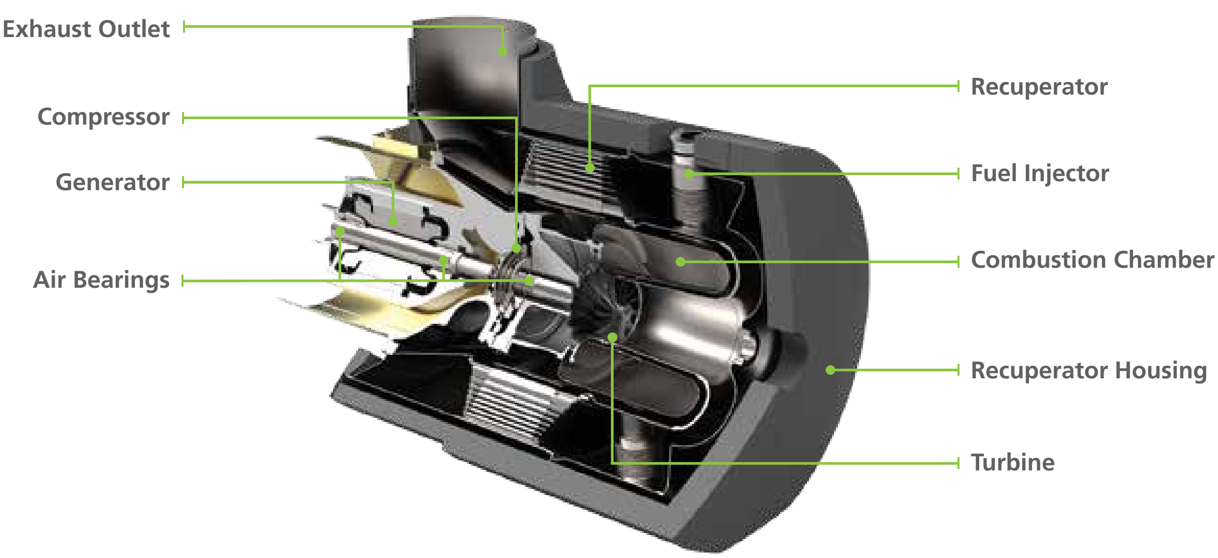
Acoustic Emissions

Nominal at Full Power at 10 m (33 ft)[5]	70 dBA

Certifications

- UL 2200 Listed
- CE Certified
- Certified to the following grid interconnection standards: UL 1741, VDE, and BDEW
- Compliant to California Rule 21

C65 Engine Components



(1) Nominal full power performance at ISO conditions: 15°C (59°F), 14.696 psia, 60% RH
(2) Approximate dimensions and weights
(3) Height dimensions are to the roofline. Exhaust stack extends at least 178 mm (7 in) above the roofline
(4) Clearance requirements may increase due to local code considerations
(5) The optional acoustic inlet hood kit can reduce acoustic emissions at the front of the Microturbine as much as 5 dBA

Specifications are not warranted and are subject to change without notice.

21211 Nordhoff Street | Chatsworth, CA 91311 | 866.422.7786 818.734.5300
 P0516 C65 Natural Gas Data Sheet CAP139 | Capstone P/N 331035A
www.capstoneturbine.com

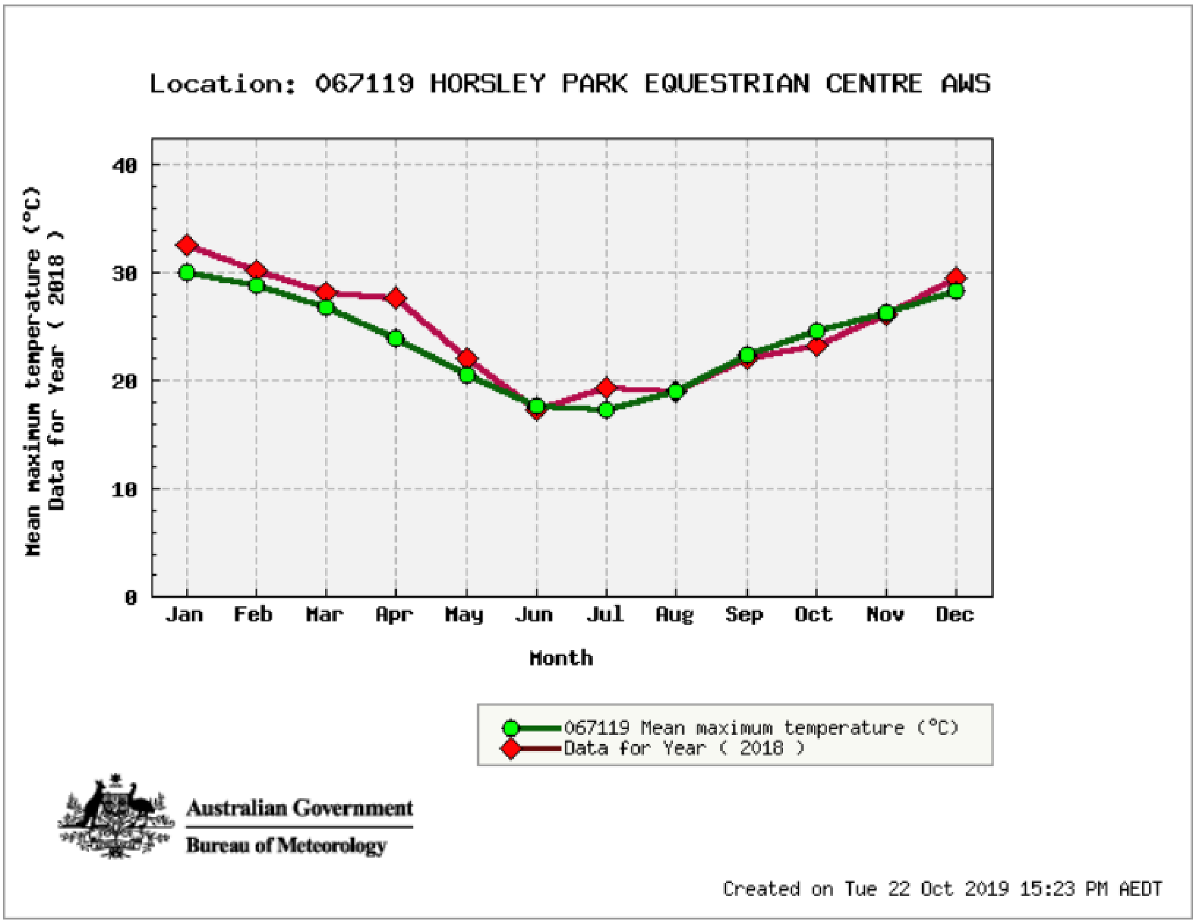
Attachment 2: Horsley Park Equestrian Centre AWS weather comparison of 2014-2018

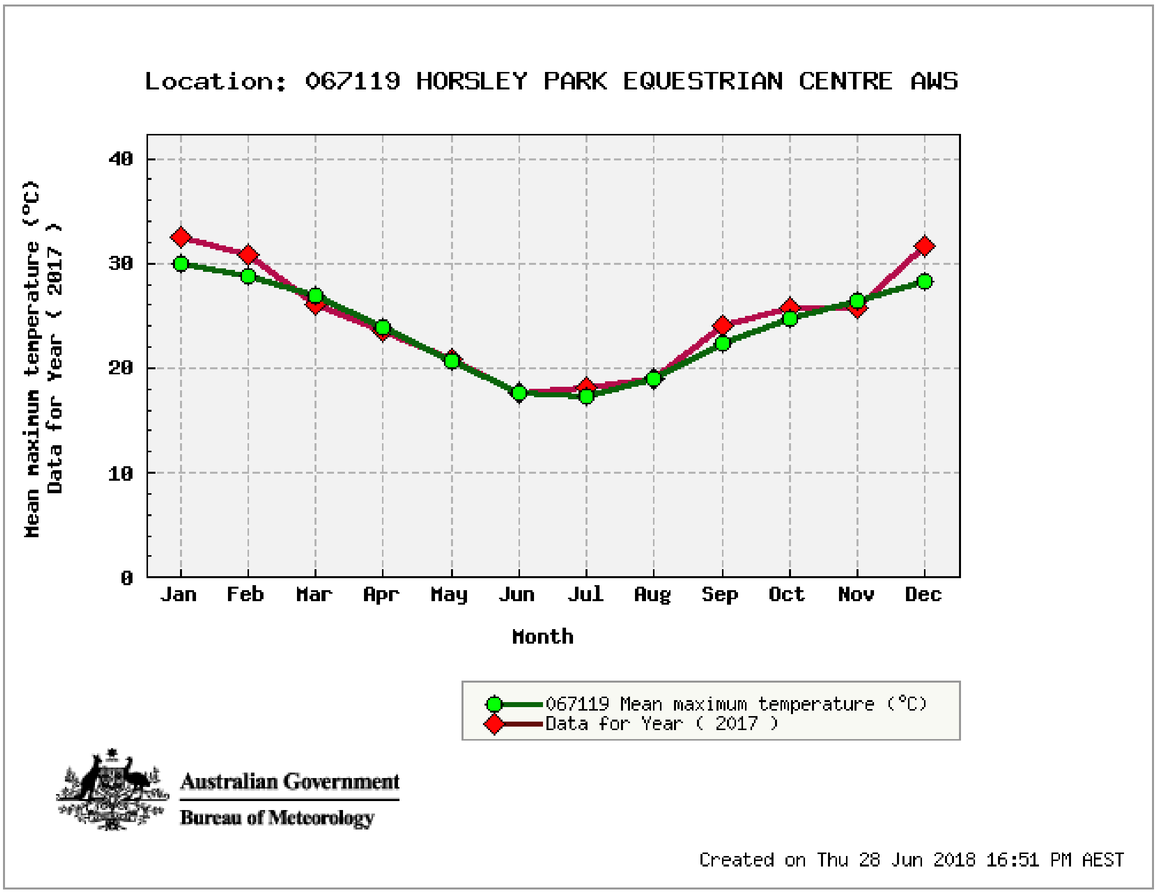
Representative Year

We have selected 2015 as the most representative year for weather after examination of the five years preceding 2018.

The mean maximum temperatures of 2015 and 2014 follow the overall trend very closely in comparison with the other years, with 2017 being the most different. Mean minimum temperatures for 2013 and 2014, respectively, were most similar to the overall trend. Still, 2015 and 2014 were quite close to the trend but 2017 was again the most different. However, mean daily wind run data was incomplete for all years except 2015 and 2013. As these two years were similarly representative of the overall trend, 2015 was chosen due to being the most recent and therefore most temporally representative.

Mean Maximum Temperature




Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean maximum temperature (°C)
Data for Year (2017)
40
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067119 Mean maximum temperature (°C)
Data for Year (2017)
Australian Government
Bureau of Meteorology
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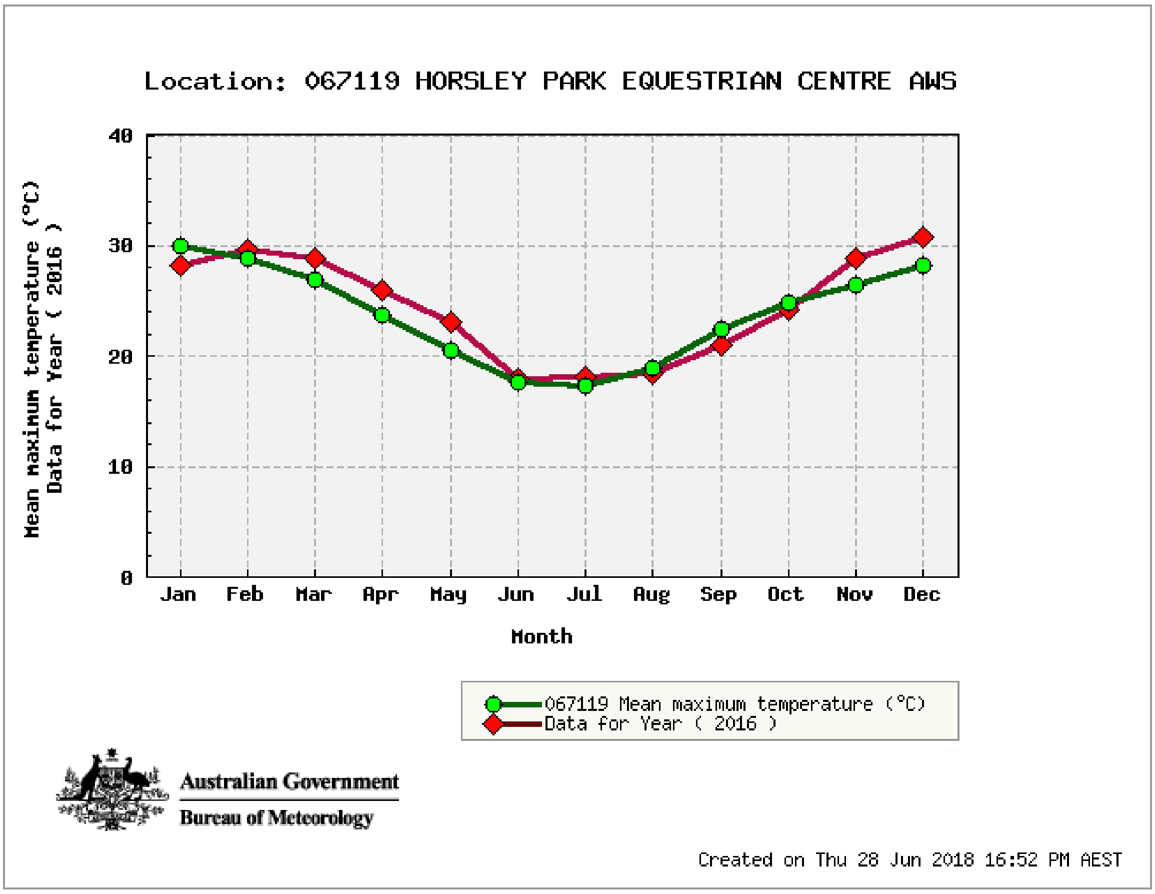
Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean maximum temperature (°C)
Data for Year (2016)
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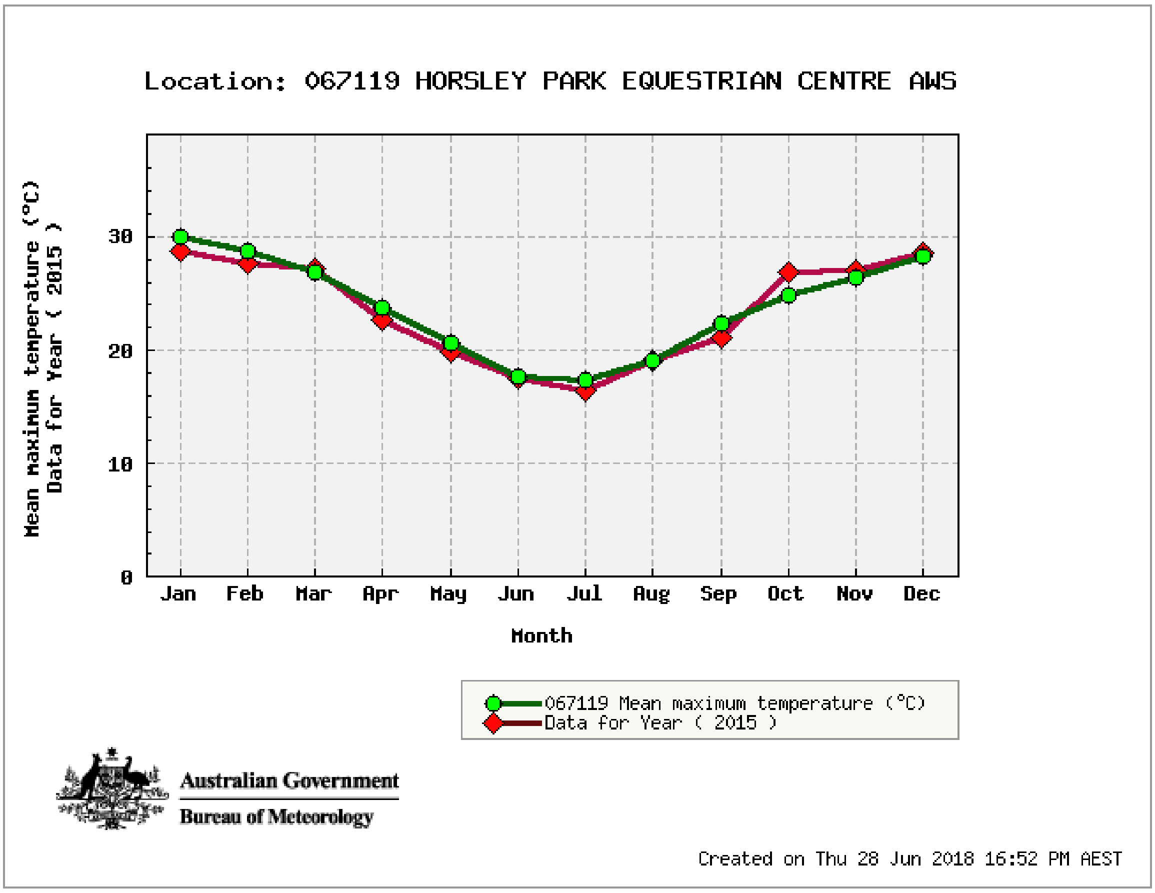
067119 Mean maximum temperature (°C)
Data for Year (2016)
Australian Government
Bureau of Meteorology
Created on Thu 28 Jun 2018 16:52 PM AEST



Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean maximum temperature (°C)
Data for Year (2015)
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067119 Mean maximum temperature (°C)
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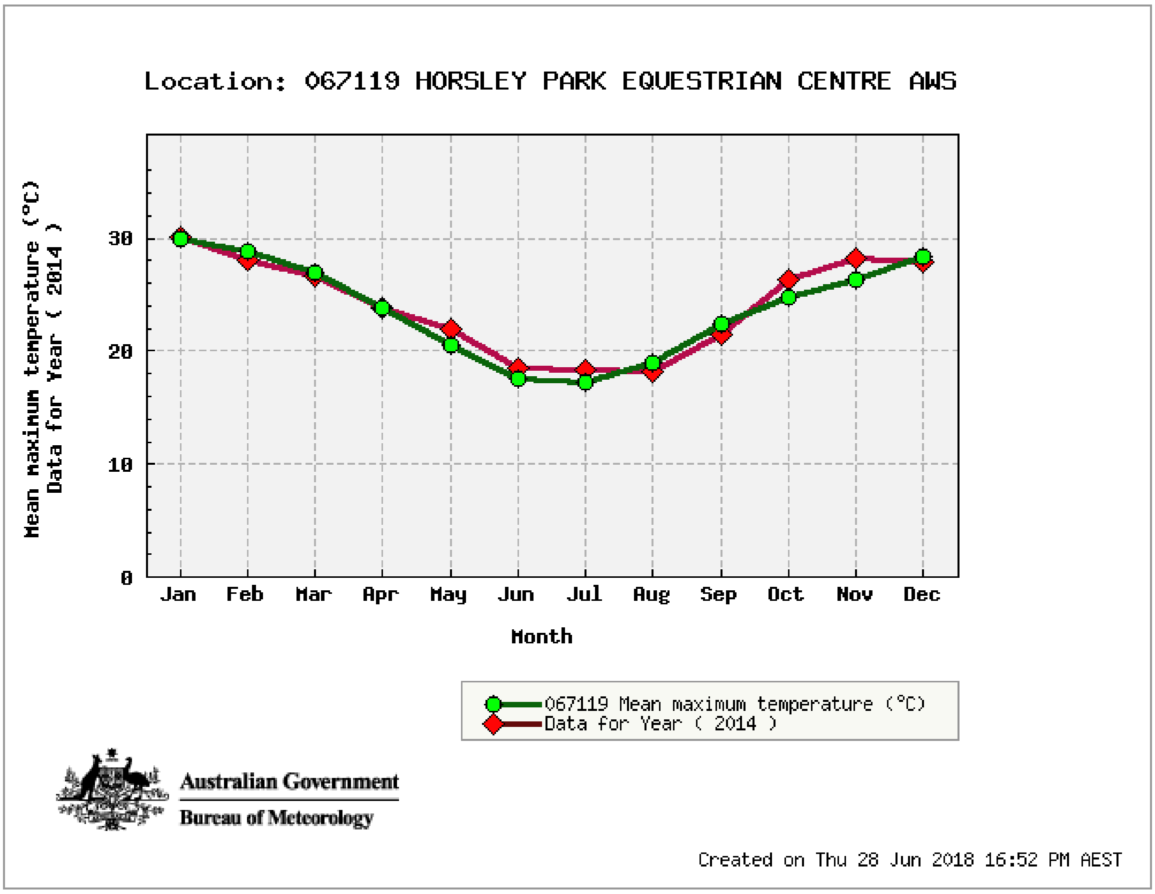

Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean maximum temperature (°C)
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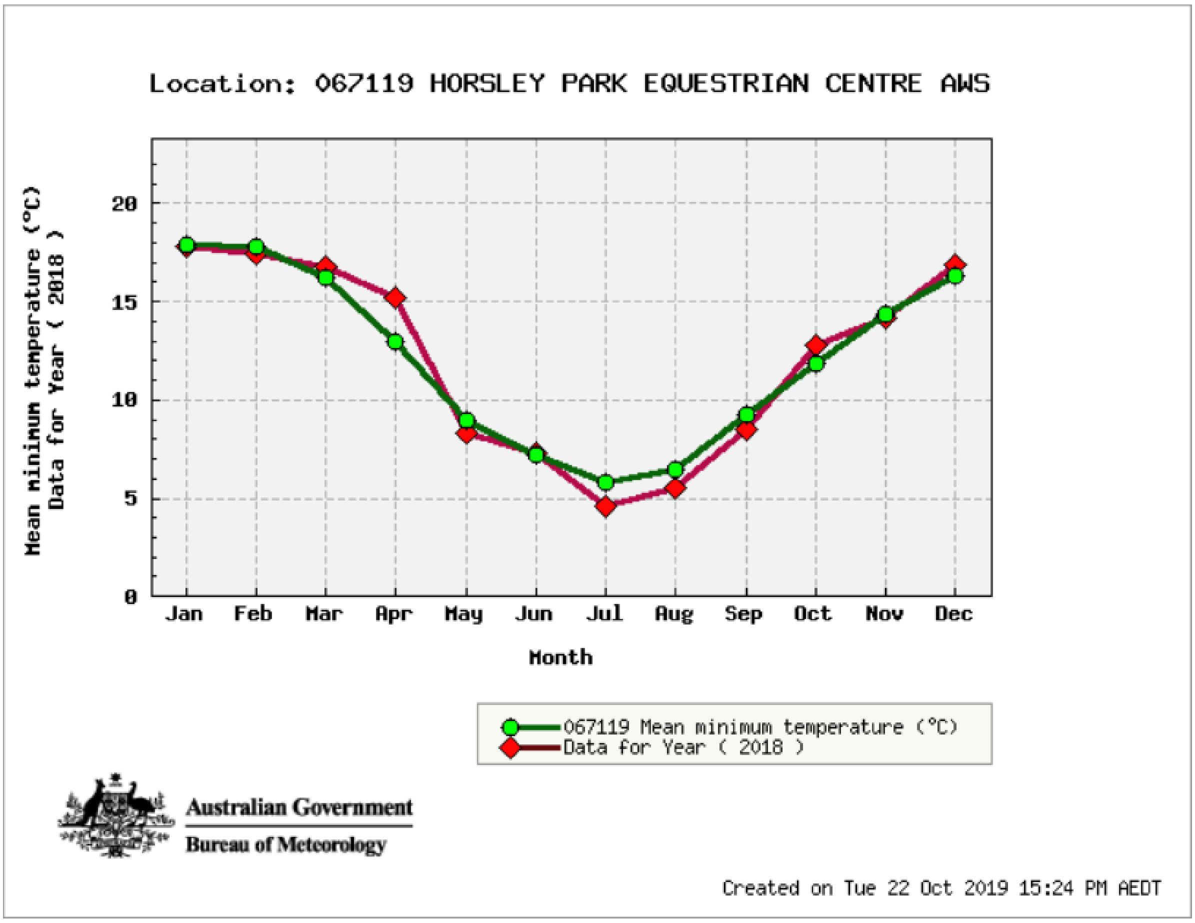
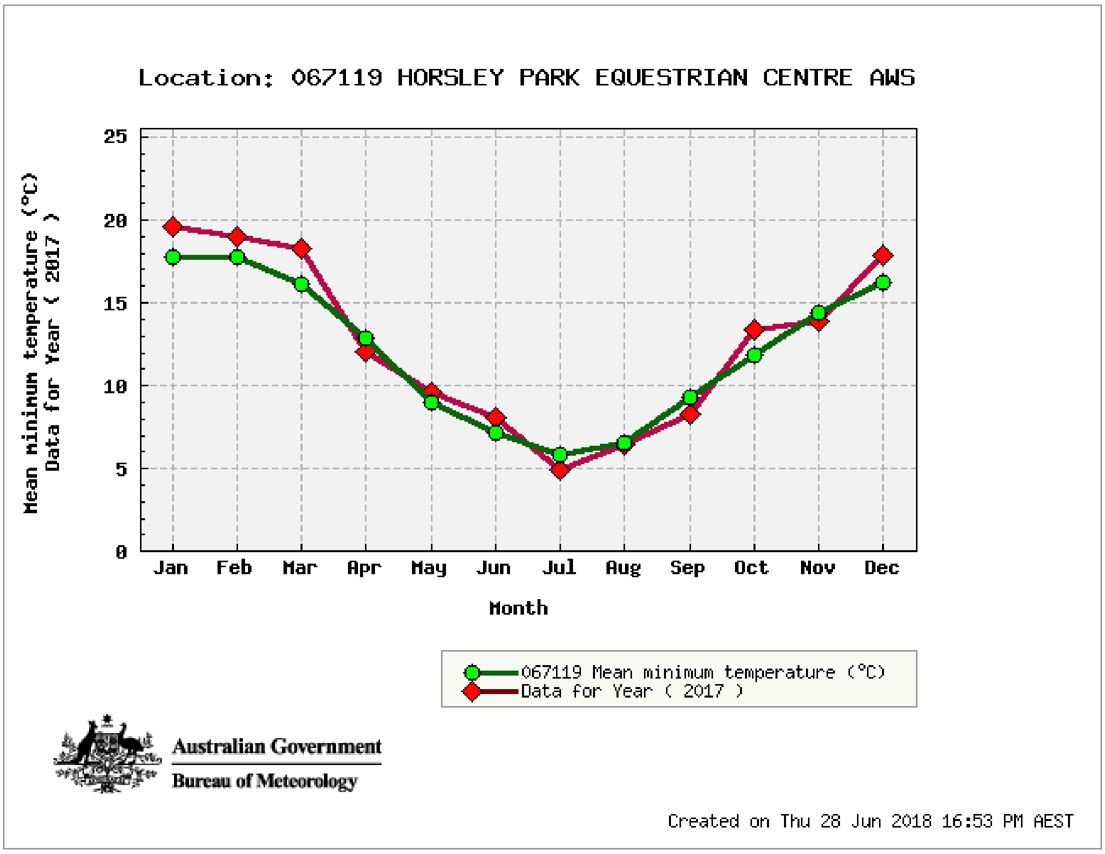
067119 Mean maximum temperature (°C)
Data for Year (2014)
Australian Government
Bureau of Meteorology
Created on Thu 28 Jun 2018 16:52 PM AEST

Mean Minimum Temperature




Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean minimum temperature (°C)
Data for Year (2017)
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067119 Mean minimum temperature (°C)
Data for Year (2017)
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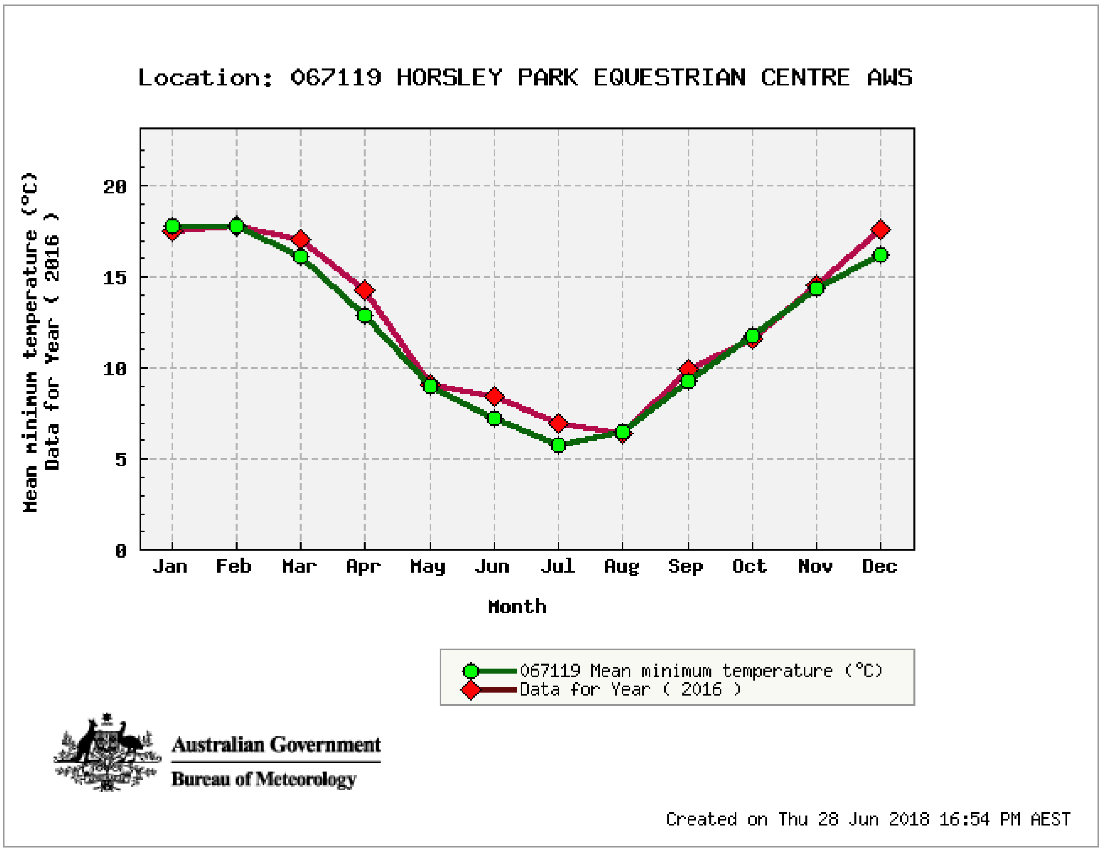
Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean minimum temperature (°C)
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067119 Mean minimum temperature (°C)
Data for Year (2016)
Australian Government
Bureau of Meteorology
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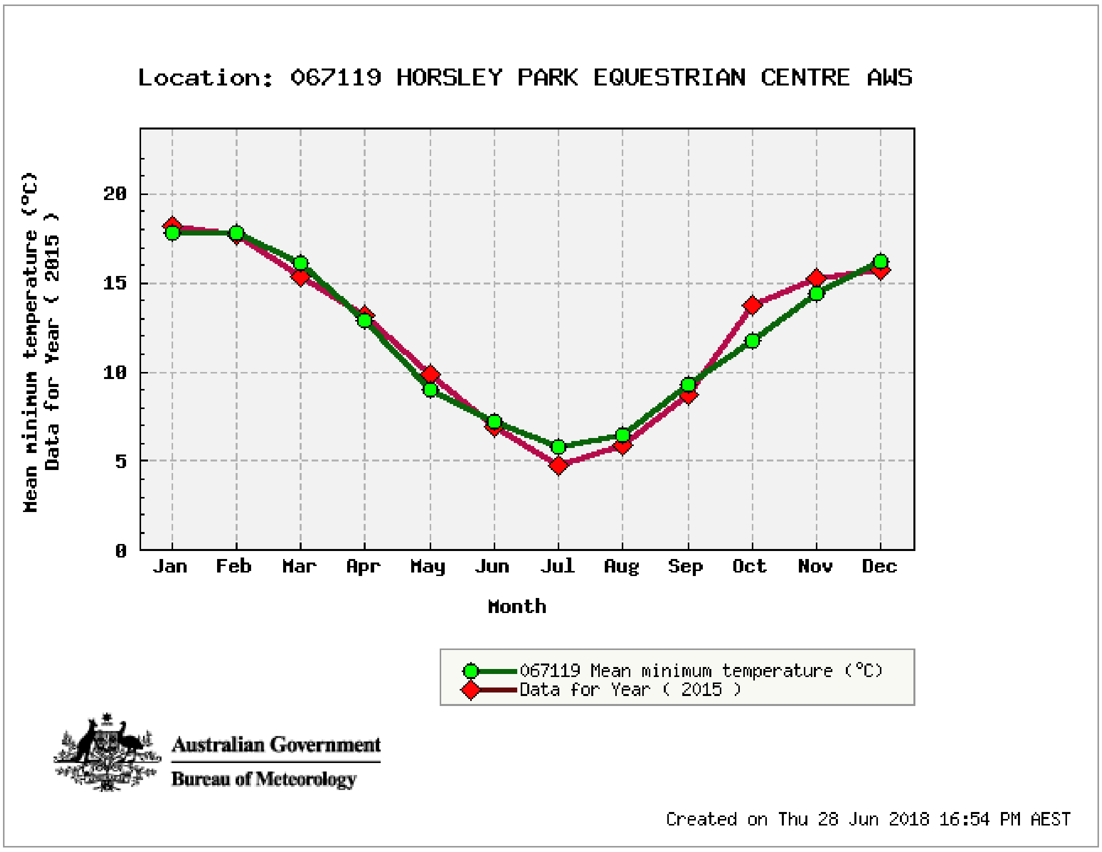

Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean minimum temperature (°C)
Data for Year (2015)
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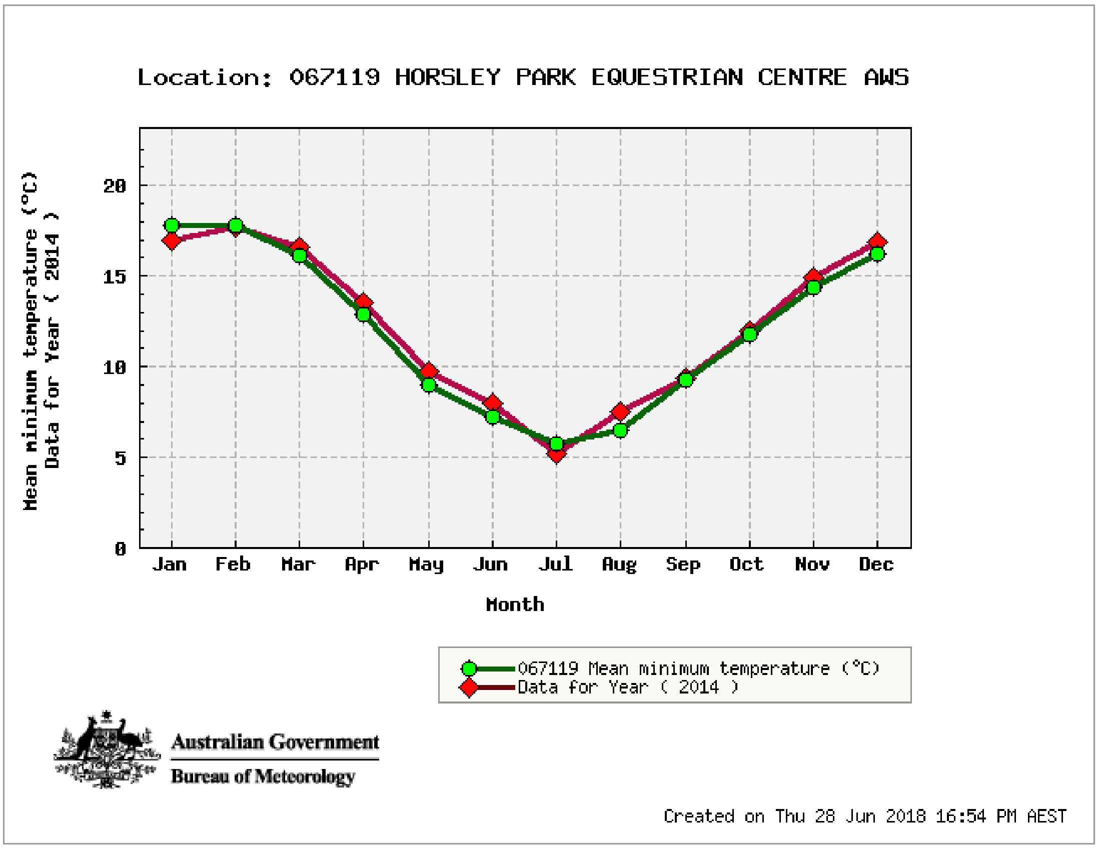
067119 Mean minimum temperature (°C)
Data for Year (2015)
Australian Government
Bureau of Meteorology
Created on Thu 28 Jun 2018 16:54 PM AEST



Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean minimum temperature (°C)
Data for Year (2014)
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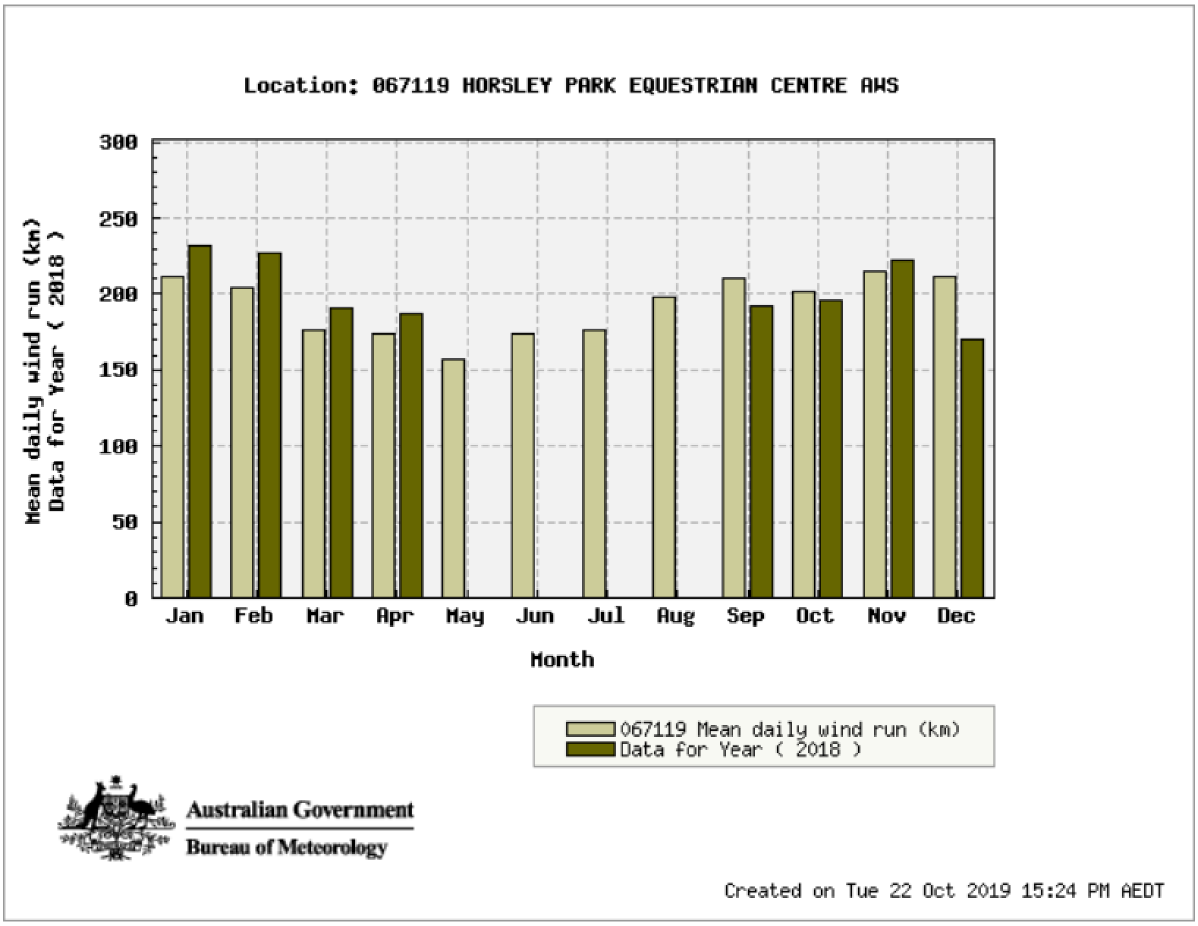
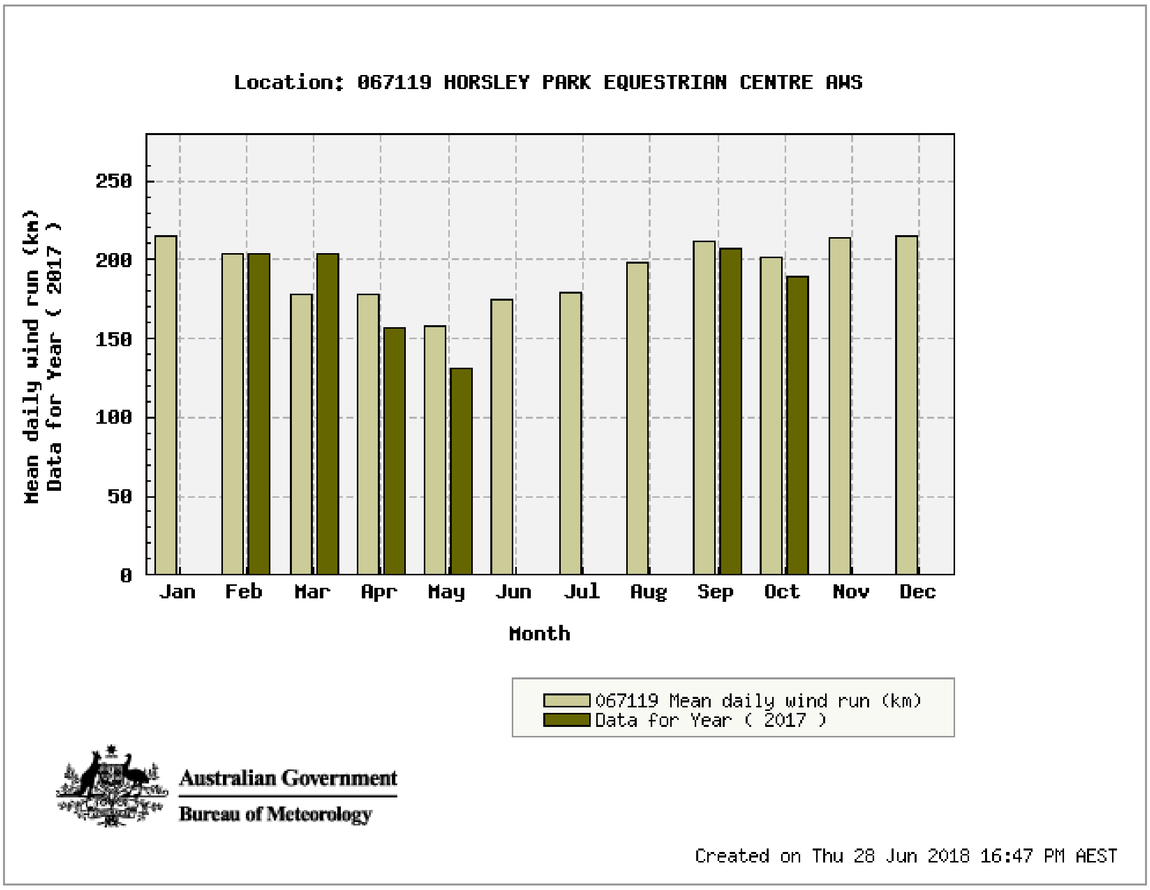
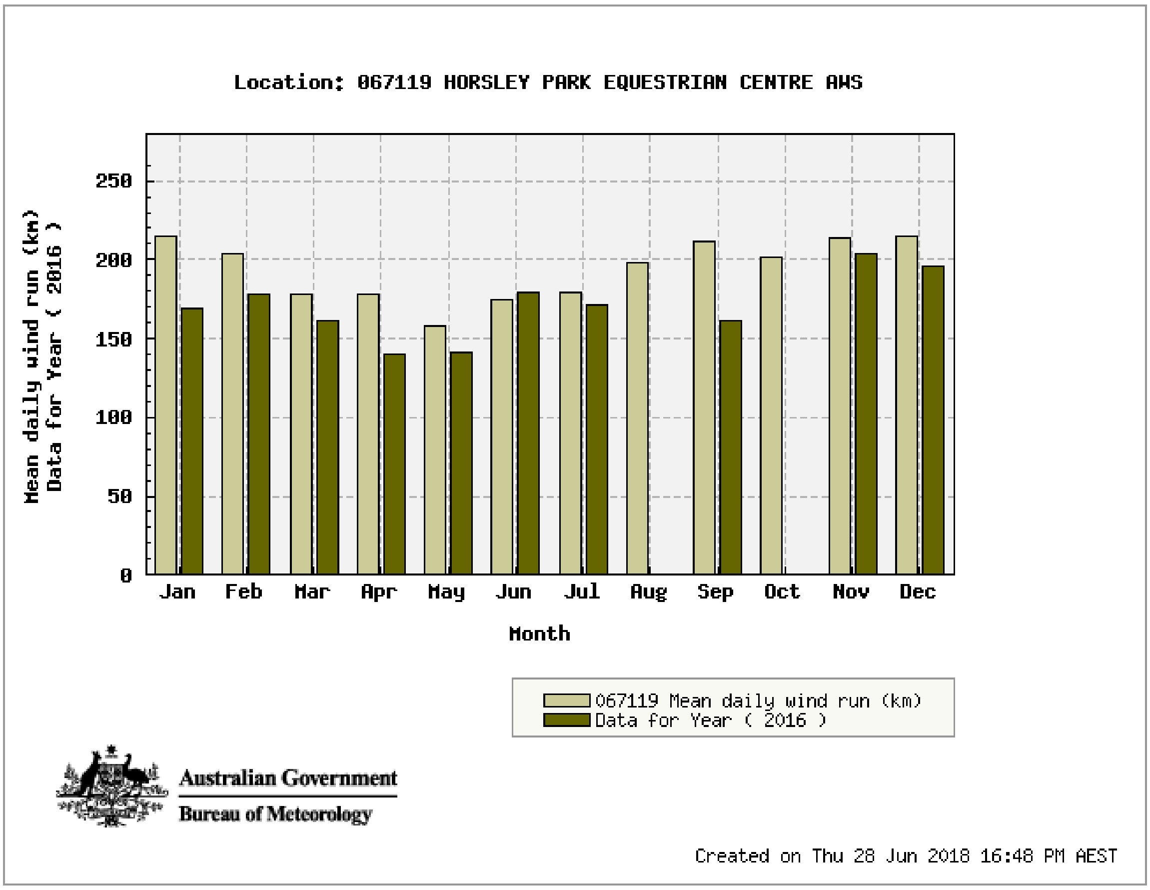
Month
067119 Mean minimum temperature (°C)
Data for Year (2014)
Australian Government
Bureau of Meteorology
Created on Thu 28 Jun 2018 16:54 PM AEST

Mean Daily Wind Run





Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean daily wind run (km)
Data for Year (2017)
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
067119 Mean daily wind run (km)
Data for Year (2017)
Australian Government
Bureau of Meteorology
Created on Thu 28 Jun 2018 16:47 PM AEST



Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean daily wind run (km)
Data for Year (2016)
250
200
150
100
50
0
Jan
Feb
Mar
Apr
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Jul
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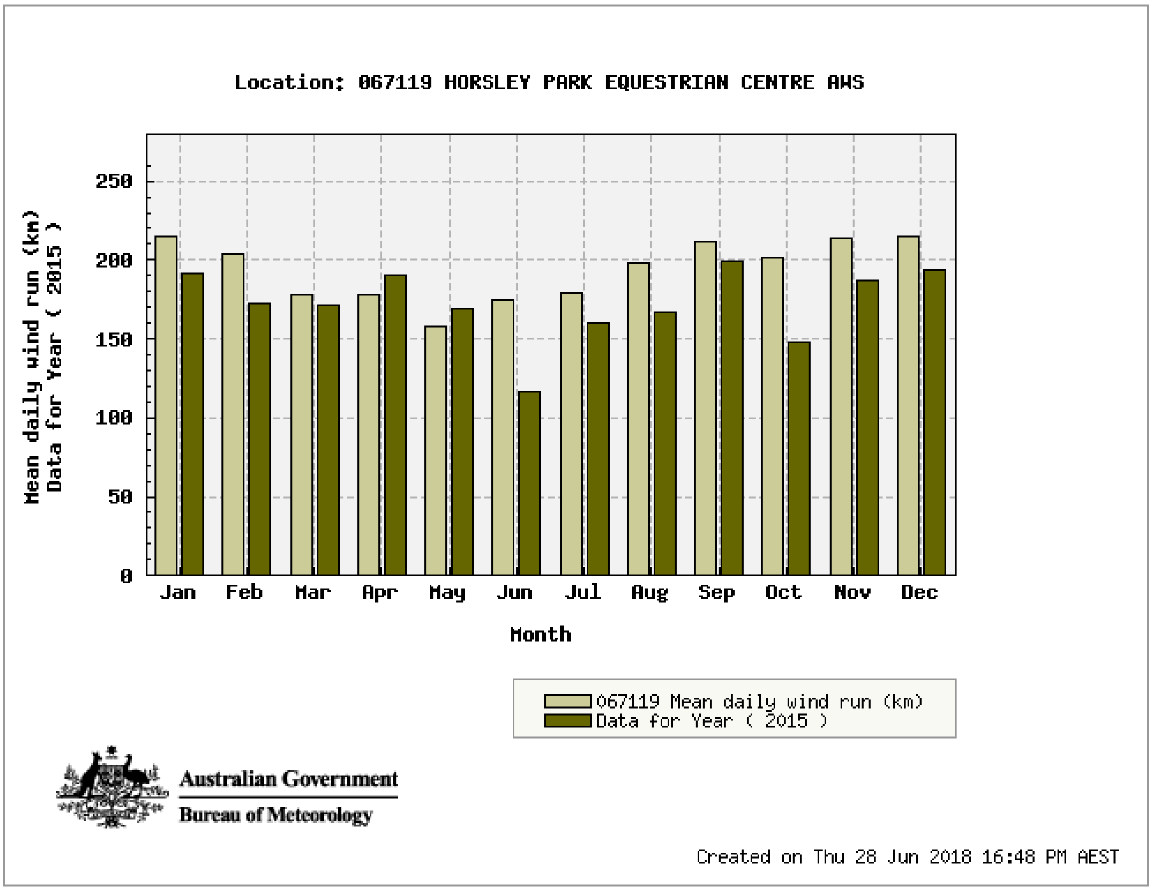
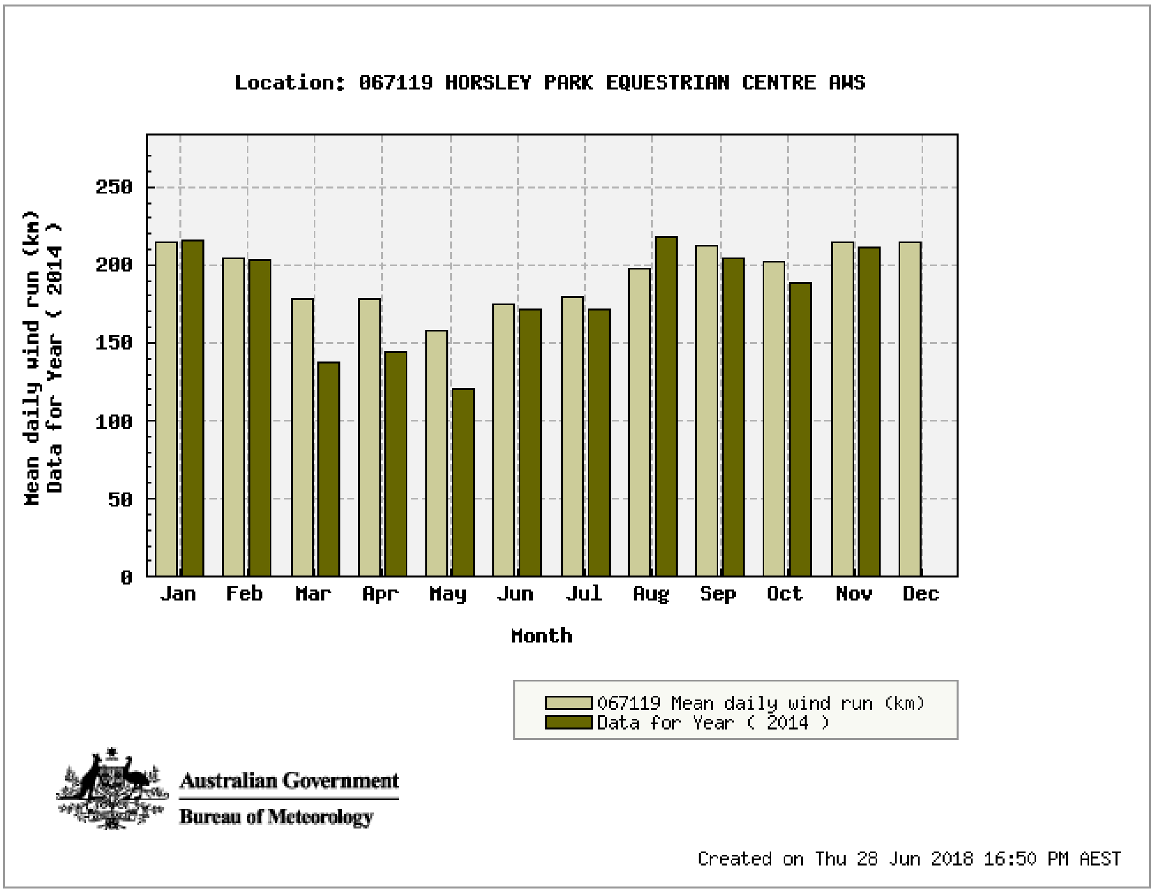
Month
067119 Mean daily wind run (km)
Data for Year (2016)
Australian Government
Bureau of Meteorology
Created on Thu 28 Jun 2018 16:48 PM AEST



Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean daily wind run (km)
Data for Year (2015)
0
50
100
150
200
250
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
067119 Mean daily wind run (km)
Data for Year (2015)
Australian Government
Bureau of Meteorology
Created on Thu 28 Jun 2018 16:48 PM AEST



Location: 067119 HORSLEY PARK EQUESTRIAN CENTRE AWS
Mean daily wind run (km)
Data for Year (2014)
0
50
100
150
200
250
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
067119 Mean daily wind run (km)
Data for Year (2014)
Australian Government
Bureau of Meteorology
Created on Thu 28 Jun 2018 16:50 PM AEST

Appendix H Downstream Impact Assessment

GPA ENGINEERING

Downstream Impacts Report

Jemena - Detailed Design for Hydrogen Generation (Western Sydney Green Gas Trial)

Jemena Ltd

Jemena Document No: PG2-2099-RP-RM-004

Rev	Date	By	Checked	QA	Description
0	08/11/2019	DK	JHW	IIK	Issued for use
			JHW		

CONTENTS

1 OVERVIEW

1.1 PROJECT BACKGROUND

Jemena Gas Networks is the asset owner of the Horsley Park high pressure gas facilities, comprised of a number of pressure letdown and pipeline pigging facilities, for the Eastern Gas Pipeline (EGP) pipeline, Jemena Gas Network (JGN) Trunk, Sydney Primary Loop and local secondary network, located on Chandos Road in Horsley Park, NSW.

Figure 1 provides an overview of the location of the Jemena Sydney secondary mains network.

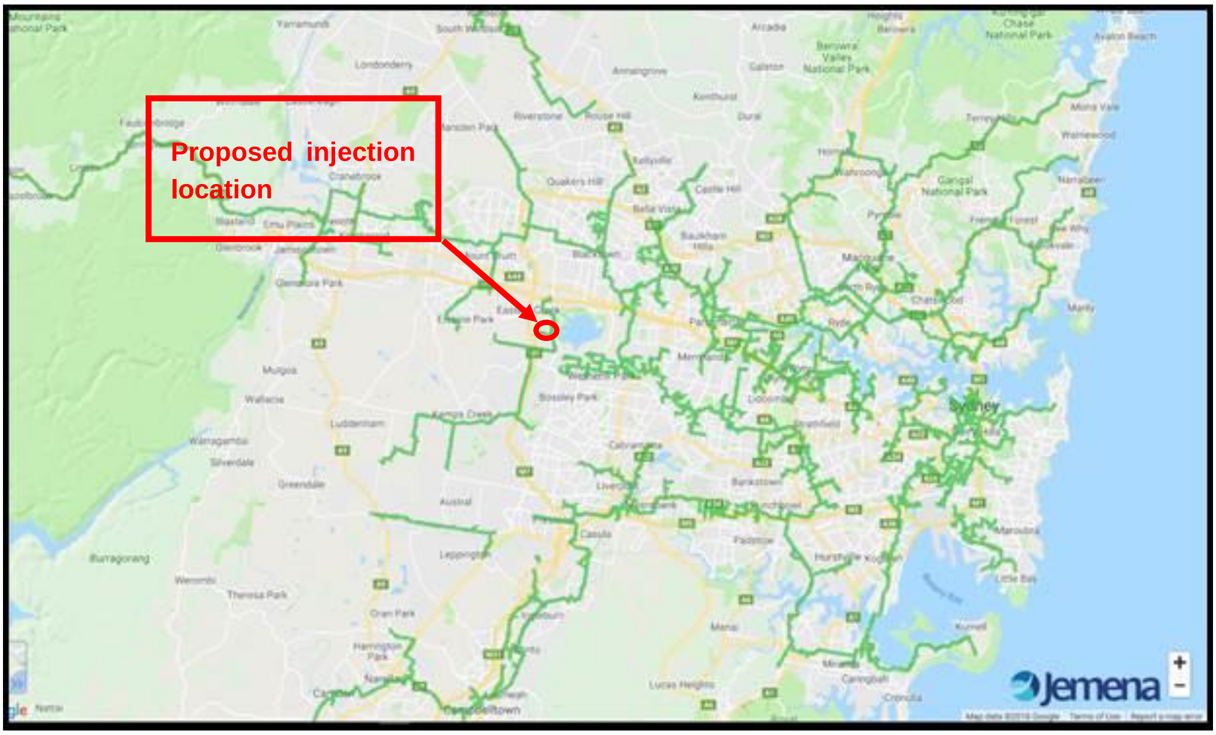


Figure 1 Network layout of the Sydney Secondary Mains network

The uptake in renewable power generation, coupled with growing demand for decarbonising of energy sectors in Australia, presents a series of challenges and opportunities to the gas transmission and distribution network in NSW.

Jemena, as the sole owner of the network, seeks to understand and develop technologies that allow for a transition to a low or zero carbon gas network, whilst delivering a competitive and sustainable consumer product. Jemena believes that multiple technologies will be required, one of which is known as Power to Gas, or P2G.

The objective of the WSGGT project is to test and demonstrate power to gas (P2G) technology in the gas distribution network. This will help facilitate the development of commercially viable systems in the future.

The project comprises the construction of a P2G hydrogen production facility at Jemena’s Horsley Park High Pressure Gas Facility for supply of hydrogen gas to the natural gas distribution network, generation of power from hydrogen. The P2G facility will perform the following key functions:

- Convert mains water into hydrogen gas using grid electricity through electrolysis;
- Store hydrogen gas in a buried on-site carbon steel pipeline; this will be used for backup hydrogen gas supply and injection management;

- Control and safely manage hydrogen gas pressures, temperatures and flow rates for injection into Jemena's Sydney Secondary Mains gas pipeline network; and
- Provide hydrogen to a microturbine generator to convert stored hydrogen into electrical energy to generate power back to the grid.

The project may also consider on-site hydrogen bus refuelling. This would include a locally operated hydrogen compressor and dispenser system and vehicle turnaround adjacent to the Jemena Horsley Park Meter Station.

1.2 DOCUMENT PURPOSE

The purpose of this report is to identify the impacts to the distribution network downstream of the injection point at the Horsley Park Trunk Receiving Station. This includes the Sydney Secondary Mains distribution network, including the downstream medium and low pressure mains:

- Hydrogen of up to 2% (by volume), the target injection percentage, is added to the natural gas mixture.
- Hydrogen of up to 10% (by volume) is temporarily released into the network. This scenario is only possible during failure of the hydrogen injection flow control valve and coincident low flow of natural into the Secondary Mains. A shutdown has been included in the design to isolate hydrogen injection in the event of low natural gas flow for a predetermined setpoint to limit volume to less than 10%.

The assessment includes analysis of the impacts of a hydrogen blend on the following:

- **Network materials**; including the carbon steel Secondary Mains and downstream polyethylene, nylon, cast iron, and carbon steel low pressure and medium pressure mains.
- **Gas composition & quality**; including assessment against the requirements and limits of AS4564 and analysis of the change in properties introduced by the blend.
- **Safety**; including impact on gas build-up in buildings, radiation distance and odorisation.

This document also addresses the Environmental Assessment Requirements to "*provide verification that natural gas injected with a specified quantity of hydrogen can comply with Australian Standard 4564: Specification for general purpose natural gas and that this gas will not adversely impact pipeline integrity and safety*".

Management of the impacts will be further assessed independently to this report in Jemena's Safety and Operating Plan (SAOP). This includes further assessment of **Downstream user appliance operation**; including domestic, commercial and industrial cases.

2 PREVIOUS STUDIES & CURRENT RESEARCH

A number of international projects and studies have assessed various impacts of hydrogen blending with existing natural gas distribution networks. Additionally there are a number of research programs underway, including the FFCRC in Australia. This section provides a high level summary of these relevant projects and the FFCRC research program.

2.1 INTERNATIONAL PROJECTS

2.1.1 HyDeploy

Of particular relevance to this study is the HyDeploy study being undertaken in the UK. HyDeploy is a pioneering hydrogen energy project to reduce UK carbon dioxide CO_2 emissions. Its aim is to investigate if blending up to 20% hydrogen with natural gas is feasible in reducing CO_2 emissions from home cooking and heating, without changing customer appliances.

As part of the HyDeploy, UK safety case exemption for the live pilot testing of a small private network of 100 homes for a 20% hydrogen natural gas blend has been approved and injection is scheduled for commencement in September 2019.[1] The approval for undertaking the live test was based on a submission that tabled evidence that the proposed hydrogen-natural gas blend was “as safe as” natural gas. The submission included specific investigation and findings including the following:

1. Short term appliance behaviour;
2. Long term appliance behaviour;
3. Effect of hydrogen blend on materials;
4. Risks of poor mixing;
5. Fire and explosion risk;
6. Hydrogen detection; and
7. Customer perception.

This body of work is a useful reference for developing a frame work setting criteria for injecting hydrogen into an existing low pressure gas distribution network. In this body of work a quantitative risk assessment covering appliances, their installation and impact on detectability of leaking gas was completed comparing the risks associated with a hydrogen blended and unblended consumer gas installations.

2.1.2 H21 Leeds City Gate and H21 North of England

The H21 Leeds City Gate project is a study aimed at determining the feasibility, from both a technical and economic viewpoint, of converting the existing natural gas network in Leeds, one of the largest UK cities, to 100% hydrogen.[2] The project was designed to minimise disruption for existing customers, and to deliver heat at the same cost as current natural gas to customers.

The project has shown that:

- The gas network has the correct capacity for such a conversion;
- It can be converted incrementally with minimal disruption to customers;
- Minimal new energy infrastructure will be required compared to alternatives; and
- The existing heat demand for Leeds can be met via steam methane reforming and salt cavern storage using technology in use around the world today.

[1] (Isaac, 2019)
[2] (Sadler, 2016)

The H21 Leeds City Gate project later became H21 North of England (H21 NoE), with a broader scope and the aim of transitioning the gas networks across the North of England to hydrogen. H21 NoE is a detailed engineering solution for converting gas distribution networks to 100% hydrogen between 2028 and 2034, with potential scope for further decarbonisation of the UK networks by 2050[3].

2.2 RESEARCH PROGRAMS (AUSTRALIA)

2.2.1 Future Fuels Cooperative Research Centre (FFCRC)

The Future Fuels CRC will develop solutions for gas networks to use hydrogen today and well into the future. Collaborating with over 60 companies, 6 universities, and several progressive regulators, the FFCRC is delivering three interdisciplinary research programs, as well as comprehensive education & training program involving 48 PhD students.

Research Program 1 focuses on the understanding of the technical, commercial and market barriers to, and opportunities for, the use of hydrogen.

Research Program 2 studies the social and policy context, including public acceptance and safety, for technology and infrastructure associated with hydrogen.

Research Program 3 identifies and addresses gaps in relevant Australian industry codes and standards associated with design, construction and operation of gas networks.

A number of projects

2.3 HISTORICAL HYDROGEN USE IN NETWORKS

Until the 1970s town gas was used in the gas distribution networks rather than the currently used natural gas.[4] Town gas, also known as ‘syngas’ or ‘coal gas’, used coal or oil as the feedstock to produce an impure gas that was comprised of carbon monoxide, methane, hydrogen, carbon dioxide and other constituents. The final composition used in the network was dependant on the feedstock used and the process used.

High levels of hydrogen were found in town gas which was used in the gas distribution network. It was common to see hydrogen concentrations of 30% or above in the network which, at that stage, included a high proportion of pipelines constructed of cast iron.

Singapore Gas Company (City Gas) is currently the sole producer and retailer of low-pressure pipe town gas in Singapore. The hydrogen content limit set-out in City Gas guidelines is currently between 41-65% hydrogen.[5] A high hydrogen content town gas has been operating in Singapore since 1861.

[3] (Sadler & Solgaard Anderson, 2018)
[4] Transition to natural gas commenced in 1969 and was progressive over the following decades.
[5] (City Gas, 2017)

3 JEMENA NETWORK

The following section provides an overview of the Jemena Sydney natural gas distribution network.

3.1 SYDNEY SECONARY MAINS GAS NETWORK

Jemena own and operate the Sydney Secondary Mains network. The network directly or indirectly supplies gas to over 900,000 domestic and industrial customers across Sydney region.

3.2 DESIGN STANDARDS

The secondary mains network is designed to the following standards:

- AS/NZS 4645 Series – Gas Distribution Networks – Parts 1, 2, and 3
- AS/NZS 4809 – Copper Pipes
- AS 4564 – Specification for Natural Gas
- AS/NZS 5601.1 – Gas Installations – General Installations (downstream of the consumer billing meter)

3.3 KEY REFERENCE DOCUMENTS

Table 1 Reference Documents

Item	Title	Document Number	Date
1	Jemena Gas Networks – Asset Management Plan 2019-2025	GAS-999-PA-IN-001	31 May 2019
2	Safety Case (SAOP) of Jemena Gas Assets (NSW)	GAS-999-PA-HSE-002	1 May 2018

3.4 CONFIGURATION

3.4.1 Network Overview

Figure 2 shows the configuration of Jemena's NSW JGN gas distribution network.

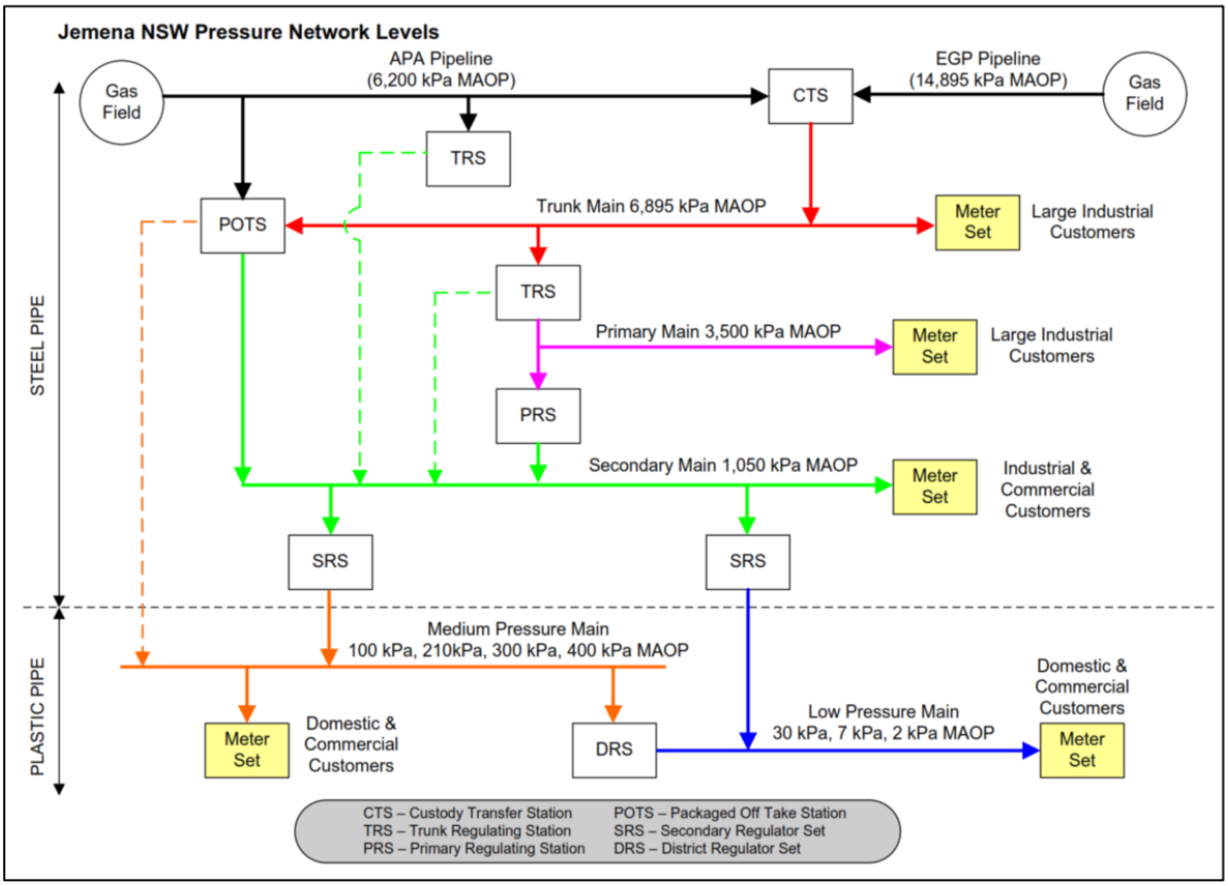


Figure 2 Jemena Sydney network overview

The hydrogen injection location is located immediately downstream of the Primary Regulator Station (PRS) in the common outlet header at the inlet to the Secondary Mains at Horsley Park, as shown indicatively in Appendix 1A.

3.4.2 Secondary Mains

The Secondary Mains is supplied with natural gas from either the Cooper Basin via the Moomba to Sydney Pipeline (MSP) or from the Gippsland Basin in Victoria via the Eastern Gas Pipeline (EGP). The Secondary Mains provide gas to the downstream medium and low pressure distribution networks and also directly supply a number of larger industrial and commercial customers.

The gas supply from the EGP is regulated at the Horsley Park with a series of pressure reduction facilities that also with the final inlet to the mains downstream of the Pressure Reducing Station (PRS). The supply from the MSP is provided from various gas regulation facilities at Packaged Off Take Stations (POTS) for Jemena's regional country networks. As part of the SAOP revision Jemena intend to complete flow modelling to further assess how far the blended hydrogen may travel within their network and likelihood of further dilution.

The Secondary Mains is a carbon steel pipeline system operating with an MAOP of 1,050 kPag and minimum pressure of 545 kPag with a diameter range of 50mm to 450mm. The Secondary Mains consists of approximately 1,450 km of carbon steel linepipe, either API 5L Grade B or API 5L Grade

X42, constructed in the 1960s, coated in HDPE or Tri-laminate / FBE for more recent sections, post 2012, and internally lined to reduce friction losses. The network includes approximately 10km of 250mm HDPE (SDR9 PE100) secondary pipe inserted into a 350mm steel main, constructed in 2011. Sections are laid through High Density Community Use (HDCU) areas.

The system is operated and maintained in accordance with AS/NZS 4645.

3.4.3 Medium & Low Pressure Mains

Supply from the Secondary Mains to the downstream medium and low pressure mains are via District Regulator Sets (DRS) or Secondary Regulator Sets (SRS). The medium and low pressure mains and services supply natural gas to domestic, industrial and commercial users.

The medium pressure networks have a MAOP of 210 kPag, 300 kPag or 400 kPag, with a small number operating at 15 kPag, 30 kPag and 100 kPag. The low pressure mains have a MAOP of 2 kPag or 7 kPag. The medium and low pressure network consists of more than 25,000 km of plastic pipe, polyethylene (HDPE) and nylon, with approximately 10% being cast iron or steel.

Jemena's Asset Management Plan identifies that the vast majority of the low and medium pressure network are within their design life. Most plastic mains in the network is less than 30 years old, due to the large scale rehabilitation program carried out in the 1990s to replace the then ageing network. During the renewal program most of the cast iron and steel pipe in the low and medium pressure networks was inserted with nylon. The cast iron and steel pipe that remains in service is more than 50 years old. Jemena monitor these sections of the network via leakage surveys and leakage data analysis, and prioritise these sections for replacement based on risk.[6]

All planned future works, including new market expansions, like for like replacements and rehabilitation works are expected to be constructed from 100% HDPE.

3.5 NETWORK OPERATING PRESSURES SUMMARY

Table 2 gives the percentage breakdown by operating pressures for piping systems used in the secondary mains.

Table 2 Secondary mains gas distribution network operating pressures[7]

Network Section	Operating Pressures	Total Length
Secondary Mains	>545 and ≤1,050 kPag	1,450 km
Medium Pressure	>15 kPag and ≤ 400 kPag	25,000 km
Low Pressure Mains	>2 and ≤7 kPag	

3.6 NETWORK MATERIALS SUMMARY

As the pressure decreases the pipeline materials utilised generally progress from steel to grades of plastics for the medium and low pressure mains.

Table 3 gives a breakdown of materials used in the secondary mains gas distribution network. Three main materials groups found in the natural gas distribution network were identified: plastic (PE and Nylon); steel (protected and unprotected); and cast iron. The table does not distinguish between the ages of the materials or the operating pressures.

[6] (Jemena Gas Networks – Asset Management Plan 2019-2025, Section 11.2.2)
[7] (Energy Network Australia, 2019)

At the transition of the distribution network to the appliance, it is typical to find copper piping systems.

Table 3 Secondary Mains & Downstream network materials[8]

<table>
<tr><th>Network Section</th><th>Material</th><th>Length (km)</th><th>% of Total Length</th></tr>
<tr><td rowspan="2">Secondary Mains</td><td>Carbon Steel, API 5L Grade B or API 5L Grade X42</td><td rowspan="2">1450 km</td><td>99%</td></tr>
<tr><td>SDR9 PE100</td><td>1%</td></tr>
<tr><td rowspan="5">Medium & Low Pressure Mains</td><td>Polyethylene</td><td rowspan="5">25,000 km</td><td rowspan="2">90%</td></tr>
<tr><td>Nylon</td></tr>
<tr><td>Cast Iron[9]</td><td rowspan="3">10%</td></tr>
<tr><td>Unprotected Steel</td></tr>
<tr><td>Protected Steel</td></tr>
</table>

[8] (Energy Network Australia, 2019)
[9] Cast Iron is only found in low pressure applications (less than 1,050 kPa).

4 IMPACT TO NETWORK MATERIALS

This section reviews the impacts of 2% and 10% hydrogen on network materials. Downstream gas appliances, feedstock users, gas installations and CNG are assessed separately.

4.1 NETWORK MATERIALS

The following sections consider the materials issues presented by injecting concentrations of 2% and up to 10% hydrogen into the distribution networks and the impact on both leakage and pipeline integrity.

4.1.1 Secondary Mains (Carbon Steel)

4.1.1.1 *HYDROGEN EMBRITTLEMENT*

Absorbed hydrogen can accumulate in carbon steel microstructure leading to hydrogen embrittlement, manifested by a reduction in the material toughness and tensile ductility of the steel. Embrittlement reduces the steel's tolerance to defects, making the pipeline more vulnerable to failure and potentially susceptible to worse failure modes (rupture rather than leak).

In general, hydrogen embrittlement does not affect the steel's yield or tensile strength, but the reduced defect tolerance may require a reduction in allowable operating pressures.[10]

The susceptibility of particular carbon steels to hydrogen embrittlement depends on three factors; environment, materials and stress.[11] In the Secondary Mains system, the strength of carbon steels and other ferrous alloys used is relatively low (API 5L Grade B and Grade X42). The Secondary Main is also designed to AS 4645 and has low design stress – limited to less than 20% of the yield strength, and an operating pressure less than 1050 kPag. This low strength, combined with low operating pressure and low operating stress in the case of the Secondary Mains, mean that the steels are not particularly vulnerable hydrogen embrittlement.[12]This means that there will be insufficient load to fracture the pipe in the event of a failure (fracture typically is a concern above 30% of SMYS). It is most likely that if a failure were to occur, the resultant hole size would be a pin hole or a hole.

The secondary main network is designed to AS/NZS 4645 and has low design stress – limited to less than 20% of the yield strength. This means that there will be insufficient load to fracture the pipe in the event of a failure (fracture typically is a concern above 30%). It is most likely that if a failure were to occur, the resultant hole size would be a pin hole or a hole.

4.1.1.2 *PRESSURE CYCLING & FATIGUE*

In the same way that it reduces the toughness of the steel, hydrogen also reduces the fatigue life. This has been demonstrated consistently with laboratory experiments such as those in Figure 4-1. The effect is called Hydrogen-Assisted-Fatigue Crack Growth (HA-FCG). The effect on fatigue life is similar for both high- and low-strength steel grades (unlike critical crack conditions).

[10] (Messaoudani, 2016)
[11] (Bathelemy, 2005)
[12] (EPCRC, 2017)

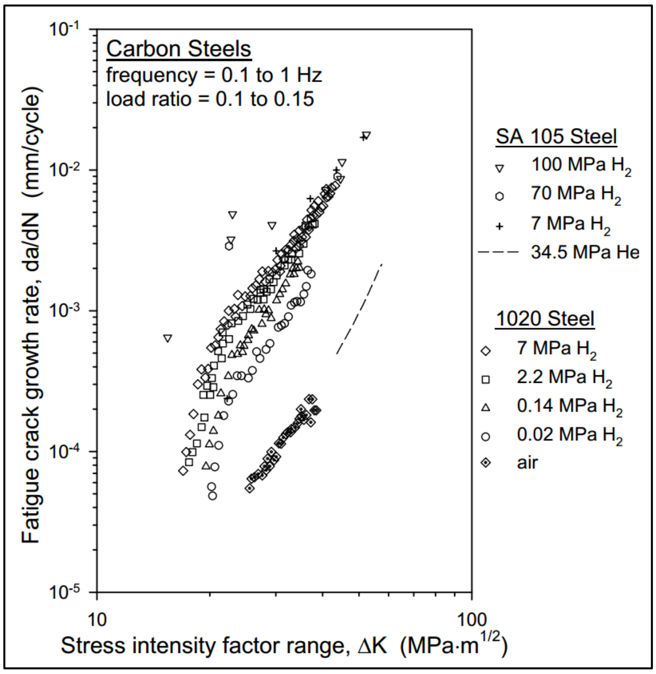


Figure 4-1 : Fatigue crack growth rates in hydrogen and air

At high stress intensities, it also appears that the fatigue crack growth rate is less dependent on hydrogen pressure than at low stress intensities. It should also be noted that there is evidence that HA-FCG is dependent on load frequency (slower is worse) and load ratio/mean stress (higher is worse).

Research into HA-FCG has been conducted for the American Society of Mechanical Engineers (ASME), and in 2018 they published a model for predicting the crack growth rate, which is likely to be included in the next revision of ASME B31.12 (a standard for hydrogen pipeline and facility piping design).

Where specific material data is not available, the ASME report provides a simplified model with conservative material constants. This can be used to understand the effect of hydrogen on the fatigue crack growth rate. The difference in crack growth rate between hydrogen service and air service has been plotted in Figure 4-2. (Note that the crack growth rate in natural gas would be practically the same as air.)

The model predicts that at low stress amplitudes, the fatigue crack growth rate in hydrogen and in air are very similar, but at high load amplitudes, the crack growth rate with hydrogen increases to be about 40 times that in air.

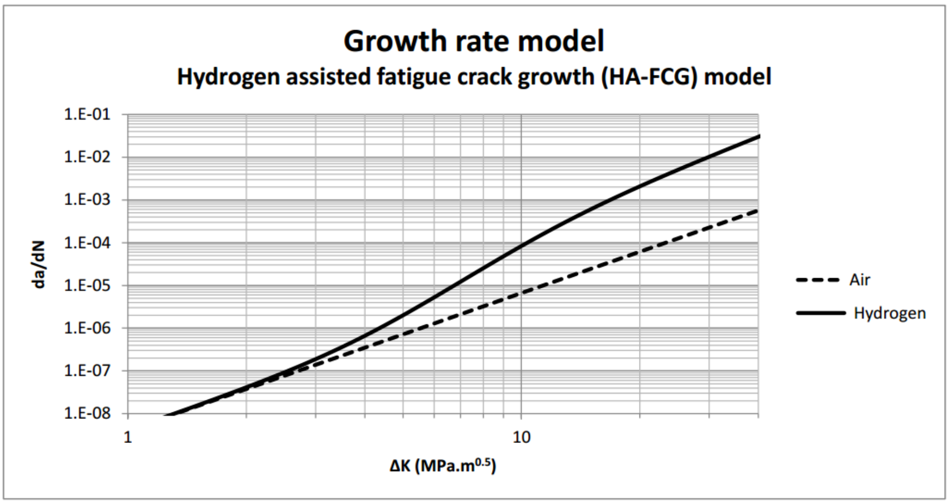


Figure 4-2 : Fatigue crack growth rate

The simplified model graphed here is not a function of the hydrogen pressure, though the more sophisticated model included in the ASME report does take hydrogen pressure into account. It is likely that fatigue crack growth rate in a hydrogen/natural gas mixture would relate to the partial pressure of the hydrogen in the gas.

The Secondary Mains system operates with limited pressure cycling, at low pressure (<1050 kPag) and low stress (<20% SMYS). Consequently in a 2% hydrogen / natural gas mixture it would be highly unlikely to experience fatigue.

4.1.2 Medium & Low Pressure Mains (Cast Iron / Carbon Steel)

Carbon steel consideration and the risk of embrittlement and loss of fatigue are less of a concern than the Secondary Mains due to the comparatively lower operating stress and pressure in medium and low pressure mains.

Cast item can absorb hydrogen in the same manner as high strength grades of carbon steel, but because of the low operating pressure in distribution networks, they are considered not to be at risk of hydrogen damage under the operating conditions.

Leakage from steel and ductile iron systems mainly passes through the threads or the mechanical joints. The leakage measurements carried out by Gas Technology Institute (GTI) on gas distribution systems in the United States of America indicated that the volume leakage rate for hydrogen is approximately three times that of natural gas.[13]

For a 2-10% hydrogen blend in natural gas the use of carbon steel or cast iron in medium and low pressure mains does not have any significant technical or commercial implications.

4.1.3 Medium & Low Pressure Mains (Polyethylene & Nylon)

4.1.3.1 Polymer Degradation

A study of 20% hydrogen in natural gas (primarily consisting of methane) of both PE100 (PE) and PA11 (Nylon) over 3 years at 100 bar showed no significant changes in mechanical properties.[14] Further testing completed on polymer pipes indicated that pure hydrogen would not increase the degradation of polymer pipe materials.

For a 2% blend of hydrogen in natural gas distribution networks, degradation is not considered an issue for new plastic piping systems. For aged plastic piping addition of 10% is not expected to be an issue but further work is required to confirm this.

4.1.3.2 Polymer Permeation

The relative size of the hydrogen molecule compared to methane results in an increased permeation rate of hydrogen through PE pipes.[15]

A study completed shows that for new plastic piping with hydrogen concentrations up to 20%, the losses are about 1.5-2.0 times that of methane; the report concluded that economically this was insignificant.[16]

[13] (Gas Technology Institute, 2010)
[14] (EPCRC, 2017)
[15] (Messaoudani, 2016)
[16] (Gas Technology Institute, 2010)

Hydrogen concentrations of over 20% start to exhibit noticeable losses[17]. For 100% hydrogen the losses are 66 times that of pure methane at 414 kPa. The losses increase exponentially with pressure increases[18].

Studies completed as part of the NaturalHy project concluded no apparent significant effect on permeation coefficients in aged PE pipe.[19] Testing completed in America by the Gas Technology Institute also concluded that aging PE pipes seem to have no significant influence on the permeation coefficients in the experimental conditions.[20]

Addition of 2% hydrogen will have a negligible impact in terms of losses due to leakage.

4.1.4 Consumer Piping (Copper)

Pure copper is resistant to hydrogen embrittlement as copper and hydrogen do not readily react under expected normal consumer piping conditions[21] but inclusion of oxygen in the material composition can significantly raise the level of susceptibility.[22] Fracture toughness of copper does not appear to be affected by exposure to hydrogen.

[17] Note that testing completed by Evoenergy however, does not necessarily reflect these results.
[18] (NREL, 2017)
[19] (NREL, 2017)
[20] (Gas Technology Institute, 2010)
[21] (Bathelemy, 2005)
[22] (San Marcki, 2008)

5 GAS COMPOSITION

The following sections outline the impacts and key considerations identified by this study associated with blending 2-10% hydrogen into the Secondary Mains and downstream distribution networks in terms of gas quality and composition.

5.1 GAS QUALITY LIMITS

NSW Gas Supply (Safety and Network Management) Regulation 2013 defines compliant natural gas as that which complies with the standards set out in AS 4564-2011.

AS4564 specifies limits for the major physical and chemical characteristics of natural gas providing a range for gas composition ensuring connected appliances operate safely. The key parameters specified include:

- minimum and maximum Wobbe Index (WI);
- maximum higher heating value (HHV),
- maximum oxygen (O_2),
- maximum inerts,
- maximum hydrogen sulphide (H_2S),
- maximum water content,
- maximum hydrocarbon dewpoint
- maximum oil

AS4645 also includes expected ranges for heating value (i.e. recognition of an expected minimum) and relative density, though these two parameters are not mandatory limits.

In addition to the physical and chemical characteristics, the combustion parameters that are used to specify a particular gas composition are:

- Methane Number (MN),
- the Flame Speed Factor (S), and
- Sooting Index (I). [23]

AS 4564 Table 3.1 outlines the requirements for natural gas quality.

[23] (EPCRC, 2017)

TABLE 3.1

SPECIFICATION LIMITS

Characteristics and components	Limit	
Wobbe Index	Minimum	46.0 MJ/m³
	Maximum	52.0 MJ/m³
Higher heating value	Maximum	42.3 MJ/m³
Oxygen	Maximum	0.2 mol%
Hydrogen sulphide	Maximum	5.7 mg/m³
Total sulphur	Maximum	50 mg/m³
Water content	Maximum	Dewpoint 0°C at the highest MAOP in the relevant transmission system (in any case, no more than 112.0 mg/m³)
Hydrocarbon dewpoint	Maximum	2.0°C at 3500 kPa gauge
Total inert gases	Maximum	7.0 mol%
Oil	Maximum	20 mL/TJ

NOTES:

1 m³ means 1 cubic metre of dry gas at the standard conditions (see Clause 1.5.9).

2 mol% means the mole faction of gas expressed as a percentage.

3 The sulphur level upstream of the point(s) of addition of odorant needs to be such as to allow for any increase due to the odorant.

4 The hydrocarbon dewpoint limit is intended to ensure that condensation, and in particular retrograde condensation, does not occur to an excessive extent.

5 *Higher heating value*: For the previous edition of this Standard it was expected that for all practical gases available, or likely to be available commercially, higher heating values would be in the range of 37 to 42 MJ/m³ and no limit was specified. A normative maximum limit has now been included in this edition.

6 *Relative density*: It is expected that for all practical gases available, or likely to be available commercially, relative density values would be in the range of 0.55 to 0.70.

7 For applications such as natural gas vehicles requiring compression to higher pressure than the maximum transmission pressure it may be necessary to use a gas dryer to remove moisture from the gas to prevent liquid water or hydrate formation.

8 See Appendix A for explanatory information.

5.2 IMPACT TO PROPERTIES

Adding hydrogen to natural gas alters the gas composition which in turn impacts the following physical and combustion parameters: Higher Heating Value (HHV), Specific Gravity (SG), Wobbe Index (WI), Methane Number (MN), Flame Speed Factor, Sooting Index (SI), Flammability Limit, Minimum Ignition Energy, and the Joule-Thomson Coefficient.

5.2.1 Higher heating value

Blending hydrogen will decrease the HHV, thereby reducing the energy content in a volume of gas when completely burnt in air at standard conditions. The likely technical consequence of natural gas with hydrogen used as a fuel in reciprocating engines or gas turbines, without tuning, is a loss of efficiency.[24] The lower HHV and the lower density of the gas also affect the efficiency of gas appliances

[24] (Dodge, 1994).

such as burners and cookers.

5.2.2 Relative Density

Specific gravity (SG), otherwise known as relative density, is the ratio of the density of a gas mixture compared with air density at standard conditions and is an important parameter in gas flow measurement and gas transactions. The low density of hydrogen (0.083 kg/Nm^3) is approximately 11% of natural gas, with increasing hydrogen in a blend the mass per unit volume will decrease, lowering the specific gravity of the mixture.[25] A decrease in SG will tend to increase the flow of gas and resultant gas velocity and pressure losses through the equipment for the same mass flow. The SG is also used in the calculation of the Wobbe Index which is further discussed in this report.

5.2.1 Wobbe index

The Wobbe Index (WI), sometimes called the exchangeability factor,[26] is a physical parameter of gas quality.[27] It is expressed in MJ/Sm^3 and is calculated when the higher heating value of the gas is divided by the square root of the relative density of that same gas. The WI accounts for the flow and heat inputs of the gas through an orifice at constant pressure. It represents an amount of energy that can be delivered through an appliance and is a good indicator of gas combustion, although it is recognised by the gas industry that the WI, on its own, is not a sufficient determining factor of gas exchangeability. This is because it does not fully predict or define combustion behaviour.[28]

The high and low gas quality limits define the values beyond which the WI is not permitted to vary. Within these limits appliances have been designed and tested to operate safely.[29] For gases that are outside the defined limits there may be technical, safety, regulatory and commercial impacts.

Addition of 10% hydrogen to a typical natural gas blend decreases the WI approximately 2%, although this is dependent on the original natural gas composition. While this seems relatively insignificant it has implications for a lean natural gas that is near the lower limit of the WI.

The likely consequences of falling below the lower limit are flame lifting, flame blowouts, release of unburned hydrocarbons and, in some cases, increased carbon monoxide generation.[31] In addition, a WI that is outside the limits may need commercial consideration. WI is used as the basis for calculating the value of gas in commercial contracts. A WI that is outside the limits set in the contract could lead to the incorrect valuation of gas.

5.2.2 Methane number

The Methane Number (MN) is generally referenced with respect to fuel supply to internal combustion engines to describe the “knock” characteristics of the fuel.[32] The ultimate impact on the performance of an engine depends on the specific gas composition of the fuel and in particular the amounts of higher hydrocarbons (C3, C4, and C5) and hydrogen in the fuel gas.

[25] (Kuczynski, 2018)
[26] “Gas exchangeability” is defined in the definitions and abbreviations section of this report.
[27] (SAE International, 1986)
[28] (Haeseldonckx, 2007)
[29] (Standards Australia - AS 4564, 2011)
[31] (EPCRC, 2017)
[32] (Malenshek, 2009)

The methane number for a blend of 90% methane and 10% hydrogen is 90.[33] The methane number reduces for a richer blend of natural gas due to the presence of heavier hydrocarbons.

Technically, a methane number that is not within the manufacturer's recommended limits could result in engine knock.[34] Knock is detrimental for the performance and reliability of gas engines.[35]

5.2.1 Flame speed factor

The flame speed factor is a calculated combustion parameter related to flash back and flame stability. The parameter is important in appliances for pilot orifice sizing, flame length and flame turndown.[36]

Flame speed also has a significant impact on the magnitude of the compressive wave developed when the gas ignites particularly in enclosed areas For pure hydrogen flame the speed of the flame means that during a depressurisation event (such as a blow down) when the pressure in the system drops the flame could burn back into the vent.

Previous research suggests that for a 10% hydrogen blend in natural gas, the flame speed may increase by approximately 10%.[37] This may have an impact on flame stability in connected appliances as detailed in previous sections.

5.2.2 Sooting Index

The sooting index describes the potential for incomplete combustion of the gas mixture and the propensity to form carbon monoxide or solid depositions following combustion in burners.[38]

It is referred to as a calculated parameter for compliance and is only a requirement in the Gas Regulations 2012 South Australia. The 2011 revision of *AS 4564:2011 – Specification for General Purpose Natural Gas* considered sooting indexing but it was not deemed necessary for inclusion.[39]

Depending on the gas composition the sooting index will decrease by approximately 3-5% for 10% hydrogen in the natural gas.[40] The addition of 10% hydrogen in natural gas improves the completeness of combustion and lowers the sooting index.

5.2.1 Flammability limit

The lower flammability limit (LFL) and upper flammability limit (UFL), also commonly referred to as lower explosive limit (LEL) and upper explosive limit (UEL), describe the concentration of a gas mixture in air within which an explosive gas atmosphere will be formed.[41]

The LFL and UFL of pure methane is 4.4% and 17.0% while the LFL and UFL of pure hydrogen is 4.0 % and 77.0% respectively. The most significant impact of a differing LFL and UFL is with respect to the classification of hazardous flammable gas atmospheres as defined in AS/NZS 60079.10.[42]

The extent of hazardous area zones calculated using 10% hydrogen with natural gas will be larger than that calculated using pure natural gas due to the lower LFL. The effect of the lower LFL, however, is

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[33] (Altfeld, 2018)
[34] (Ryan, 2008)
[35] (Sivabalakrishman, 2013)
[36] (Committee on Advanced Energy Storage Systems, 1979)
[37] (Altfeld, 2018)
[38] (South Australian Government, 2017)
[39] (Standards Australia - AS 4564, 2011) Section A3.9
[40] **Error! Reference source not found.** – Gas Properties Calculation
[41] (Standards Australia - AS/NZS 60079.10.1, 2009) Section 3.17 and 3.18
[42] (Standards Australia - AS/NZS 60079.10.1, 2009)

minimal (less than 5% difference for a 10% blend), and within typical conservatism used in hazardous area extent calculations (50%) and therefore does not change the expected risk profile.

For blends of up to 10% hydrogen in a natural gas distribution system it is envisaged that the existing hazardous area sizing guidelines presented in AS/NZS 60079.10 will remain applicable.

5.2.1 Flame emissivity

A pure hydrogen flame has different burn characteristics than that of natural gas[43]. Light emitted from burning pure hydrogen is in the ultraviolet range and is not visible to the human eye[44]. However it does burn with a coloured flame in the presence of combustion process contaminants and certain metal and non-metal components e.g. iron and sodium.

A typical natural gas flame is a blue in colour, with a luminous yellow region at the flame tip. A gradual spreading for the yellow colour flame, triumphed over the blue colour, is observed with the increase of the hydrogen concentration.[45]

For 10% hydrogen blends in natural gas the flame emissivity is considered similar to that of 100% natural gas. There is no identified increased risk associated with 10% hydrogen with regards to the flame colour.

5.3 OTHER SAFETY CONSIDERATIONS

5.3.1 Gas build-up in buildings

Hydrogen has the potential to change the risk profile of gas build-up in buildings due to the wider flammability range, lower ignition energy, and higher mobility of the gas.

The HyDeploy study found that the dispersion characteristics and relative leak rate of natural gas containing up to 20% hydrogen to be comparable with natural gas. A 10% hydrogen blend will result in only a 3% increase in the extent of the hazardous area, which is considered insignificant. Therefore the risk profile is not noticeably different for 10% hydrogen blend and relatively insignificant for a 2% hydrogen blend in natural gas provided that upon the release separation does not occur.

The NaturalHy study investigated build-up behaviour in two experimental releases for increasing hydrogen blends, in a smaller room representative of domestic dwellings and another in a larger room, representing a commercial or industrial building. The study observed that no separation of hydrogen from the mixture occurred. In general, the steady-state concentration following a release is only slightly higher for blends of up to 50% hydrogen, but concentration increases become more significant for hydrogen blends greater than 70%.[46]

Based on the above, gas build-up in buildings for 10% hydrogen in natural gas blend in domestic or industrial premises is similar to natural gas and does not present a major change in risk.

5.3.2 Radiation distance

Radiation contours are used in the pipeline industry to determine the largest area in which infrastructure and people may be affected by an ignited gas leak. This informs consequence modelling and hence risk ranking for public safety. Previous assessments completed using plume modelling software have

[43] (EPCRC, 2017)
[44] (Altfeld, 2018)
[45] (Schefer, 2009)
[46] (NREL, 2017)

demonstrated that the radiation contour is reduced for a 10% blend and negligible change for a 2% blend, therefore is an improvement in the risk profile.

5.3.3 Odorisation

Addition of a chemical substance is required in a natural gas distribution network to enable it to be detected by smell. Similar to that of 100% natural gas, pure hydrogen is odourless and will require an odorant be added to the system. Selecting the specific odorant to be injected involves knowledge of:

- the chemical composition of the gas;
- the physical and chemical characteristics of available odorants;
- the physical layout of the pipeline system and buffer storage tank (if applicable);
- ambient conditions;
- the need to be able to identify the specific gas (e.g. natural gas vs liquid petroleum gas vs hydrogen etc.);
- the desired odorant level; and
- recognition of the local population's current sensitivity to odorant.[47]

Typically for gas distribution networks, odorant level is required to be detectable at a minimum of one fifth the lower flammability limit (or lower explosive limit) of the gas composition[48].

Jemena will review their odorant injection strategy and determine whether it is necessary to increase odorant injection rates to account for the dilution effect of blending with hydrogen. Based on dilution of the odorised natural gas by 10% hydrogen, it is necessary that natural gas odorant levels be maintained at 14 mg/m^3 level.[49] It is recommended that the existing odourant levels are reviewed as part of the SAOP development to determine if any adjustment to existing levels is required.

5.4 GAS COMPOSITION ASSESSMENT

Appendix 1 provides a calculation of the impacts to the gas quality when hydrogen is added to the current natural gas composition expected in the Secondary Mains network.

Historical data obtained from the Gas Chromatograph located at Horsley Park was used to determine the representative likely range of compositions. Three cases were assessed, the median composition, a lean and a rich composition.

Table 4 provides a summary a summary of this calculation.

[47] (Parrott, 2017)
[48] (Standards Australia - AS 4564, 2011)
[49] Appendix 1 - Gas Composition Calculation

Table 4 Summary of the natural gas quality for NSW with addition of hydrogen

		AS 4564	Horsley Park (median) + Hydrogen Blend		Horsley Park (lean) + Hydrogen Blend		Horsley Park (rich) + Hydrogen Blend	
Characteristics	**Units**	**Limits**	**Median NG + 2%H_2**	**Median NG + 10%H_2**	**Lean NG + 2%H_2**	**Lean NG + 10%H_2**	**Rich NG + 2%H_2**	**Rich NG + 10%H_2**
Wobbe Index	MJ/m³	46-52	49.06	48.10	46.95	46.07	50.23	49.20
Higher Heating Value	MJ/m³	<42.3	38.14	36.02	36.98	34.95	39.57	37.33
Relative Density		N/A	0.604	0.561	0.620	0.575	0.621	0.576

		Horsley Park Historical Composition		
Characteristics	**Units**	**Median NG**	**Lean NG**	**Rich NG**
Wobbe Index	MJ/m³	49.30	47.17	50.48
Higher Heating Value	MJ/m³	38.67	37.49	40.13
Relative Density		0.615	0.632	0.632

All natural gas and hydrogen blends are compliant with the national standard AS 4564-2011.

The notes from the limits for combustion properties table in AS 4564-2011 state an expected minimum higher heating value although a hard limit has not been set. The expected minimum higher heating value of 37 MJ/m³ is not met by the median natural gas with 10% hydrogen blend or any of the hydrogen blends with lean natural gas or rich natural gas.

At the target blending percentage of 2% and at the 10% shutdown limit the limits stipulated in AS 4564-2011 are within the allowable range for the expected range of natural gas compositions. At a 10% blending percentage the Wobbe Index is marginally below the minimum limit for lean gas compositions.

As previously Jemena will complete further modelling to review the extent of the network likely exposed to the blended gas and likelihood of dilution as part of the SAOP. The likelihood of the historical lean blend as being representative lower limit for ongoing operation will be reviewed as part of the SAOP, to verify if the 10% shutdown setpoint requires further adjustment.

APPENDIX 1 GAS COMPOSITION CALCULATION

GPA ENGINEERING

Gas Properties Calculation

Detailed Design for Hydrogen Generation (Western Sydney Green Gas Trial)

Jemena Ltd

Jemena Document No: TBA

GPA Document No: 18667-CALC-001

Rev	Date	By	Checked	QA	Description
0	22/10/2019	AMB	SH	FPL	Issued for use
		AMB.	SH	FPL	

CONTENTS

1 AIM

The aim of this calculation is to determine compliance of the Horsley Park natural gas blended with 2 mol% and 10 mol% hydrogen.

The NSW Gas Supply (Safety and Network Management) Regulation 2013 Section 22 states that compliant natural gas is natural gas that complies with the standards set out in AS 4564-2011.

The calculated gas properties at Horsley Park will be compared to AS 4564-2011 to determine if they are compliant.

2 DESIGN DATA

Physical properties are calculated based on the following cases:

- Case 1:
  - 1a. Typical Horsley Park natural gas (median composition)
  - 1b. 2 mol% hydrogen blend with typical Horsley Park (median) natural gas
  - 1c. 10 mol% hydrogen blend with typical Horsley Park (median) natural gas
- Case 2:
  - 2a. Lean Horsley Park natural gas
  - 2b. 2 mol% hydrogen blend with lean Horsley Park natural gas
  - 2c. 10 mol% hydrogen blend with lean Horsley Park natural gas
- Case 3:
  - 3a. Rich Horsley Park natural gas
  - 3b. 2 mol% hydrogen blend with rich Horsley Park natural gas
  - 3c. 10 mol% hydrogen blend with rich Horsley Park natural gas

3 ASSUMPTIONS

The following assumptions have been made:

1. The typical Horsley Park natural gas composition used is the median Wobbe Index composition from plant data (GC A) over five years (11/10/2014 to 28/09/2019), refer to Appendix 3.
2. The lean Horsley Park natural gas composition used is the 0.1st percentile Wobbe Index composition from the plant data (GC A) over five years (11/10/2014 to 28/09/2019), refer to Appendix 3.
3. The rich Horsley Park natural gas composition used is the 99.9th percentile Wobbe Index composition from the plant data (GC A) over five years (11/10/2014 to 28/09/2019), refer to Appendix 3.
4. Gases will be assessed at standard conditions, 15 ^{o}C and 101.325 kPa(a).

4 METHODOLOGY

4.1 DETERMINATION OF GAS PROPERTIES

The following gas properties were calculated according to the methodology used in the GPA template - Gas Properties, which uses equations from the GPSA handbook.

- Gas Molecular Mass
- Specific gravity relative to air
- Gas standard density
- Gross heating value (Higher heating value)
- Net Heating value (Lower heating value)
- Wobbe Number from GHV

The methods used to calculate the above properties are included in Appendix 2.

4.2 NATIONAL AS 4564-2011 LIMITS

Compliance with AS 4564-2011 shall be demonstrated by showing that the value of a characteristic or concentration of a component does not lie beyond the limits set out in Table 1 (AS 4564-2011 Table 3.1).

Injected hydrogen is considered to be 99.999% pure with only trace impurities. Addition of hydrogen to natural gas will therefore dilute content of impurities such as oxygen, hydrogen sulphide, Sulphur and inerts and as such only Wobbe Index, higher heating value and relative density will be assessed.

Table 1 – National AS 4564-2011 limits for combustion properties of natural gas

Characteristics and components	Limit	
Wobbe Index	Minimum	46.0 MJ/m³
	Maximum	52.0 MJ/m³
Higher heating value	Maximum	42.3 MJ/m³
Oxygen	Maximum	0.2 mol%
Hydrogen sulphide	Maximum	5.7 mg/m³
Total sulphur	Maximum	50 mg/m³
Water content	Maximum	Dewpoint 0°C at the highest MAOP in the relevant transmission system (in any case, no more than 112.0 mg/m³).
Hydrocarbon dewpoint	Maximum	2.0°C at 3500 kPa gauge
Total inert gases	Maximum	7.0 mol%
Oil	Maximum	20 mL/TJ

NOTES:

1. m³ means 1 cubic metre of dry gas at the standard conditions (15°C and an absolute pressure of 101.325 kPa).
2. *Higher heating value:* For the previous edition of AS 4564 (2005) it was expected that for all practical gases available, or likely to be available commercially, higher heating values would be in the range of 37 to 42 MJ/m³ and no limit was specified. A normative maximum limit has now been included in AS 4564-2011.
3. *Relative density:* It is expected that for all practical gases available, or likely to be available commercially, relative density values would be in the range of 0.55 to 0.70.
4. Refer to Appendix 4 for explanatory information.

5 RESULTS

A summary of the key combustion characteristics for each of the natural gas compositions and blends with hydrogen, obtained from the calculation spreadsheet, are shown in Table 2, Table 3 and Table 4. The full calculation spreadsheets can be found in Appendix 1.

Table 2 – Case 1: Summary of Gas Properties Calculation using median Natural Gas

		Horsley Park	Horsley Park + Hydrogen Blend	
Characteristics	**Units**	**Median NG**	**Median NG + 2%H_2**	**Median NG + 10%H_2**
Wobbe Index	MJ/m³	49.30	49.06	48.10
Higher Heating Value	MJ/m³	38.67	38.14	36.02
Relative Density		0.615	0.604	0.561

Table 3 – Case 2: Summary of Gas Properties Calculation using lean Natural Gas

		Horsley Park	Horsley Park + Hydrogen Blend	
Characteristics	**Units**	**Lean NG**	**Lean NG + 2%H_2**	**Lean NG + 10%H_2**
Wobbe Index	MJ/m³	47.17	46.95	46.07
Higher Heating Value	MJ/m³	37.49	36.98	34.95
Relative Density		0.632	0.620	0.575

Table 4 – Case 3: Summary of Gas Properties Calculation using rich Natural Gas

		Horsley Park	Horsley Park + Hydrogen Blend	
Characteristics	**Units**	**Rich NG**	**Rich NG + 2%H_2**	**Rich NG + 10%H_2**
Wobbe Index	MJ/m³	50.48	50.23	49.20
Higher Heating Value	MJ/m³	40.13	39.57	37.33
Relative Density		0.632	0.621	0.576

6 CONCLUSIONS

The comparison between the calculated combustion characteristics (Table 2, Table 3 and Table 4) and the limits for these combustion characteristics (Table 1) show that all natural gas compositions and all natural gas/hydrogen blend compositions are compliant with the national standard AS 4564-2011.

The notes from the limits for combustion properties table in AS 4564-2011 (Table 1 above) state an expected minimum higher heating value although a hard limit has not been set. The expected minimum higher heating value of 37 MJ/m^3 is not met by the median natural gas with 10 mol% hydrogen blend or either of the hydrogen blends with lean natural gas (2 and 10 mol% hydrogen).

APPENDIX 1 CALCULATION SPREADSHEETS

Document Title	Document Number	Rev
Gas Properties Calculation - Case 1a	18667-CALC-001	0

Scenario/Design Case	WSGGT - Horsley Park (median composition) - Natural gas

Scenario/Design Case Input Data

Tag #		Units	Metric	Key	Input
Equipment #					Calculated
Location					
P&ID #					

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.91152
Ethane					0.04592
Propane					0.00799
i-Butane					0.00109
n-Butane					0.00144
i-Pentane					0.00050
n-Pentane					0.00033
Neopentane					0.00001
n-Hexane					0.00047
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.02215
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					
Oxygen					
Nitrogen					0.00859
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	17.819
Specific gravity rel. to air			*SG*	-	0.615
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.7536
Gross heating value			*GHV*	*MJ/std.m^3*	38.67
				MJ/kg	51.32
Net heating value			*NHV*	*MJ/std.m^3*	34.89
				MJ/kg	46.29
Wobbe number (from GHV)			*W#*	-	49.30
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	79
Heat available based on NHV - for combustion calculations				*MJ/h*	3,680
				MW	1.0
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

Document Title	Document Number	Rev
Gas Properties Calculation - Case 1b	18667-CALC-001	0

Scenario/Design Case	WSGGT - Horsley Park (median composition) - Natural gas with 2 mol% hydrogen

Scenario/Design Case Input Data

Tag #		Units	Metric	Key	Input
Equipment #					Calculated
Location					
P&ID #					

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.89329
Ethane					0.04500
Propane					0.00783
i-Butane					0.00107
n-Butane					0.00141
i-Pentane					0.00049
n-Pentane					0.00032
Neopentane					0.00001
n-Hexane					0.00046
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.02171
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					0.02000
Oxygen					
Nitrogen					0.00842
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	17.503
Specific gravity rel. to air			*SG*	-	0.604
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.7403
Gross heating value			*GHV*	*MJ/std.m^3*	38.14
				MJ/kg	51.52
Net heating value			*NHV*	*MJ/std.m^3*	34.39
				MJ/kg	46.46
Wobbe number (from GHV)			*W#*	-	49.06
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	78
Heat available based on NHV - for combustion calculations				*MJ/h*	3,628
				MW	1.0
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

Document Title	Document Number	Rev
Gas Properties Calculation - Case 1c	**18667-CALC-001**	**0**

Scenario/Design Case: WSGGT - Horsley Park (median composition) - Natural gas with 10 mol% hydrogen

Scenario/Design Case Input Data

Tag #		**Units**	**Metric**	**Key**	**Input**
Equipment #					**Calculated**
Location					
P&ID #					

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.82037
Ethane					0.04133
Propane					0.00719
i-Butane					0.00098
n-Butane					0.00130
i-Pentane					0.00045
n-Pentane					0.00030
Neopentane					0.00001
n-Hexane					0.00042
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.01994
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					0.10000
Oxygen					
Nitrogen					0.00773
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	16.239
Specific gravity rel. to air			*SG*	-	0.561
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.6868
Gross heating value			*GHV*	*MJ/std.m^3*	36.02
				MJ/kg	52.44
Net heating value			*NHV*	*MJ/std.m^3*	32.42
				MJ/kg	47.21
Wobbe number (from GHV)			*W#*	-	48.10
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	72
Heat available based on NHV - for combustion calculations				*MJ/h*	3,420
				MW	1.0
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

Document Title	Document Number	Rev
Gas Properties Calculation - Case 2a	18667-CALC-001	0

Scenario/Design Case	WSGGT - Horsley Park (lean composition) - Natural gas

Scenario/Design Case Input Data

Tag #		**Units**	**Metric**	**Key**	**Input**
Equipment #					**Calculated**
Location					
P&ID #					

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.89771
Ethane					0.03858
Propane					0.00679
i-Butane					0.00106
n-Butane					0.00110
i-Pentane					0.00053
n-Pentane					0.00025
Neopentane					0.00001
n-Hexane					0.00039
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.04480
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					
Oxygen					
Nitrogen					0.00877
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	18.294
Specific gravity rel. to air			*SG*	-	0.632
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.7737
Gross heating value			*GHV*	*MJ/std.m^3*	37.49
				MJ/kg	48.45
Net heating value			*NHV*	*MJ/std.m^3*	33.81
				MJ/kg	43.70
Wobbe number (from GHV)			*W#*	-	47.17
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	82
Heat available based on NHV - for combustion calculations				*MJ/h*	3,567
				MW	1.0
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

Document Title	Document Number	Rev
Gas Properties Calculation - Case 2b	**18667-CALC-001**	**0**

Scenario/Design Case: WSGGT - Horsley Park (lean composition) - Natural gas with 2 mol% hydrogen

Scenario/Design Case Input Data

Tag #		**Units**	**Metric**	**Key**	**Input**
Equipment #					**Calculated**
Location					
P&ID #					

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.87976
Ethane					0.03781
Propane					0.00665
i-Butane					0.00104
n-Butane					0.00108
i-Pentane					0.00052
n-Pentane					0.00025
Neopentane					0.00001
n-Hexane					0.00038
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.04390
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					0.02000
Oxygen					
Nitrogen					0.00859
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	17.968
Specific gravity rel. to air			*SG*	-	0.620
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.7599
Gross heating value			*GHV*	*MJ/std.m^3*	36.98
				MJ/kg	48.66
Net heating value			*NHV*	*MJ/std.m^3*	33.34
				MJ/kg	43.87
Wobbe number (from GHV)			*W#*	-	46.95
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	80
Heat available based on NHV - for combustion calculations				*MJ/h*	3,517
				MW	1.0
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

Document Title	Document Number	Rev
Gas Properties Calculation - Case 2c	**18667-CALC-001**	**0**

Scenario/Design Case: WSGGT - Horsley Park (lean composition) - Natural gas with 10 mol% hydrogen

Scenario/Design Case Input Data

Tag #			**Units**	**Metric**		**Key**	**Input**
Equipment #							**Calculated**
Location							
P&ID #							

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.80794
Ethane					0.03472
Propane					0.00611
i-Butane					0.00095
n-Butane					0.00099
i-Pentane					0.00048
n-Pentane					0.00023
Neopentane					0.00001
n-Hexane					0.00035
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.04032
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					0.10000
Oxygen					
Nitrogen					0.00789
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	16.666
Specific gravity rel. to air			*SG*	-	0.575
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.7049
Gross heating value			*GHV*	*MJ/std.m^3*	34.95
				MJ/kg	49.58
Net heating value			*NHV*	*MJ/std.m^3*	31.45
				MJ/kg	44.62
Wobbe number (from GHV)			*W#*	-	46.07
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	74
Heat available based on NHV - for combustion calculations				*MJ/h*	3,318
				MW	0.9
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

Document Title	Document Number	Rev
Gas Properties Calculation - Case 3a	**18667-CALC-001**	**0**

Scenario/Design Case	WSGGT - Horsley Park (rich composition) - Natural gas

Scenario/Design Case Input Data

Tag #		**Units**	**Metric**	**Key**	**Input**
Equipment #					**Calculated**
Location					
P&ID #					

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.89191
Ethane					0.05568
Propane					0.01899
i-Butane					0.00294
n-Butane					0.00293
i-Pentane					0.00100
n-Pentane					0.00054
Neopentane					0.00002
n-Hexane					0.00048
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.01682
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					
Oxygen					
Nitrogen					0.00868
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	18.298
Specific gravity rel. to air			*SG*	-	0.632
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.7739
Gross heating value			*GHV*	*MJ/std.m^3*	40.13
				MJ/kg	51.85
Net heating value			*NHV*	*MJ/std.m^3*	36.24
				MJ/kg	46.83
Wobbe number (from GHV)			*W#*	-	50.48
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	82
Heat available based on NHV - for combustion calculations				*MJ/h*	3,823
				MW	1.1
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

Document Title	Document Number	Rev
Gas Properties Calculation - Case 3b	**18667-CALC-001**	**0**

Scenario/Design Case: WSGGT - Horsley Park (rich composition) - Natural gas with 2 mol% hydrogen

Scenario/Design Case Input Data

Tag #		**Units**	**Metric**	**Key**	**Input**
Equipment #					**Calculated**
Location					
P&ID #					

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.87407
Ethane					0.05457
Propane					0.01861
i-Butane					0.00288
n-Butane					0.00287
i-Pentane					0.00098
n-Pentane					0.00053
Neopentane					0.00002
n-Hexane					0.00047
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.01648
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					0.02000
Oxygen					
Nitrogen					0.00851
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	17.972
Specific gravity rel. to air			*SG*	-	0.621
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.7601
Gross heating value			*GHV*	*MJ/std.m^3*	39.57
				MJ/kg	52.05
Net heating value			*NHV*	*MJ/std.m^3*	35.72
				MJ/kg	46.99
Wobbe number (from GHV)			*W#*	-	50.23
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	80
Heat available based on NHV - for combustion calculations				*MJ/h*	3,768
				MW	1.0
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

Document Title	Document Number	Rev
Gas Properties Calculation - Case 3c	18667-CALC-001	0

Scenario/Design Case: WSGGT - Horsley Park (rich composition) - Natural gas with 10 mol% hydrogen

Scenario/Design Case Input Data

Tag #		Units	Metric	Key	Input
Equipment #					Calculated
Location					
P&ID #					

Input data

Description	Definition	Source	Symbol	Units	Value
Gas flow rate				std.m^3/d	2,532
Gas Composition					
Component			y_i	mole fraction	
Methane					0.80272
Ethane					0.05011
Propane					0.01709
i-Butane					0.00265
n-Butane					0.00264
i-Pentane					0.00090
n-Pentane					0.00049
Neopentane					0.00002
n-Hexane					0.00043
n-Heptane					
n-Octane					
n-Nonane					
n-Decane					
Cyclopentane					
Methylcyclopentane					
Cyclohexane					
Benzene					
Toluene					
Xylenes					
Carbon monoxide					
Carbon dioxide					0.01514
Hydrogen sulphide					
Sulphur dioxide					
Ammonia					
Hydrogen					0.10000
Oxygen					
Nitrogen					0.00781
Water					
Total					1.000

Calculation and Results

Description	Formula/ criteria	Section/ref	Symbol	Units	Value
Gas properties					
Gas molecular mass			*MW*	*kg/kmol*	16.671
Specific gravity rel. to air			*SG*	-	0.576
Gas standard density (Z = 1)			ρ	*kg/std.m^3*	0.7050
Gross heating value			*GHV*	*MJ/std.m^3*	37.33
				MJ/kg	52.94
Net heating value			*NHV*	*MJ/std.m^3*	33.64
				MJ/kg	47.71
Wobbe number (from GHV)			*W#*	-	49.20
Flow calculations					
Gas flow rate				*std.m^3/h*	105
				kg/h	74
Heat available based on NHV - for combustion calculations				*MJ/h*	3,548
				MW	1.0
Heat available based on GHV - for commercial calculations				*TJ/d*	0
Water content			c_i	*mg/std.m^3*	

APPENDIX 2 GPA TEMPLATE METHODOLOGY FOR VARIOUS GAS PROPERTIES

GPA template 99965-TEM-354-r0 uses equations from the following table to calculate the various ideal gas properties listed in section 4.1. These equations are obtained from the GPSA handbook and are the same as per the equations set out in ISO 6976.

Variable	Equation	Description
Molecular mass of gas mixture	$M_{mix} = \sum_{i-1}^{N} x_i \cdot M_i$	M_{mix} molecular mass of the gas mixture, in kg/kmol M_i molecular mass of component i, in kg/kmol x_i mole fraction of component i
Specific gravity relative to air	$SG = \frac{M_{mix}}{M_{air}}$	SG specific gravity (rel. dry air) M_{mix} molecular mass of the gas mixture M_{air} molar mass of dry air of standard composition, 28.9639 kg/kmol
Standard density	$\rho = \frac{P}{RT} \cdot M_{mix}$	ρ Density of the gas mixture, in kg/std.m^3 P Absolute standard pressure, in kPa T Absolute standard temperature, in kelvin R molar gas constant, 8.31447 kJ/kmol·K
Gross heating value	$GHV_v = \sum_{i-1}^{N} x_i \cdot GHV_i$ $GHV_m = \frac{GHV_v}{\rho}$	GHV_v Gross heating value of gas mixture, in MJ/std.m^3 GHV_m Gross heating value of gas mixture, in MJ/kg GHV_i Gross heating value of component i at standard conditions, in MJ/std.m^3 ρ Density of the gas mixture, in kg/std.m^3 x_i mole fraction of component i
Net heating value	$NHV_v = \sum_{i-1}^{N} x_i \cdot NHV_i$ $NHV_m = \frac{NHV_v}{\rho}$	NHV_v Net heating value of gas mixture, in MJ/std.m^3 NHV_m Net heating value of gas mixture, in MJ/kg NHV_i Net heating value of component i at standard conditions, in MJ/std.m^3 ρ Density of the gas mixture, in kg/std.m^3 x_i mole fraction of component i
Wobbe number	$W = \frac{GHV_{tot}}{\sqrt{SG}}$	W Wobbe number SG specific gravity (rel. dry air) GHV_{tot}
Standard conditions		P Absolute standard pressure, 101.325 kPa T Absolute standard temperature, 273.15K +15K

APPENDIX 3 HORSLEY PARK NATURAL GAS COMPOSITION

Table 5 – Horsley Park Natural Gas Composition (from GC A)

Component	GC A (mol%)		
	Median	**Lean**	**Rich**
Methane	91.152	89.771	89.191
Ethane	4.592	3.858	5.568
Propane	0.799	0.679	1.899
i-Butane	0.109	0.106	0.294
n-Butane	0.144	0.110	0.293
i-Pentane	0.050	0.053	0.100
n-Pentane	0.033	0.025	0.054
neo-Pentane	0.001	0.001	0.002
n-Hexane & heavier	0.047	0.039	0.048
Nitrogen	0.859	0.877	0.868
Carbon Dioxide	2.215	4.480	1.682
Wobbe Index	49.37	47.24	50.56

Ref. Second Mains Gas Composition, Response to Technical Query, Mail Number JAM-RESTECHQ-000008, Reference Number GPA-TECHQ-000005. 1st Oct 2019. Data from GC A was used.

To obtain the median, lean (0.1st percentile for Wobbe Index) and rich (99.9th percentile for Wobbe Index) the original data was cleaned to get rid of any outliers. Refer to Figure 1 below to view outlier data points removed from the data.

Median uses the '=median' function across all the components. Values were then normalised.

The lean gas composition was determined by finding the 0.1st percentile composition value for Wobbe Index, using '=percentile.exc(datarange, 0.001)'. The corresponding composition was then taken for the remaining components, and normalised.

The rich gas composition was determined by finding the 99.9th percentile composition value for Wobbe Index, using '=percentile.exc(datarange, 0.999)'. The corresponding composition was then taken for the remaining components, and normalised.

Table 6 shows the median, lean and rich Horsley Park natural gas compositions obtained from GC B for comparison. The Selected GC data did not contain Wobbe Index values.

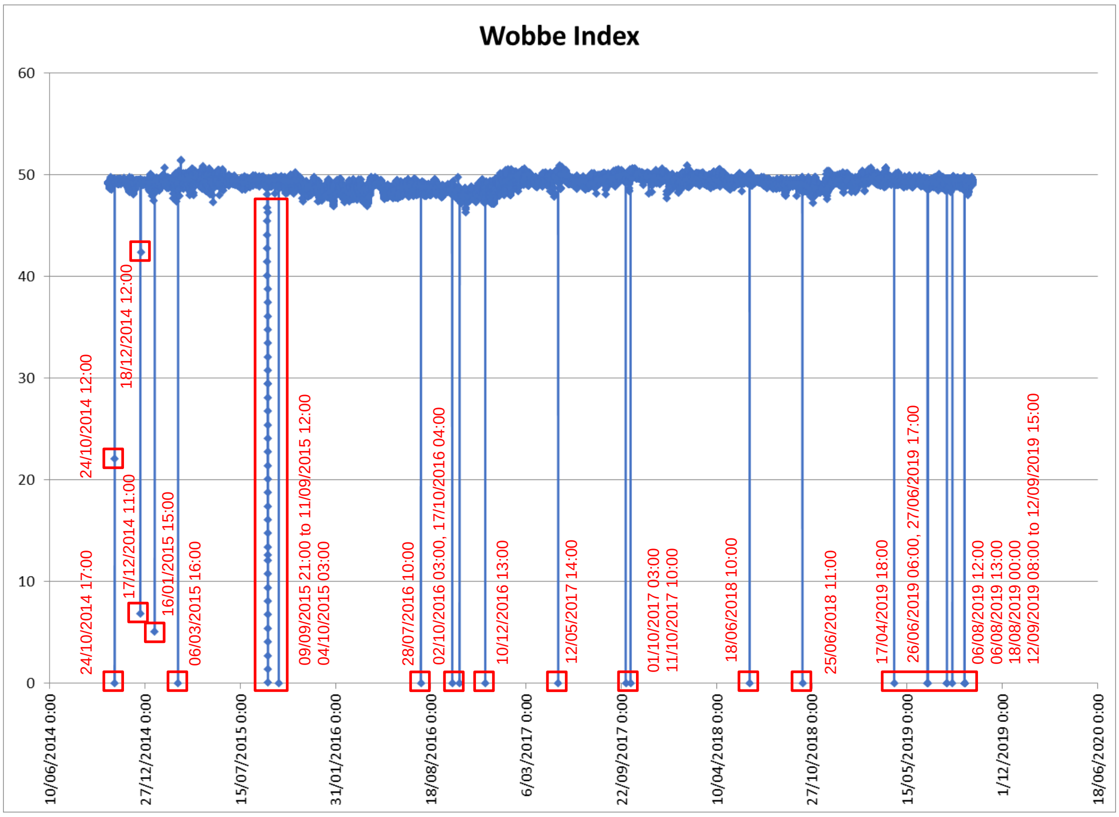


Figure 1 – Raw Wobbe Index data showing outliers removed (from GC A)

Table 6 – Horsley Park Natural Gas Composition (from GC B)

Component	GC B (mol%)		
	Median	Lean	Rich
Methane	96.352	89.353	92.145
Ethane	1.380	4.298	4.683
Propane	0.156	0.632	0.999
i-Butane	0.017	0.098	0.135
n-Butane	0.023	0.104	0.139
i-Pentane	0.006	0.042	0.045
n-Pentane	0.005	0.020	0.023
Neo-Pentane	0.000	0.001	0.001
n-Hexane & heavier	0.004	0.031	0.028
Nitrogen	1.038	0.945	0.840
Carbon Dioxide	1.018	4.477	0.962
Wobbe Index	49.38	47.23	50.55

APPENDIX 4 AS 4564-2011 EXTRACT

TABLE 3.1

SPECIFICATION LIMITS

Characteristics and components	Limit	
Wobbe Index	Minimum	46.0 MJ/m^3
	Maximum	52.0 MJ/m^3
Higher heating value	Maximum	42.3 MJ/m^3
Oxygen	Maximum	0.2 mol%
Hydrogen sulphide	Maximum	5.7 mg/m^3
Total sulphur	Maximum	50 mg/m^3
Water content	Maximum	Dewpoint 0°C at the highest MAOP in the relevant transmission system (in any case, no more than 112.0 mg/m^3)
Hydrocarbon dewpoint	Maximum	2.0°C at 3500 kPa gauge
Total inert gases	Maximum	7.0 mol%
Oil	Maximum	20 mL/TJ

NOTES:

1 m^3 means 1 cubic metre of dry gas at the standard conditions (see Clause 1.5.9).

2 mol% means the mole faction of gas expressed as a percentage.

3 The sulphur level upstream of the point(s) of addition of odorant needs to be such as to allow for any increase due to the odorant.

4 The hydrocarbon dewpoint limit is intended to ensure that condensation, and in particular retrograde condensation, does not occur to an excessive extent.

5 *Higher heating value*: For the previous edition of this Standard it was expected that for all practical gases available, or likely to be available commercially, higher heating values would be in the range of 37 to 42 MJ/m^3 and no limit was specified. A normative maximum limit has now been included in this edition.

6 *Relative density*: It is expected that for all practical gases available, or likely to be available commercially, relative density values would be in the range of 0.55 to 0.70.

7 For applications such as natural gas vehicles requiring compression to higher pressure than the maximum transmission pressure it may be necessary to use a gas dryer to remove moisture from the gas to prevent liquid water or hydrate formation.

8 See Appendix A for explanatory information.

APPENDIX A

DERIVATION OF SPECIFICATION

(Informative)

A1 BACKGROUND

The specification encompasses the range of Australian natural gases in general purpose use at the time of publication.

In order to retain the greatest flexibility of supply no attempt has been made to detail the composition of the gas beyond those compounds normally regarded as gas contaminants and which have a detrimental effect on the properties of the gas. Specification limits are generally consistent with overseas practice. Australian gas appliance manufacturers and most overseas manufacturers, including those in Canada, Japan, New Zealand, the UK and the USA, design appliances to operate safely with gases within the range of this specification. In this respect the specification is intended to cover only those gases that are primarily methane. This specification does not cover other gases such as LP Gas/air mixtures and synthetic natural gas.

Normative specification limits on particular characteristics and components are contained in Table 3.1, while more information on those characteristics and components, and on other contaminants, is provided further in this Appendix.

A2 LIMITS

In any natural gas specification a balance must be achieved between optimum performance, which requires the narrowest possible combustion limits, and cost of supply, which if possible, requires no limits at all so that any available gas can be used. In an endeavour to resolve this issue the limits are set as wide as possible while still maintaining safe combustion performance in gas burning appliances certified for use in Australia. If the specification of gas deviates from these limits both safety and performance may be compromised. This is dependent on the duration and extent of the deviation.

Although rate of change of variables within the limits is not addressed in this specification, it is a matter that may be addressed in gas supply contracts. It is relevant to the performance of combustion control systems particularly in lean burn and low NOx applications. In addition, rapid changes in Wobbe Index, for example, may lead to customer complaints, as there may be a noticeable change in performance with some appliances.

A3 CHARACTERISTICS AND COMPONENTS

A3.1 Wobbe Index

Wobbe Index is a measure of the energy input rate to a burner at constant supply pressure and also relates to the combustion characteristics of the burner. A change in the Wobbe Index of the gas will result in a proportional change in the energy output of all gas appliances and equipment supplied, and in the energy carrying capacity of gas pipelines and distribution networks.

The permissible range of Wobbe Index is the range over which the present Australian population of gas appliances and equipment can be expected to operate safely.

Too low a Wobbe Index may cause flame abnormality. It can also cause increased carbon monoxide formation in surface combustion burners.

Too high a Wobbe Index may give rise to high levels of carbon monoxide in the combustion products of conventional appliances. It can also give rise to overheating.

A3.2 Higher heating value

A maximum higher heating value of 42.3 MJ/m^3 is required by this specification. Gases with higher heating values greater than this limit have an unacceptably higher propensity for incomplete combustion and sooting, which would not necessarily be detected by tests using existing appliance Standard limit gases.

A3.3 Oxygen

A maximum oxygen concentration of 0.2 mol% is required by this specification.

Corrosion products from oxidation in steel pipelines have the effect of stripping the injected odorant from gas.

A3.4 Hydrogen sulphide

The limitation on hydrogen sulphide in the gas is necessary because of its corrosive effects. In the presence of water, hydrogen sulphide can cause hydrogen induced cracking and sulphide stress cracking in high tensile steels at high pressure. This is of particular importance for transportation of gas in steel pipes and for the use of natural gas in vehicles where natural gas is typically stored at pressures up to 26 MPa.

Hydrogen sulphide has also been associated with chemical attack on copper and its alloys leading to the formation of copper sulphide, which can cause malfunctions in appliances, including the blockage of pilot jets.

Further information on the effects of hydrogen sulphide is contained in AS 2885.1.

A3.5 Total sulphur

A maximum permitted sulphur concentration of 50 mg/m^3 includes sulphur from all sources including odorization of the gas. Odorants commonly used in Australia contribute to the sulphur level in the gas. In setting the sulphur limit, the use of flueless heating in Australia has been taken into account.

Sulphur in the gas burns to sulphur dioxide (SO_2) which enters the indoor atmosphere when flueless gas appliances are used. SO_2 is an irritant gas and is limited under WHO guidelines to a 10 minute maximum of 500 μg/m^3 and a 24 hour average of 20 μg/m^3. It is noted that at the appliance code limit conditions under which a flueless space heater is required to automatically shut down (0.0075% CO, 2.0% CO_2, 18% O_2), SO_2 concentrations may exceed the WHO guidelines if the total sulphur concentration is at 50 mg/m^3 for an extended period.

Elemental sulphur deposition is an operating issue in some transmission systems, see Paragraph A3.11. This has occurred in some systems with sulphur concentrations below 50 mg/m^3 and further research is required.

A3.6 Water

This specification covers water content by nominating the dewpoint at maximum transmission pressures. Additionally, an absolute limit (mg/m^3) is stated. Figure A1 defines the water content in mg/m^3 producing a dewpoint of 0°C for a range of transmission pressures.

Liquid phase water can cause corrosion and the formation of gas hydrates in transmission systems. In combination with hydrogen sulphide and carbon dioxide, water can also lead to stress corrosion cracking and hydrogen embrittlement.

The stated limits are designed to ensure that hydrate formation and excessive corrosion do not occur in transmission systems.

For applications such as natural gas vehicles requiring compression to higher pressure than the maximum transmission pressure it may be necessary to use a gas dryer to remove moisture from the gas to prevent liquid water or hydrate formation.

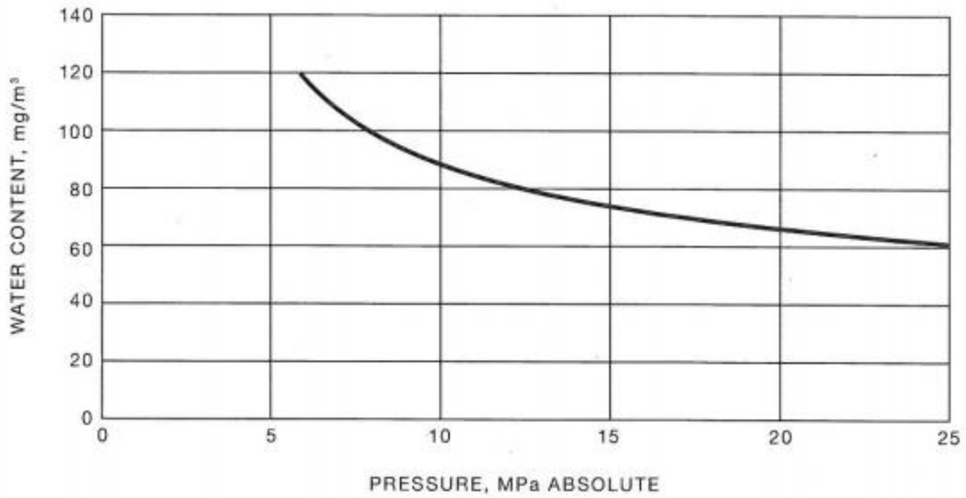


FIGURE A1 DEWPOINT AT ZERO DEGREES CELSIUS

A3.7 Hydrocarbon dewpoint

The hydrocarbon dewpoint limit controls the level of heavy hydrocarbons (propane and heavier) in the gas. At high pressures, condensation of heavy hydrocarbons may occur at low temperatures. The pressure and temperature specified do not guarantee the total absence of retrograde condensation.

Additionally, retrograde condensation can occur in transmission systems at pressures lower than the MAOP. It is this phenomenon that effectively determines the maximum allowable limits of heavy hydrocarbons in natural gas. The pressure and temperature specified are designed to limit retrograde condensation for typical Australian natural gases (refer to ISO 13686).

The pressure specified approximates the cricondentherm pressure which for typical Australian natural gases is usually within the range of 2 to 4 MPa.

A3.8 Total inert gases

The specification for total inert gases is intended, in conjunction with the Wobbe Index limits, to limit the levels of higher hydrocarbons. High levels of CO_2 in particular could have significant implications for some gas consumers that have specific needs. However this is a commercial issue and, where necessary, would be specified in contracts.

A3.9 Other combustion parameters

Other combustion parameters, e.g. sooting index, flame speed and lift index, were considered but not deemed necessary for inclusion in the specification.

A3.10 Oil

The limit of 20 mL/TJ for oil contamination is based on the Queensland Petroleum and Gas (Production and Safety) Regulation 2004, which in turn was based on Australian Pipeline Industry Association (APIA) 'good current practice' for compressor station operation. The limit is an acknowledgment that, whilst undesirable, it is almost inevitable that some oil will escape from filters and coalescers downstream from compressors and other facilities. The limit is intended to restrict oil accumulation in transmission systems to manageable quantities, and to avoid network operation and appliance safety problems in distribution systems.

There are currently no suitable real time methods for measurement of entrained oil. Compliance is verified by retrospective logging of oil collected from filters or other entrapment elements.

A3.11 Other contaminants

Examples of the level at which some objectionable constituents might cause damage or be a hazard to health are listed below:

Elemental Sulphur: 1.0 μg/m^3

Elemental sulphur deposition has caused operational problems in a number of transmission systems. Elemental sulphur vapour concentration should be below 1.0 μg/m^3 in order to avoid deposition of elemental sulphur at operating temperatures above 2°C. The elemental sulphur formation and deposition process is extremely complicated and depends on a number of contributing factors. This limit is based on elemental sulphur/natural gas phase equilibria data published as part of elemental sulphur deposition studies by Dr. D. Pack.

Mercury: 1.0 μg/m^3

Mercury is hazardous to human health if ingested, absorbed through the skin or inhaled. Mercury can also cause 'liquid metal embrittlement' and subsequent failure of aluminium alloys.

Commercially available mercury removal equipment for natural gas is quoted as being able to get down to 0.1 μg/m^3 from inlet concentrations of 25–50 μg/m^3. The atmospheric concentration (depending on location) is generally around 0.02 μg/m^3 (but higher in some industrial centres).

The figure of 1 μg/m^3 in natural gas will not add significantly to the background level in indoor air, is technically feasible and, upon dilution of the combustion products, will lead to concentrations well below the occupational health exposure level.

Radioactivity: 600 Bq/m^3

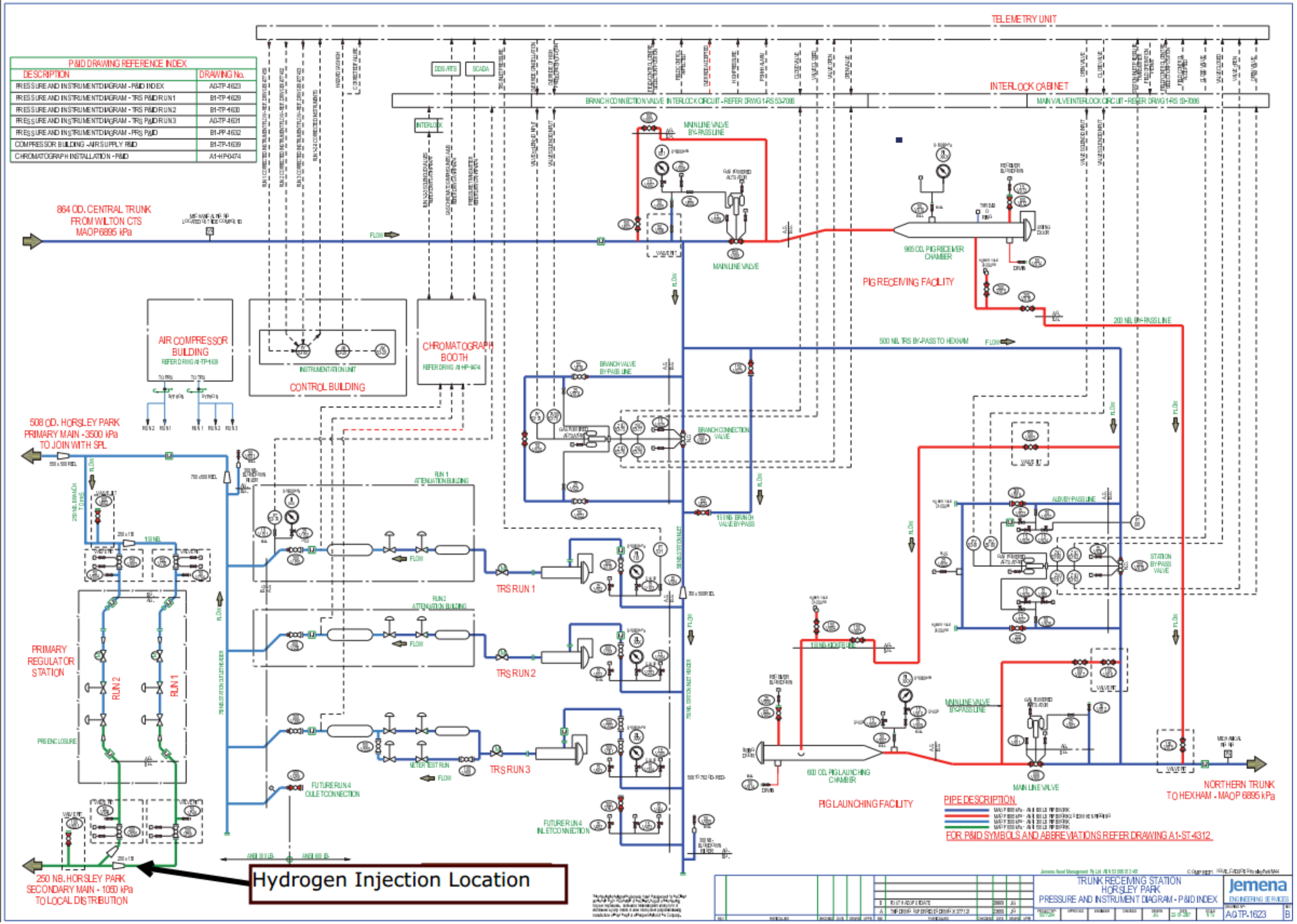
Radioactivity has not been significant in most Australian gases. The level indicated is in line with Western Australian practice and provides guidance for the development of future gas sources and interstate gas transfers.

Radioactivity in natural gas is due primarily to radon. The limit of 600 Bq/m^3 is such that the contribution of combustion products to the indoor radiation level will not exceed the exposure monitoring limit of 200 Bq/m^3 set by the Australian Radiation Protection and Nuclear Safety Agency and will not add significantly to the background level in a house or factory from gas combustion. The average concentration of radon in Australian homes is about 12 Bq/m^3.

Radon is a chemically inert gas which produces radiation as it decays to polonium 218. Polonium 218 also then produces radiation as it decays to lead 214. This sequence of decay continues with the creation and decay of several different isotopes of polonium, lead and bismuth, and finally lead 206 which does not decay further. Thus the decay products of radon can create heavy-metal dusts which may accumulate in pipelines, vessels, filters, etc. In systems where natural gas is known to contain radon, appropriate protective measures should be taken in dealing with dust accumulations. The differing rates of decay of the various isotopes mean that most of the radon-initiated dust will consist of isotopes of lead.

APPENDIX 2 REFERENCE DRAWINGS

Appendix 1A Horsley Park TRS P&ID (injection location shown)



Appendix I Noise and Vibration Assessment

MARSHALL DAY Acoustics

WESTERN SYDNEY GREEN GAS PROJECT
ENVIRONMENTAL NOISE ASSESSMENT

Rp 001 R01 20190608 | 8 November 2019

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Project:	**WESTERN SYDNEY GREEN GAS PROJECT**
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1.0 INTRODUCTION

Jemena Gas Networks (NSW) Ltd (Jemena) propose to undertake a Power to Gas (P2G) project, at the Horsley Park high pressure gas facility. The trial project involves transformation of electrical energy into a hydrogen gas either for injection into the Sydney gas network, for fuel supply to an adjacent hydrogen bus refuelling facility, or power generation back into the electricity grid by means of gas microturbines. The proposal is referred to as the Western Sydney Green Gas Project (WSGGP).

It is understood that the WSGGP has been declared a State Significant Development (SSD 10313) under the Environmental Planning and Assessment Act 1979 (EP&A Act) and Environmental Planning and Assessment Regulation 2000. On this basis draft Secretary Environmental Assessment Requirements (SEARs) have been issued.

The draft SEARs outline a requirement for the assessment of noise and vibration for the construction and operation of the project.

Eco Logical Australia, on behalf of Jemena has engaged Marshall Day Acoustics to investigate potential noise impacts due to the construction and operation of the new facility. This report presents the results of an assessment of operational and construction noise associated with the project.

The assessment of operational noise has been undertaken in accordance with the requirements of the NSW EPA's Noise Policy for Industry (NPfI).

The operational noise assessment presented in this report is based on:

- Operational noise limits determined in accordance with the NPfI, accounting for existing background noise levels at neighbouring sensitive locations;
- Predicted noise levels for the WSGGP based on the proposed site layout and noisy equipment; and
- A comparison of the predicted noise levels with the criteria derived in accordance with the NPfI.

The assessment of construction noise and vibration assessment has been undertaken in accordance with the requirements of the Environment Protection Authority's (EPA) *Interim Construction Noise Guideline (ICNG)* and Environment Protection Authority's (EPA) *Assessing Vibration: A Technical Guideline (AV:TG).*

Acoustic terminology used in this report is described in Appendix A.

2.0 SECRETARY ENVIRONMENTAL ASSESSMENT REQUIREMENTS

The Secretary Environmental Assessment Requirements for application SSD 10313 states the following:

> *'The EIS must address the following specific issues with the level of assessment of likely impacts proportionate to the significance of, or degree, of impact on, the issue, within the context of the project location and the surrounding environment:..'*

Noise and vibration are listed as a specific issue. An extract of the SEARs requirements for noise and vibration is presented in Figure 1.

Figure 1: SEARs requirement for noise and vibration.

- **Noise and Vibration** – including:
  - an assessment of the likely construction noise impacts of the project under the *Interim Construction Noise Guideline* (DECCW, 2009);
  - an assessment of the likely operational noise impacts of the project under the *NSW Industrial Noise Policy (EPA, 2000)*;
  - an assessment of the likely road noise impacts of the project under the *NSW Road Noise Policy* (EPA, 2011); and
  - an assessment of the likely vibration amenity and structural impacts of the project under *Assessing Vibration: A Technical Guideline* (DEC, 2006) and *German Standard DIN 4150-3 Structural Vibration – effects of vibration on structures*;

3.0 SITE AND PROJECT DESCRIPTION

3.1 Site description

The proposed WSGGP development site is within an existing Jemena Gas Network facility on Chandos Road, Horsley Park. The site is located on land within the Western Sydney Parklands (WSP) within the Fairfield City Council (FCC) area.

The land surrounding the site is predominantly bushland with low density, semi-rural residential properties in the immediate environs.

3.2 Site operations

The WSGGP involves transformation of electrical energy into a hydrogen gas either for injection into the Sydney gas network, for fuel supply to an adjacent hydrogen bus refuelling facility, or power generation back into the electricity grid by means of gas microturbines.

The major equipment items will be the electrolyser processing package and electrolyser power package (equipment housed in shipping containers), air cooled chiller and water pump. Various tanks and a network of pipes will also be used to connect and integrate the system. Most site equipment will be located within a compound measuring ≈ 27m x 22m.

Buses will access the refuelling bay adjacent to the equipment compound via the existing facility access road off Chandos Road.

An equipment layout drawing (PWG-2099-DW-CV-001 rev F dated 9/4/2019) is presented in Appendix B.

3.3 Nearest residential receivers

The nearest residential dwellings are identified in the project scoping report[1]. A summary of the nearest residential receivers considered in this assessment is presented in Table 1. For brevity, a reference has been assigned to each receiver, consistent with those in the scoping report. The location of the site in relation to the nearest residential receptor is presented in Figure 2.

Table 1: Nearest residential receivers considered in assessment

Receiver reference	Address	Distance to nearest site boundary (m)
R1	187-201 Chandos Road	≈ 90
R3	203-209 Chandos Road	≈ 130
R6	168-174 Chandos Road	≈ 160

[1] Jemena – Western Sydney Green Gas Trial Jemena Gas Networks (NSW) Ltd GPA Document No: 18667-REP-003

Figure 2: Site location relative to nearest residential receptor

3.4 Operating hours

3.4.1 Operations

The site would operate 365 day per year for the duration of the 5-year trial period. It is understood that the hydrogen production equipment would operate intermittently over a 24-hour period, depending on the hydrogen demand.

Use of the microturbine for power generation can be restricted if required in order to satisfy noise limit requirements.

3.4.2 Construction

Construction activities would be limited to the following hours:

- 0700 – 1800hrs Monday – Friday
- 0800 – 1300hrs Saturday

No activities likely to generate noise would be carried out on Sundays or Public Holidays or outside standard construction hours.

3.5 Noise sources

3.5.1 Operational equipment

Details of the operational equipment associated with the WSGGP have been provided by GPA Engineering. Based on discussions with GPA Engineering, the following noisy equipment items have been identified and considered in this assessment:

- Microturbine

- Extraction fan
- Wastewater pump
- Electrolyser package – Power container
- Transformer
- Electrolyser chiller/condenser
- Chiller (Dry cooler)
- Refueller package – compressor
- Refueller package – Chiller
- Buses (1 accessing site, 1 refuelling)
- Discharge vents (hydrogen, oxygen, blow down)

Equipment noise level data is provided in Appendix F.

Bus and vehicle movements

Some noise will be generated on the site by buses accessing the refuelling facility. The expected number of buses is in the order of three buses per day, to a maximum of seven per day.

In addition to buses, vehicles will access the site for maintenance of the WSGGP facility however this would be infrequent. The scoping document states that up to three trucks per month would access the site for wastewater removal purpose.

For the purposes of vehicle noise assessment, is has been assumed up to 3 buses per day would access the site and, during a worst-case 15-minute assessment period, two buses would access the site.

3.5.2 Proposed construction works

Based on information provided by GPA Engineering, the anticipated construction stages that may generate significant noise will be as follow:

- Trenching, lay pipeline, covering
- Civil and foundation works for major equipment and access road
- Piping, tubing and cabling between major equipment

4.0 NOISE SURVEY DETAILS

4.1 Attended noise survey

An attended noise survey was carried out near the site on Wednesday 11 September 2019, during the noise logger deployment site visit between 1400-1500hrs. The purpose of the survey was to make observation of the noise environment at each of the noise logger locations and to carry out spot measurement for noise logger level validation purposes.

The spot measurement results have not been reported here but were found to be consistent with measured logger noise level for the same time of day. Details of the observations at each location are provided in the relevant sections below.

4.2 Unattended noise survey

Ambient and background noise levels at the site were measured using ARL EL-316 precision integrating noise loggers fitted with weatherproof windshields. Two noise loggers were deployed at the site; one near the southern site boundary (herein referred to as Logger 1); and, one on the southern side of Chandos Road opposite the site, at a location considered to have a noise environment that was representative of the nearest residential receiver (herein referred to as Logger 2). The logger locations are shown in Appendix C.

The loggers were configured to continuously measure noise levels over consecutive 15-minute periods. Measurements were obtained using the fast (‘F’) response time and A-weighting frequency network.

The logger microphones were mounted on poles at a height of approximately 1.5m above ground level in freefield conditions.

A field calibration check was carried out during equipment deployment and at retrieval and no significant change in level was noted for the survey period.

4.2.1 Weather conditions

All measured noise levels have been correlated to weather data taken from the Horsley Park Equestrian Centre Bureau of Meteorology (BOM) weather station which is located approximately 5km to the south of the subject site.

Some periods of the measurement survey were affected by rainfall or strong winds and therefore this data has been excluded from the analysis, in accordance with the NPfI. For days when there were significant periods of weather affected data, the entire day has been excluded from the analysis. The days are identified in the analysis in the following sections.

4.3 Discussion

Review of the logger data shows noise levels patterns consistent with a city fringe semi-rural setting. During weekday periods, noise levels increase during the early morning period most likely due to peak hour traffic on the M7 and other nearby roads. Levels tend to drop during the middle of the day and steadily rise in the early evening and into the night-time period, again likely as a result of increasing traffic volumes. It was noted that the lowest background levels on some days occurred during the middle of the day which could be considered unusual but is plausible given the nature of the surrounding area.

In general, the daily background levels were relatively consistent during weekday periods. Background noise levels on weekend days were noticeably lower, particularly on Sundays.

Review of the noise level data shows good consistency between the two loggers, as would be expected given the proximity of the locations. In general, background levels at Logger 2 (southern site boundary) were higher than Logger 1, most likely due to the greater influence on existing gas facility operations at the Logger 2 location.

For the purposes of this noise assessment, the noise criteria applicable at the nearest residential receivers will be derived using the approach defined in the NPfI and based on the Logger 2 data, as presented in Appendix D.

4.4 Noise level summary

In the EPA’s NSW Noise Policy for Industry (NPfI), the background noise level is termed the Rating Background Level (RBL) and is used to derive assessment criteria for environmental noise. The RBL and L_{Aeq} noise levels for the relevant Day, Evening and Night periods have been derived in accordance with the procedures detailed in the NPfI and based on the Logger 2 data. A summary of the RBL and L_{Aeq} noise levels is provided in Table 2.

Table 2: NPfI time periods and measured background noise levels summary

Period	Time of day	RBL, $L_{A90,15min}$ (dB)	$L_{Aeq,15min}$ (dB)
Day	0700-1800hrs	41	54
Evening	1800-2200hrs	43	52
Night	2200-0700hrs	41	52

5.0 PROJECT NOISE CRITERIA

5.1 Operational noise (Project Noise Trigger Levels)

As per the SEARs, operational noise associated with the WSGGP development must be assessed in accordance with the NPfI. The NPfI outlines noise levels to be achieved at the residential and commercial boundaries adjoining industrial development. These levels are referred to as Project Noise Trigger Levels and are used to assess the potential impacts of noise from industry and indicate the noise level at which feasible and reasonable noise management measures should be considered.

The Project Noise Trigger Levels applicable to the WSGGP are outlined in. A full derivation of these levels is provided in Appendix E.

Table 3: Project Noise Trigger Levels applicable to the WSGGP

Receiver type	Time of day	Project Trigger Level $L_{Aeq, 15min}$ (dB)
Residential	Day	46
	Evening	43
	Night	38
Commercial	When is use	63

5.2 Operational noise (Maximum noise level events)

The NPFI provides the following maximum event noise criteria to determine when a detailed assessment of maximum noise level events should be conducted for the night-time period:

- $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,

In this case the L_{AFmax} criterion is governed by the RBL and is L_{AFmax} 56 dB.

The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period.

5.1 Construction noise criteria

As per the SEARs, construction noise associated with the WSGGP development must be assessed in accordance with the Environment Protection Authority's (EPA) *Interim Construction Noise Guideline* (ICNG).

It is assumed that demolition and construction activities on-site will comply with the recommended standard hours for construction work on-site, as described in the ICNG:

- Monday to Friday 0700hrs to 1800hrs
- Saturday 0800hrs to 1300hrs

- No work on Sundays or public holidays

Primary site access will be via Chandos Road.

Construction noise criteria for the project have been derived based on the background levels (RBL) in Table 2 and are presented Table 4. Only the day-time period is considered as no construction work is expected outside of this period.

Table 4: Construction noise management levels

Receiver type	Management level type	ICNG Management Level, dB $L_{Aeq, 15min}$
Residential	Noise affected	51 (external)
	Highly noise affected	75 (external)
Commercial	All	75 (external)

The ‘noise affected’ level is the point above which there may be some community reaction to noise. The ‘highly noise affected’ level represents the point above which there may be a strong community reaction to noise. Where the “noise affected” management level is predicted to be exceeded, the ICNG requires that all feasible and reasonable work practices be employed. Where it is predicted that the “highly noise affected” management level will be exceeded, respite periods may need to be considered.

5.2 Construction vibration criteria

As per the SEARs, assessment of vibration must be carried out considering the following:

- The assessment of construction vibration effects on structures must be assessed in accordance the *German standard DIN4150-3 Structural vibration – Effects of vibration on structures -1999*.
- The assessment of vibration effects on people must be assessed in accordance with the EPA document *Assessing Vibration: A Technical Guideline*

5.2.1 Vibration limits – Effects on structures

DIN 4150-3 provides guidelines to use when evaluating the effects of short-term vibration on structures. The guideline vibration limits, as reproduced from the standard, are detailed in Table 5.

Table 5: Vibration limits according to DIN 4150: Peak Particle Velocity (PPV) mm/s

Line	Type of structure	Vibration at the foundation of building, at a frequency of			Vibration in horizontal plane of highest floor, at all frequencies
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz and above	
I	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40
II	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15

Line	Type of structure	Vibration at the foundation of building, at a frequency of			Vibration in horizontal plane of highest floor, at all frequencies
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz and above	
III	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines I and II and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8

Experience has shown that if the guideline values of Table 5 are complied with, damage which reduces the serviceability of the building is unlikely to occur. As the DIN standard is commonly accepted by industry, the criterion of 5mm/s PPV for dwellings is considered appropriate for this assessment.

5.2.2 Vibration limits – Effects on people

The EPA document *Assessing vibration: A technical guideline* (AV:TG), provides a vibration dose value (VDV) criteria to assess the severity of intermittent vibration, such as that experienced from construction activities. The VDV criteria for residential receivers as detailed in the guideline are provided in Table 6.

Table 6: Acceptable vibration dose values for intermittent vibration (VDV m/s$^{1.75}$)

	Day-time[1]	
Receiver type	Preferred value	Maximum value
Residences	0.20	0.40
Offices	0.40	0.80

[1] 16-hour day period 0600-2200hrs.

The preferred values indicate a low probability of adverse comment, and the maximum values indicate that adverse comments may be expected.

6.0 NOISE MODELLING

A noise model has been prepared to determine the noise levels at the nearest noise sensitive receivers.

6.1 Noise Prediction Method

To predict noise levels at the measurement locations and nearby noise-sensitive receivers, the following factors have been considered:

- The amount of noise being generated at the site during operational times
- The distance between the sources and receivers
- The presence of obstacles such site buildings that obstruct the noise path
- The hardness of ground between the source and receiver

The following sections describe the data used to quantify the noise generated from the proposed operations and the modelling used to extrapolate that data to surrounding receiver locations, accounting for the above factors.

6.2 Noise model details

A 3-dimensional digital model of the site and surrounding built environment has been created using SoundPLAN proprietary modelling software (version 8.1).

Topographical and geometry data for the model has been sourced from the client. The geometries in the model are simplified representations of the built environment that have been configured to a level of detail that is appropriate for noise calculation purposes.

The SoundPLAN digital model has been used to calculate noise levels using the International Standard *ISO 9613-2: 1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613). ISO 9613 is a general environmental noise calculation standard that has been used extensively throughout Australia, New Zealand, and Europe since its publication in 1996.

The implementation of ISO 9613 within proprietary noise modelling software enables multiple sound transmission paths, including reflected and screened paths, to be accounted for in the calculated noise levels. While atmospheric effects are expected to have a negligible effect on the transmission of sound from the facility to neighbouring sensitive receiver locations, it is noted that the ISO 9613 predicts noise levels for conditions which favour the propagation of noise.

Key aspects of the model, including the model inputs and source noise level data, are summarised in Appendix F.

6.3 Noise model scenarios and assumptions

6.3.1 Operational noise

Two operational noise model scenarios have been considered in this assessment: operational noise from equipment that typically operates in a constant or continuous manner; and, operational noise from equipment that operates intermittently and is associated with maximum noise level events. The equipment considered in each scenario is outlined in Table 7.

The operational noise model for continuous noise sources has been prepared for assessment against the NPfI Trigger Levels criteria. This model assumes all equipment operating simultaneously and at full capacity, except for buses accessing the site. For buses using the access road, a duration adjustment has been applied to account for the period it takes for the buses to travel along the access road.

The operational noise model for single noisy events has been prepared for assessment against the NPfI maximum noise level criteria. It should be noted that venting events from the sources listed for the maximum event noise scenario are only likely to occur very occasionally and would not be considered a regular occurrence.

Building screening

For each of the operational noise models, the screening effects of existing and new site buildings, as well as off-site buildings near the receiver locations have been taken into account. The height of site buildings is based on information provided by GPA Engineering. The height of off-site buildings has been assumed as being single storey based on site observations and photographs.

Table 7: Operational noise scenarios

Operational noise scenario	Sources considered in model
Continuous noise	– Microturbine – Extraction fan – Wastewater pump – Electrolyser package – Power container – 1 x buses driving along access road and 1 refuelling – Transformer – Electrolyser chiller/condenser – Chiller (Dry cooler) – Refueller package – compressor – Refueller package – Chiller – 1 bus accessing site, 1 bus refuelling (considered for day and evening periods only)
Maximum event noise	– Hydrogen vent – Oxygen Vent – Pipeline Blow down vent

Mitigation options

Preliminary modelling found that the noise contribution from operation of the microturbine may give rise to noise levels exceeding the NPfI Project Trigger Levels at receiver R1. Three options have therefore been considered in the assessment to demonstrate compliance. Details and assumptions regarding each mitigation option are presented in Table 8.

Table 8: Microturbine mitigation options

Option #	Mitigation name	Description and assumptions
1	Reduced operating times	Under this scenario, the microturbine would be operated only during the NPfI daytime and evening periods
2	Noise screen	Construct a noise screen to the south side of the turbine, as shown in Figure 3. The screen should be at least 0.5m higher than the top of the microturbine and extend 1m beyond the microturbine extents. The screen construction should have a minimum surface density of 12kg/m^3 and be free of gaps.
3	Relocate unit	Move the microturbine approximately 5m to the west of the current location, as shown in Figure 4. At this location, sufficient screening is provided by the new site buildings so that compliance can be demonstrated at all receivers.

Figure 3: Mitigation option #2 - microturbine noise screen

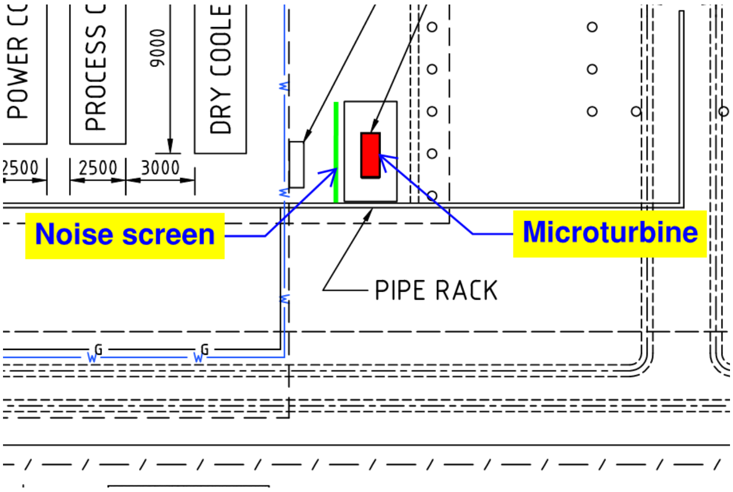
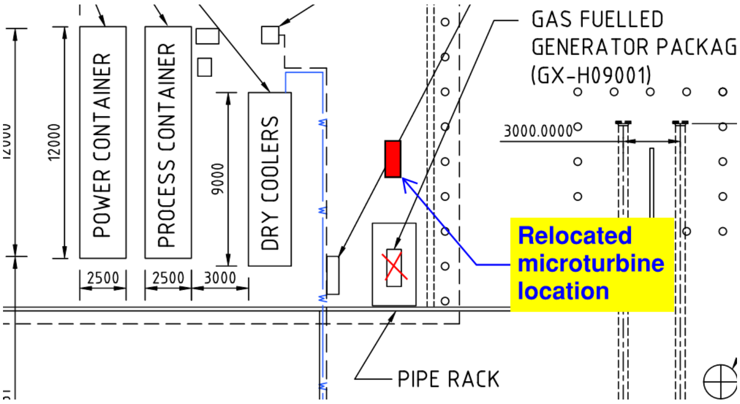


Figure 4: Mitigation option #3 - microturbine relocated



6.3.2 Construction noise

GPA Engineering has outlined the major plant items required to conduct each of the three noisy construction stages considered in this assessment.

For the purpose of our calculations, we have conservatively assumed that plant items will be operating for 100% of the time over a 15-minute period except for deliveries. In practise such a worst-case scenario may not occur, and noise levels will be lower. Duration adjustments applied to deliveries are outlined in Appendix F.

For modelling purposes, it has been assumed that the plant will operate in the general area surrounding the new equipment hard stand area.

Building screening

For each of the construction noise models scenarios, the screening effects of existing site buildings, as well as off-site buildings near the receiver locations have been taken into account. The screening effects of new site buildings has not been considered in the models since these would not be in place until after construction has commenced.

6.3.3 Corrections for annoying noise characteristics

Where a noise source contains certain characteristics, such as tonality or dominant low-frequency, adjustment corrections to the measured or predicated levels may be applicable, as outlined in Fact Sheet C of the NPfI. The required noise level measurement data is not available to make an informed assessment at this stage, however given the relatively low noise prediction (see Section 7.1) the risk of audible annoying noise characteristics is considered low, and no corrections have been applied.

Assessment of annoying noise characteristics could be carried out during commission to confirm this assumption.

6.4 Operational noise sources

Input noise levels for the operation of the facility have been taken from information provided by the client, past MDA projects, and information held within our in-house noise database.

Overall input noise levels and other details are presented in Table 9. The octave band data is presented in Appendix F

Table 9: Input Sound Power level data – operational plant

Equipment	Qty	Source Reference	Sound power level L_{WA} dB
Microturbine	1	Phoenix-E test report dated July 18 2008. (provided by GPA Engineering)	93
Chiller (Dry cooler)	1	dB(A) level from scoping report. Spectrum from MDA database (2011348PR)	92
Electrolyser chiller/condenser	1	dB(A) level from scoping report. Spectrum from MDA database (record ID 220)	65
Extraction fan	1	Provided by GPA	82
Wastewater pump	1	From MDA database (2014338SY)	78
Hydrogen vent	1	dB(A) level from GPA, spectrum from dbView record 2576	122
Oxygen Vent	1	dB(A) level from GPA, spectrum from dbView record 2576	122
Pipeline Blow down vent	1	dB(A) level from GPA, spectrum from dbView record 2576	122
Electrolyser package – Power container	1	Internal level from GPA. Spectral data from transformer, 10dB adjustment from inside to outside	68
Transformer	1	dB(A) level from data sheet provided. Spectrum from MDA database (record ID 4202)	78
Refueller package – compressor	1	dB(A) level from GPA. Spectrum from MDA database (record ID 220)	83
Refueller package – Chiller	1	dB(A) level from GPA. Spectrum from MDA database (record ID 220)	68
Bus movements	1	MDA database (record ID 3701)	94
Bus idling	1	MDA database (record ID 3702)	83

6.5 Construction noise sources

Sound power levels for the nominated items have not been provided. To determine appropriate sound power data for assessment purposes, specifications of nominated equipment have been cross referenced with that of measured equipment detailed in the following standards:

- *BS 5228-1:2009 - Code of practice for noise and vibration control on construction and open sites – Part 1: Noise*

Nominated equipment, source reference and overall sound power data used for assessment are detailed in Table 10. The octave band data is presented in Appendix F.

Table 10: Input Sound Power level data – construction plant

Activity	No(s)	Equipment	Source Reference	Activity L_w dB
Trenching, lay pipeline, cover	1	Tracked excavator (20t)	BS 5228-1:2009 Table C.6:11	103
	1	Tipper lorry	BS 5228-1:2009 Table C.8:20	107
	1	Semi-trailer/delivery truck	BS 5228-1:2009 Table C.11:11	114
	1	Wheeled backhoe loader	BS 5228-1:2009 Table C.4:66	97
Civil and foundation works for major equipment and access road.	1	Concrete mixer truck (discharging) & concrete pump (pumping)	BS 5228-1:2009 Table C.4:28	103
	1	Tracked excavator (20t)	BS 5228-1:2009 Table C.6:11	103
	1	Semi-trailer/delivery truck	BS 5228-1:2009 Table C.11:11	114
	1	Tipper lorry	BS 5228-1:2009 Table C.8:20	107
	1	Wheeled backhoe loader	BS 5228-1:2009 Table C.4:66	97
Piping, tubing and cabling between major equipment	1	Mobile telescopic crane (100t)	BS 5228-1:2009 Table C.4:41	99
	1	Telescopic handler (4t)	BS 5228-1:2009 Table C.4:54	107
	1	Semi-trailer/delivery truck	BS 5228-1:2009 Table C.11:11	114
	1	Tracked excavator (20t)	BS 5228-1:2009 Table C.6:11	103
	1	Angle grinder	BS 5228-1:2009 Table C.4:93	109

6.6 Locations assessed

The three nearest residential receivers, as outlined in Table 1 have been included for assessment in the noise model.

With regard to receptor locations in the noise model, Section 2.6 of the NPfI states the following:

> *'For a residence, the project noise trigger level and maximum noise levels are to be assessed at the reasonably most-affected point on or within the residential property boundary or, if that is more than 30 metres from the residence, at the reasonably most-affected point within 30 metres of the residence…'*

For receiver R1, the distance between the nearest boundary fence the dwelling itself is less than 30m. Therefore, the assessment location in the noise model has been placed at the nearest point on the property boundary. For receiver R3 and R6, the assessment location in the noise model has been placed at 30m from the dwelling.

7.0 NOISE ASSESSMENT

7.1 Operational noise

Predictions of the typical operational noise emission from the site have been calculated based on the assumptions outlined in Section 6.3. Results are presented below for the base case and the three mitigation options, as described in Table 8.

Table 11: Predicted operational noise levels – Base case

Receiver	Predicted noise level, L_{Aeq} dB	Project Trigger Levels (L_{Aeq})			Compliance
		Day	Evening	Night	
R1	38	46	43	38	Marginal
R3	32	46	43	38	✓
R6	34	46	43	38	✓

Table 12: Predicted operational noise levels – Mitigation option #1 (reduced operating times)

Receiver	Predicted noise level, L_{Aeq} dB day & eve (night)	Project Trigger Levels (L_{Aeq})			Compliance
		Day	Evening	Night	
R1	38 (35)	46	43	38	✓
R3	32 (30)	46	43	38	✓
R6	34 (32)	46	43	38	✓

Table 13: Predicted operational noise levels – Mitigation option #2 (noise screen)

Receiver	Predicted noise level, L_{Aeq} dB	Project Trigger Levels (L_{Aeq})			Compliance
		Day	Evening	Night	
R1	36	46	43	38	✓
R3	31	46	43	38	✓
R6	34	46	43	38	✓

Table 14: Predicted operational noise levels – Mitigation option #3 (relocated unit)

Receiver	Predicted noise level, L_{Aeq} dB	Project Trigger Levels (L_{Aeq})			Compliance
		Day	Evening	Night	
R1	37	46	43	38	✓
R3	32	46	43	38	✓
R6	34	46	43	38	✓

The assessment results in Table 11 to Table 14 demonstrate that operational noise from the WSGGP can be compliant with the applicable noise limit during all assessment periods, however mitigation options would need to be implemented to address noise from the microturbine.

7.1.1 Maximum noise level events (venting)

The predicted maximum noise levels for single events (gas venting) are presented in Table 15. As stated above, venting events are only likely to occur very occasionally (less than once per week) and would not be considered a regular occurrence.

The NSW Road Noise Policy states that 'one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly'. It should be noted that the predicted levels in Table 15 are external levels and internal levels inside dwellings are likely to be at least 10-15dB lower.

In consideration of this, and the frequency of vent noise events expected, it is not considered necessary to apply noise control measures to these noise sources.

Table 15: Predicted operational noise levels

Receiver	Predicted noise level, L_{AFmax} dB
R1	67
R3	63
R6	61

7.2 Construction noise and vibration

Predictions of the construction noise emission from the site for each of the key construction stages have been calculated based on the assumptions outlined in Section 6.3 and are presented below in Table 16 to Table 18.

Table 16: Predicted construction noise levels - Trenching, lay pipeline, cover

		Noise affected		Highly noise affected	
Receiver	**Calculated noise level, dB** $L_{Aeq, 15min}$	**Criteria** $L_{Aeq, 15min}$	**Exceedance, dB**	**Management level, dB** $L_{Aeq,15min}$	**Exceedance, dB**
R1	52	51	1	75	-
R3	46	51	-	75	-
R6	47	51	-	75	-

Table 17: Predicted construction noise levels - Piping, tubing

		Noise affected		Highly noise affected	
Receiver	**Calculated noise level, dB** $L_{Aeq, 15min}$	**Criteria** $L_{Aeq, 15min}$	**Exceedance, dB**	**Management level, dB** $L_{Aeq,15min}$	**Exceedance, dB**
R1	53	51	2	75	-
R3	48	51	-	75	-
R6	47	51	-	75	-

Table 18: Predicted construction noise levels - Trenching, lay pipeline, cover

		Noise affected		Highly noise affected	
Receiver	**Calculated noise level, dB** $L_{Aeq, 15min}$	**Criteria** $L_{Aeq, 15min}$	**Exceedance, dB**	**Management level, dB** $L_{Aeq,15min}$	**Exceedance, dB**
R1	54	51	4	75	-
R3	48	51	-	75	-
R6	48	51	-	75	-

The predicted L_{Aeq} levels from the proposed construction steps and nominated equipment indicate that noise from construction will exceed the ''noise affected'' goals from the EPA criteria at some residential receivers by up to 4dB. Predicted noise levels are comfortably within the "Highly Affected" noise goals for all steps. It should be noted that these outcomes are based on the conservative assumption that all equipment would be operating simultaneously.

On-site noise measurements indicate an average daytime noise level of $L_{Aeq\ 15\ min}$ 54 dB, as such, predicted exceedances are unlikely to be intrusive when considering the existing noise environment. Additionally, since all construction work is restricted to take place only during the daytime, noise impacts to the residential receiver will not be experienced during the most sensitive time period i.e. night-time.

Since the predicted $L_{Aeq,\ (15min)}$ is greater than the "noise affected level", in accordance with the ICNG the following should be implemented:

- the proponent should apply all feasible and reasonable work practices to meet the noise affected level.

- The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

7.2.1 Vibration assessment

Given the separation distances to residential receivers (see Table 1) and the types of construction activities, the risk of vibration impacts is considered to be insignificant and therefore vibration has not been assessed in detail. Notwithstanding this, vibration generating activity should be minimised were possible through the construction methodologies and selection of appropriate construction equipment.

8.0 CONCLUSION

Eco Logical Australia, on behalf of Jemena has engaged Marshall Day Acoustics to investigate potential noise impacts due to the construction and operation of the Western Sydney Green Gas Project (WSGGP). The project involves transformation of electrical energy into a hydrogen gas either for injection into the Sydney gas network, for fuel supply to an adjacent hydrogen bus refuelling facility, or power generation back into the electricity grid by means gas microturbines.

A noise logging survey was conducted near the site to measure the existing background noise levels and operational and construction noise limits have been calculated on the basis of the survey results.

A noise model of the site has been created to predict noise levels from the construction and operational phases of the project. The model has taken into account the noise for relevant plant and equipment that will operate at the site and noise from construction activities.

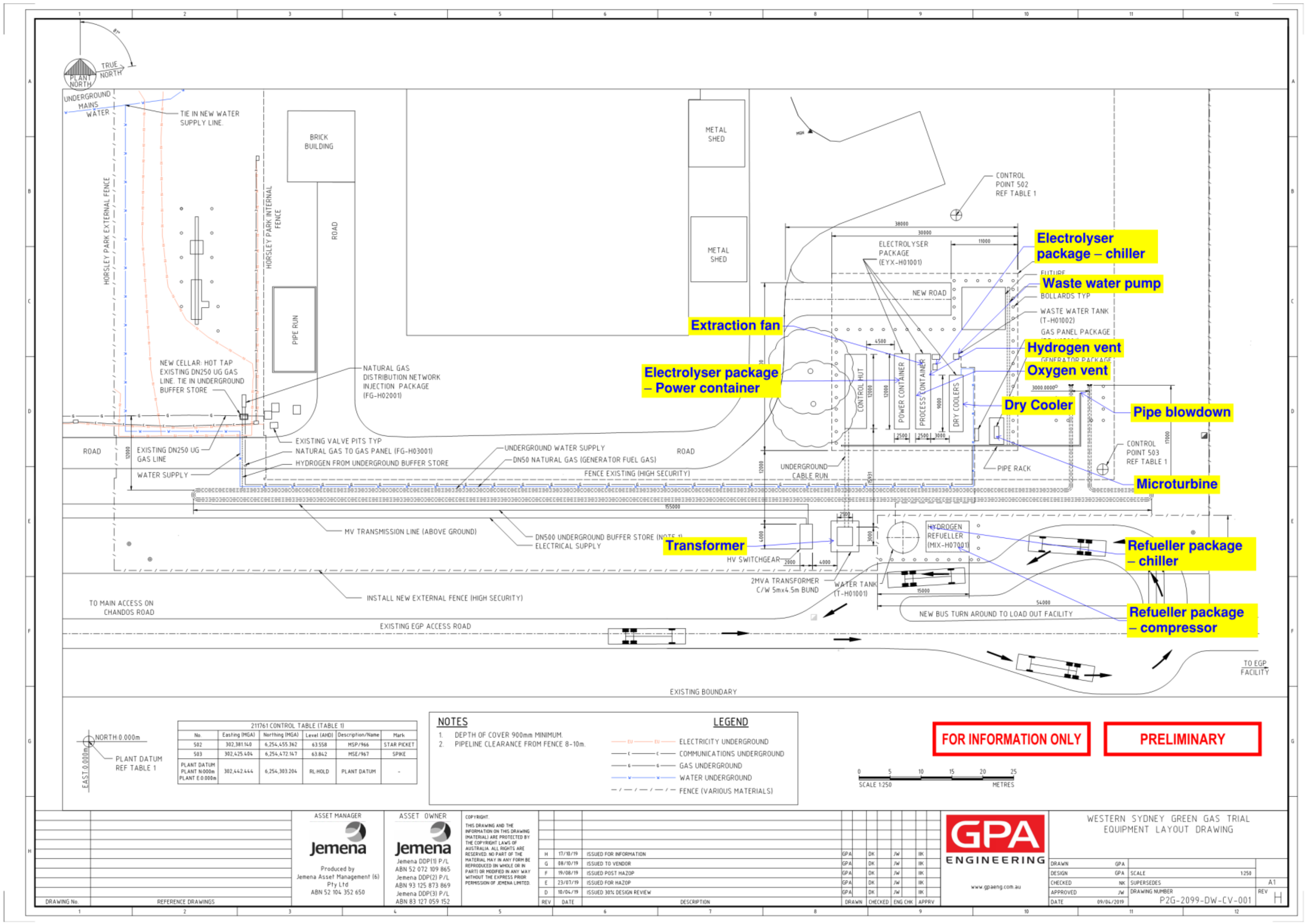
Calculations have shown that, based on the assumptions detailed in Section 6.3, the operation of the facility can comply with the relevant NPfI noise limits during all assessment periods provided one of the mitigation options is implemented to address noise from the microturbine unit, as described in Section 6.3.1.

Noise predications of construction activities were found to exceed the ICNG 'noise affected' levels at some locations, based on the conservative assumption that all plant would operate simultaneously. It is therefore recommended that all feasible and reasonable work practices are implemented to meet the noise affected level and the proponent should inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

APPENDIX A GLOSSARY OF TERMINOLOGY

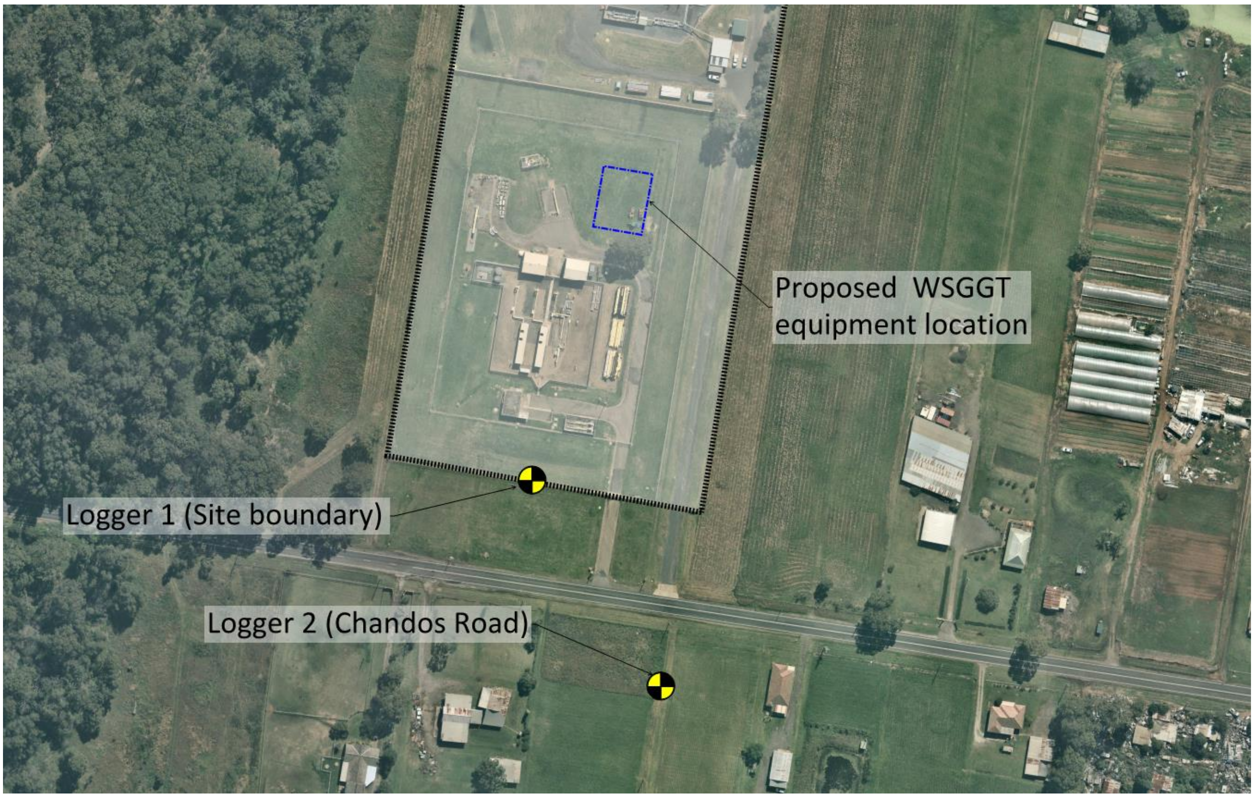
Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
C-weighting	The process by which noise levels are corrected to account for non-linear frequency response of the human ear at high noise levels (typically greater than 100 decibels).
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 µPa i.e. dB = 20 x log(P/Pr)
dBA	The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
Frequency	The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).
$L_{A90\,(t)}$	The A-weighted noise level equalled or exceeded for 90% of the measurement period. This is commonly referred to as the background noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
$L_{Aeq\,(t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
Octave Band	A range of frequencies where the highest frequency included is twice the lowest frequency. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.
SPL or L_P	Sound Pressure Level A logarithmic ratio of a sound pressure measured at distance, relative to the threshold of hearing (20 µPa RMS) and expressed in decibels.
SWL or L_W	Sound Power Level A logarithmic ratio of the acoustic power output of a source relative to 10^{-12} watts and expressed in decibels. Sound power level is calculated from measured sound pressure levels and represents the level of total sound power radiated by a sound source.

APPENDIX B Equipment Layout Drawing



Electrolyser package – chiller
Waste water pump
Extraction fan
Hydrogen vent
Oxygen vent
Electrolyser package – Power container
Dry Cooler
Pipe blowdown
Microturbine
Transformer
Refueller package – chiller
Refueller package – compressor
TRUE NORTH
PLANT NORTH
UNDERGROUND MAINS WATER
TIE IN NEW WATER SUPPLY LINE
BRICK BUILDING
METAL SHED
METAL SHED
HORSLEY PARK EXTERNAL FENCE
HORSLEY PARK INTERNAL FENCE
ROAD
PIPE RUN
NEW CELLAR: HOT TAP EXISTING DN250 UG GAS LINE. TIE IN UNDERGROUND BUFFER STORE
NATURAL GAS DISTRIBUTION NETWORK INJECTION PACKAGE (FG-H02001)
CONTROL POINT 502 REF TABLE 1
ELECTROLYSER PACKAGE (EYX-H01001)
NEW ROAD
BOLLARDS TYP
WASTE WATER TANK (T-H01002)
GAS PANEL PACKAGE
CONTROL HUT
POWER CONTAINER
PROCESS CONTAINER
DRY COOLERS
PIPE RACK
CONTROL POINT 503 REF TABLE 1
EXISTING VALVE PITS TYP
NATURAL GAS TO GAS PANEL (FG-H03001)
HYDROGEN FROM UNDERGROUND BUFFER STORE
EXISTING DN250 UG GAS LINE
WATER SUPPLY
UNDERGROUND WATER SUPPLY
DN50 NATURAL GAS (GENERATOR FUEL GAS)
FENCE EXISTING (HIGH SECURITY)
UNDERGROUND CABLE RUN
MV TRANSMISSION LINE (ABOVE GROUND)
ELECTRICAL SUPPLY
HV SWITCHGEAR
HYDROGEN REFUELLER (MIX-H07001)
2MVA TRANSFORMER C/W 5mx4.5m BUND
WATER TANK (T-H01001)
NEW BUS TURN AROUND TO LOAD OUT FACILITY
INSTALL NEW EXTERNAL FENCE (HIGH SECURITY)
TO MAIN ACCESS ON CHANDOS ROAD
EXISTING EGP ACCESS ROAD
TO EGP FACILITY
EXISTING BOUNDARY
PLANT DATUM REF TABLE 1
211761 CONTROL TABLE (TABLE 1)
NOTES
1. DEPTH OF COVER 900mm MINIMUM.
2. PIPELINE CLEARANCE FROM FENCE 8-10m.
LEGEND
ELECTRICITY UNDERGROUND
COMMUNICATIONS UNDERGROUND
GAS UNDERGROUND
WATER UNDERGROUND
FENCE (VARIOUS MATERIALS)
FOR INFORMATION ONLY
PRELIMINARY
SCALE 1:250
METRES
ASSET MANAGER
Jemena
ASSET OWNER
Jemena
GPA ENGINEERING
WESTERN SYDNEY GREEN GAS TRIAL EQUIPMENT LAYOUT DRAWING
ISSUED FOR INFORMATION
ISSUED TO VENDOR
ISSUED POST HAZOP
ISSUED FOR HAZOP
ISSUED 30% DESIGN REVIEW
P2G-2099-DW-CV-001

APPENDIX C Unattended Noise Monitoring Locations



APPENDIX D UNATTENDED NOISE SURVEY RESULTS

D1 Logger 1 (southern site boundary)

Logger 1 was located at the southern boundary of the site and measured 24-hour noise levels between Thursday, 12 September 2019 and Wednesday, 25 September 2019[2]. A photograph showing the installation of the noise logger is presented as Figure 5.

Subjective observations of the noise environment at this location included distant road traffic noise, intermittent road traffic noise on Chandos Road, and faint equipment noise from the existing gas processing operations on the Jemena site and earthmoving operations beyond. Regular light aircraft and helicopter movements were also noted.

Measured background and ambient noise levels are presented in Table 19 and Table 20.

Table 19: Measured background noise levels – Logger 1 (Southern site boundary)

Period	Average Background Noise Level, $L_{A90\ 15mins}$ dB		
	Day	Evening	Night
Thursday, 12 September 2019	46	48	45
Friday, 13 September 2019	45	48	45
Saturday, 14 September 2019	44	47	44
Sunday, 15 September 2019	42	47	44
Monday, 16 September 2019	44	45	-*
Tuesday, 17 September 2019	-*	-*	-*
Wednesday, 18 September 2019	-*	-*	-*
Thursday, 19 September 2019	47	49	46
Friday, 20 September 2019	47	48	45
Saturday, 21 September 2019	48	48	44
Sunday, 22 September 2019	44	46	44
Monday, 23 September 2019	48	49	45
Tuesday, 24 September 2019	45	47	45
Wednesday, 25 September 2019	44	46	44
Median	**45**	**48**	**45**

*- Weather affected measurement (rain or strong winds) or no weather data available

[2] Measurement were made on days either side of these dates but a complete24-hour period was not measured so these days were not included in the analysis.

Table 20: Measured ambient noise levels – Logger 1 (Southern site boundary)

Period	Average Ambient Noise Level, $L_{Aeq\ 15mins}$ dB		
	Day	Evening	Night
Thursday, 12 September 2019	54	52	53
Friday, 13 September 2019	54	52	53
Saturday, 14 September 2019	51	50	50
Sunday, 15 September 2019	52	51	54
Monday, 16 September 2019	54	50	-*
Tuesday, 17 September 2019	-*	-*	-*
Wednesday, 18 September 2019	-*	-*	-*
Thursday, 19 September 2019	54	52	53
Friday, 20 September 2019	56	52	51
Saturday, 21 September 2019	55	51	49
Sunday, 22 September 2019	50	50	52
Monday, 23 September 2019	58	53	55
Tuesday, 24 September 2019	62	53	54
Wednesday, 25 September 2019	53	52	52
Average	**56**	**52**	**53**

* - Weather affected measurement (rain or strong winds) or no weather data available

Figure 5: Noise logger location – Logger 1 (southern site boundary)

D2 Logger 2 (Chandos Road)

Logger 1 was located on the southern side of Chandos Road, opposite the site and measured 24-hour noise levels between Thursday, 12 September 2019 and Wednesday, 25 September 2019. A photograph showing the installation of the noise logger is presented in Figure 6.

Subjective observations of the noise environment at this location included distant road traffic noise, intermittent road traffic noise on Chandos Road. Regular light aircraft and helicopter movements were also noted. Noise from the existing gas processing operations on the Jemena site was not audible at this location.

Measured background and ambient noise levels are presented in Table 21 and Table 22.

Table 21: Measured background noise levels – Logger 2 (Chandos Road)

Period	Average Background Noise Level, $L_{A90\ 15mins}$ dB		
	Day	Evening	Night
Thursday, 12 September 2019	43	43	40
Friday, 13 September 2019	39	44	42
Saturday, 14 September 2019	39	41	41
Sunday, 15 September 2019	35	44	42
Monday, 16 September 2019	37	40	-*
Tuesday, 17 September 2019	-*	-*	-*
Wednesday, 18 September 2019	-*	-*	-*
Thursday, 19 September 2019	44	45	43
Friday, 20 September 2019	43	46	42
Saturday, 21 September 2019	44	46	41
Sunday, 22 September 2019	38	42	40
Monday, 23 September 2019	47	45	42
Tuesday, 24 September 2019	41	42	41
Wednesday, 25 September 2019	40	40	40
Median	**41**	**43**	**41**

*- Weather affected measurement (rain or strong winds) or no weather data available

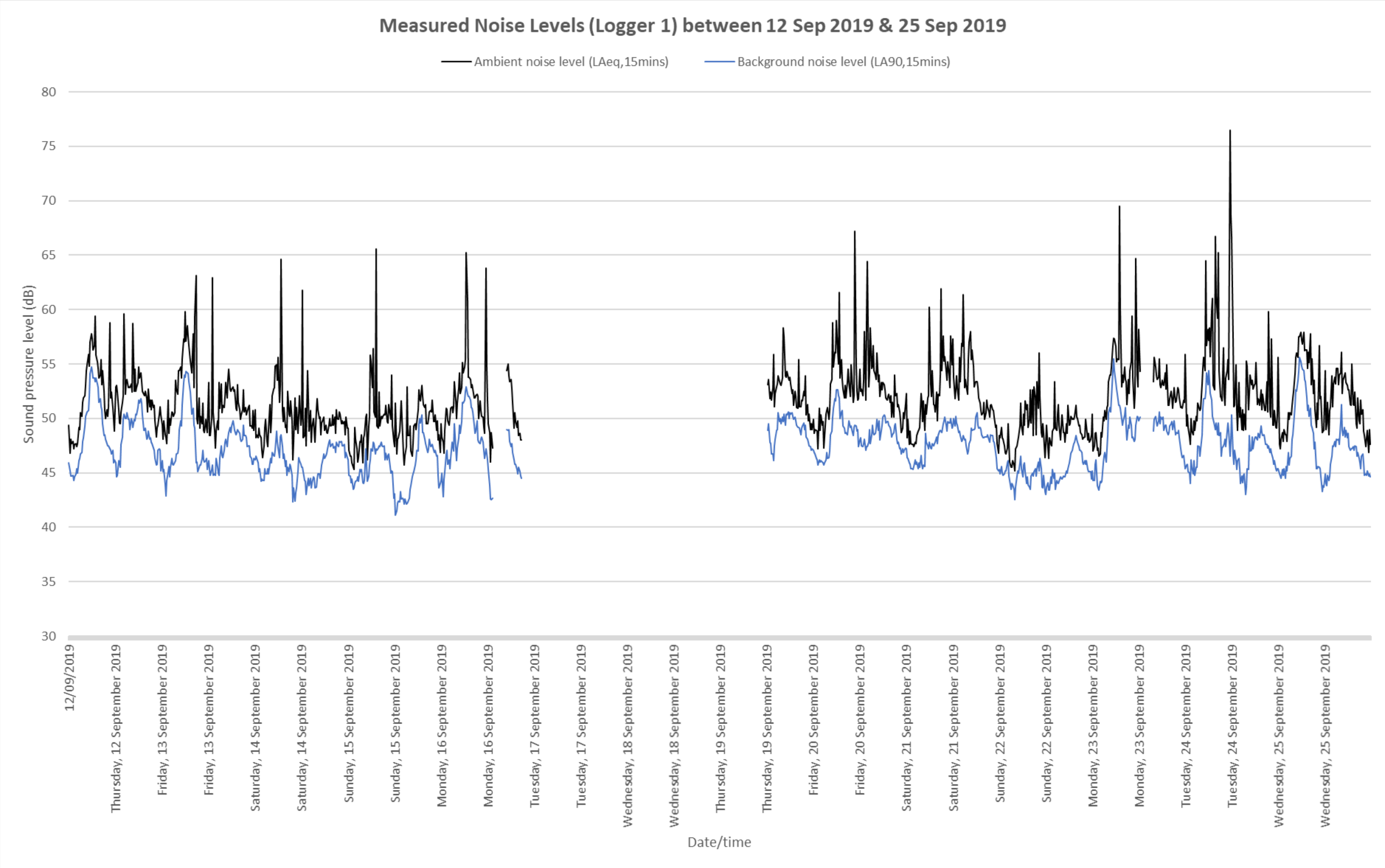
Table 22: Measured ambient noise levels – Logger 2 (Chandos Road)

Period	Average Ambient Noise Level, $L_{Aeq\ 15mins}$ dB		
	Day	Evening	Night
Thursday, 12 September 2019	54	53	53
Friday, 13 September 2019	52	51	50
Saturday, 14 September 2019	49	47	48
Sunday, 15 September 2019	49	57	53
Monday, 16 September 2019	53	46	-*
Tuesday, 17 September 2019	-*	-*	-*
Wednesday, 18 September 2019	-*	-*	-*
Thursday, 19 September 2019	54	51	53
Friday, 20 September 2019	54	53	51
Saturday, 21 September 2019	54	51	48
Sunday, 22 September 2019	48	48	53
Monday, 23 September 2019	58	52	54
Tuesday, 24 September 2019	52	52	54
Wednesday, 25 September 2019	54	50	52
Average	**54**	**52**	**52**

* - Weather affected measurement (rain or strong winds) or no weather data available

Figure 6: Noise logger location – Logger 2 (Chandos Road)

D3 Time history plots


Measured Noise Levels (Logger 1) between 12 Sep 2019 & 25 Sep 2019
Ambient noise level (LAeq,15mins)
Background noise level (LA90,15mins)
Sound pressure level (dB)
80
75
70
65
60
55
50
45
40
35
30
12/09/2019
Thursday, 12 September 2019
Friday, 13 September 2019
Friday, 13 September 2019
Saturday, 14 September 2019
Saturday, 14 September 2019
Sunday, 15 September 2019
Sunday, 15 September 2019
Monday, 16 September 2019
Monday, 16 September 2019
Tuesday, 17 September 2019
Tuesday, 17 September 2019
Wednesday, 18 September 2019
Wednesday, 18 September 2019
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Thursday, 19 September 2019
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Saturday, 21 September 2019
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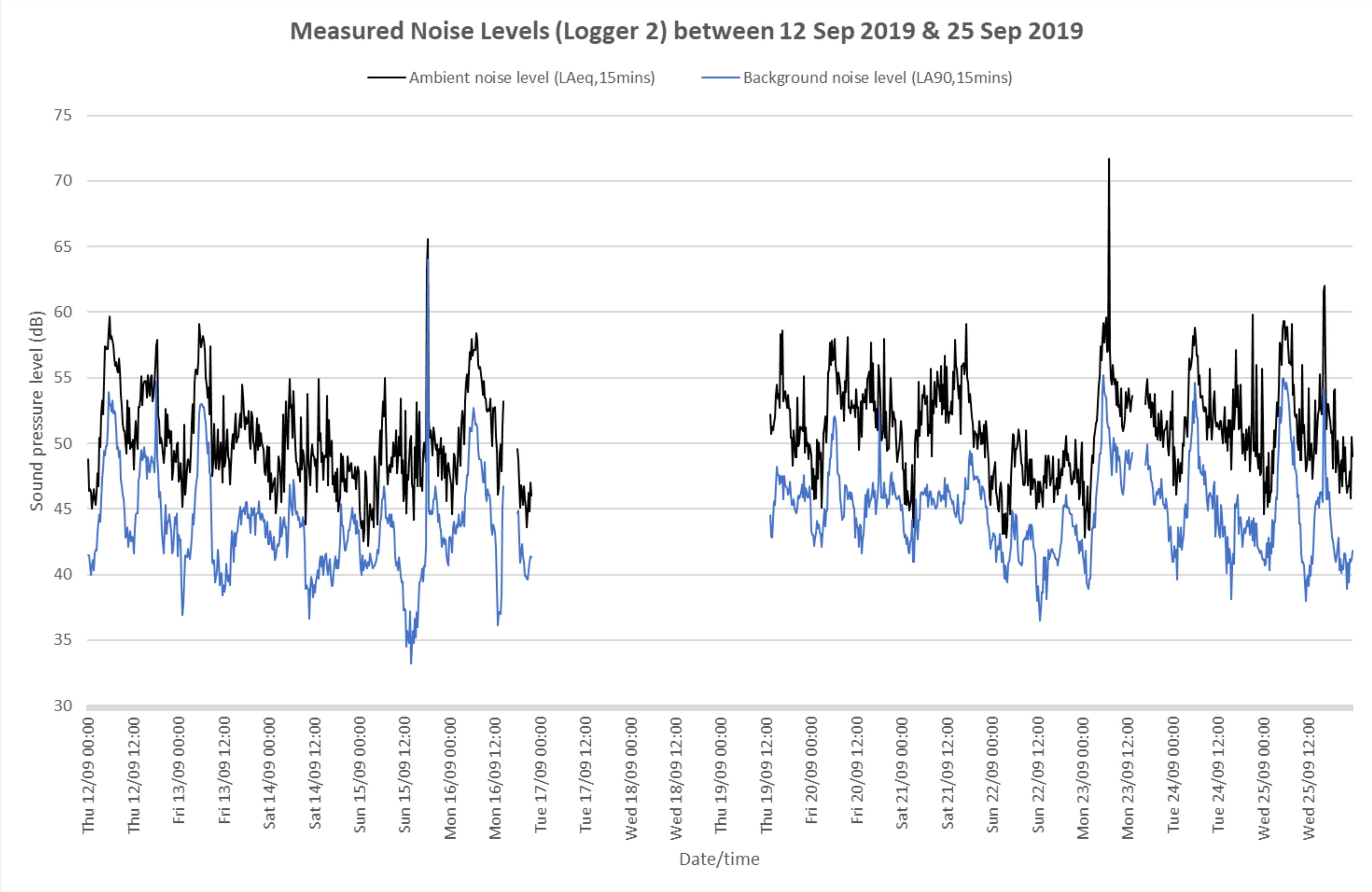
Tuesday, 24 September 2019
Wednesday, 25 September 2019
Wednesday, 25 September 2019
Date/time



Measured Noise Levels (Logger 2) between 12 Sep 2019 & 25 Sep 2019
Ambient noise level (LAeq,15mins)
Background noise level (LA90,15mins)
Sound pressure level (dB)
75
70
65
60
55
50
45
40
35
30
Thu 12/09 00:00
Thu 12/09 12:00
Fri 13/09 00:00
Fri 13/09 12:00
Sat 14/09 00:00
Sat 14/09 12:00
Sun 15/09 00:00
Sun 15/09 12:00
Mon 16/09 00:00
Mon 16/09 12:00
Tue 17/09 00:00
Tue 17/09 12:00
Wed 18/09 00:00
Wed 18/09 12:00
Thu 19/09 00:00
Thu 19/09 12:00
Fri 20/09 00:00
Fri 20/09 12:00
Sat 21/09 00:00
Sat 21/09 12:00
Sun 22/09 00:00
Sun 22/09 12:00
Mon 23/09 00:00
Mon 23/09 12:00
Tue 24/09 00:00
Tue 24/09 12:00
Wed 25/09 00:00
Wed 25/09 12:00
Date/time

APPENDIX E OPERATIONAL ASSESSMENT NOISE LEVELS - NOISE POLICY FOR INDUSTRY

In NSW, the NPfI is the guideline for assessing noise emissions from industrial facilities and other developments with noise sources that may be considered to be industrial in nature. The NPfI sets out a procedure where an industrial facility can be assessed against a series of noise levels. In the NPfI, these project specific noise levels are derived from an analysis of the ambient noise environment and zoning information.

The ambient noise levels for this project are summarised in Table 23 below. In the NPfI, the background noise level is called the Rating Background Level (RBL).

Table 23: NPfI time periods and measured background noise levels

Period	Time of day	RBL, L_{A90} (dB)	L_{Aeq} (dB)
Day	0700-1800hrs	41	54
Evening	1800-2000hrs	43	52
Night	2200-0700hrs	41	52

E1 Intrusiveness noise levels

The intrusiveness noise assessment is applicable to residential receivers and is based on knowledge of the background noise level at the receiver location. The intrusiveness level is the background noise level at the nearest noise sensitive location plus 5dB. Therefore, the noise emissions from the premises are considered to be intrusive if the A-weighted source noise level ($L_{Aeq,15min}$) is greater than the background noise level (L_{A90}) plus 5dB.

Based upon the data for summarised in Table 23, noise limits for Intrusiveness have been calculated in accordance with the NPfI and are presented in Table 24 below.

Table 24: Derived Intrusiveness noise levels

Period	RBL, L_{A90} (dB)	Intrusiveness Noise Level (RBL + 5 dB), $L_{Aeq, 15min}$ (dB)
Day	41	46
Evening	43	48
Night	41	46

E2 Amenity noise levels

The Amenity noise levels are designed to prevent industrial noise continually increasing above an acceptable level. The initial stage in determining the Amenity level is to correct the acceptable noise levels set for the appropriate amenity area with the baseline noise monitoring.

A review of the noise levels measured supports the use of a Suburban residential land-use category with mostly traffic related noise sources affecting the noise environment. Further modification is undertaken to account for standardisation of the assessment time periods (as detailed in Section 2.2 of the NPfI). The resultant levels and the relevant modifications are detailed in Table 25.

Table 25: Derived Amenity noise levels

Receiver type	Time of day	Recommended Amenity Noise Level $L_{Aeq,\ Period}$ dB	Project Amenity Noise Level, $L_{Aeq,\ 15min}$ (dB)
Residential	Day	55	53
	Evening	45	43
	Night	40	38
Commercial	When is use	65	--

E3 Determination of Project Noise Trigger Levels

The final process in determining the operational noise limits for the development is to derive the Project Noise Trigger Levels. The Project Noise Trigger Levels are levels that, if exceeded, would indicate a potential noise impact on the community, and so ‘trigger’ a management response; for example, further investigation of mitigation measures.

The Project Noise Trigger Levels are derived by selecting the more stringent of either the Intrusiveness or Amenity noise levels. For residential receivers each assessment time period is evaluated individually. For commercial receivers, only the Amenity noise level applies. The Project Noise Trigger Levels applicable to the site are shown in Table 26.

Table 26: Project Noise Trigger Levels

Receiver type	Time of day	Project Noise Trigger Level $L_{Aeq,\ 15min}$ (dB)
Residential	Day	46
	Evening	43
	Night	38
Commercial	When is use	65

APPENDIX F NOISE MODEL DATA

F1 Noise model inputs

Table 27: Noise model inputs

Feature	Description
Terrain data	Flat ground has bene used in the model. This considered acceptable for modelling purposes in this case since the area is relatively flat with nose significant topography features between the site and nearest receivers.
Environmental ground conditions	The ground within the site corresponds to acoustically hard conditions (G=0) according to ISO 9613-2. The ground around the site corresponds to acoustically soft conditions (G=1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Dwelling heights	Confirmed as single storey
Receiver heights	1.5 m above ground
Source heights	See Table 28 below for details
Noise calculation method	Noise model calculated according to ISO 9613-2:1996
Atmospheric conditions	Temperature 10^{o}C and relative humidity 70 % These represent conditions which result in relatively low levels of atmospheric sound absorption.
Description of current activities on site	Provided by the client. See Section 6.3 for overview.
Noise data for all equipment	See Table 28 below for details
Operating duration	Equipment associated with the site operation is assumed to operate continuously over any 15-minute assessment period. Duration adjustments have been applied to vehicle movement as outlined below.
Truck/bus speed on access road	Based on 25 km/h average speeds

F2 Noise level data - Operations

Table 28: Octave band input sound power level data - Operation

Category	Assumed source height (m)	Source	63	125	250	500	1k	2k	4k	Calculated Lw dB
Microturbine	2	dB(A) level from scoping report. Spectrum from MDA database (record ID 2576)	89	84	83	95	86	79	78	93
Chiller (Dry cooler)	2	dB(A) level from scoping report. Spectrum from MDA database (2011348PR)	82	91	92	90	86	83	78	92
Electrolyser chiller/condenser	2	dB(A) level from scoping report. Spectrum from MDA database (record ID 220)	67	70	68	63	59	54	48	65
Extraction fan	3	Provided by GPA	83	85	80	79	77	73	67	82
Wastewater pump	0.5	From MDA database (2014338SY)	78	78	79	77	69	68	68	78
Hydrogen vent	5.5	dB(A) level from GPA, spectrum from dbView record 2576	113	114	104	105	110	114	120	122
Oxygen Vent	5.5	dB(A) level from GPA, spectrum from dbView record 2576	113	114	104	105	110	114	120	122
Pipeline Blow down vent	5.5	dB(A) level from GPA, spectrum from dbView record 2576	113	114	104	105	110	114	120	122
Electrolyser package – Power container	2	Internal level from GPA. Spectral data from transformer, 10dB adjustment from inside to outside	69	71	66	65	63	59	53	68
Transformer	2	dB(A) level from data sheet provided. Spectrum from MDA database (record ID 4202)	72	85	81	77	72	64	55	78
Refueller package – compressor	2	dB(A) level from GPA. Spectrum from MDA database (record ID 220)	85	88	86	81	77	72	66	83
Refueller package – Chiller	1	dB(A) level from GPA. Spectrum from MDA database (record ID 220)	70	73	71	66	62	57	51	68

Category	Assumed source height (m)	Source	63	125	250	500	1k	2k	4k	Calculated Lw dB
Bus moving [1]	0.5	MDA database (record ID 3701)	66	74	77	83	89	89	85	94
Bus idle	0.5		69	73	68	76	79	78	74	83

NOTES: [1] See below for duration adjustments

F3 Noise level data - Construction

Table 29: Octave band input sound power level data – Construction

Activity	Equipment	Source	63	125	250	500	1k	2k	4k	Calculated Lw dB
Trenching, lay pipeline, cover	Tracked excavator (20t)	BS 5228-1:2009 Table C.6:11	110	112	103	97	97	95	90	103
	Tipper lorry	BS 5228-1:2009 Table C.8:20	116	110	102	102	102	101	98	107
	Wheeled backhoe loader	BS 5228-1:2009 Table C.4:66	100	91	95	95	91	90	84	97
Civil and foundation works for major equipment and access road.	Concrete mixer truck (discharging) & concrete pump (pumping)	BS 5228-1:2009 Table C.4:28	107	108	101	100	97	96	87	103
	Tracked excavator (20t)	BS 5228-1:2009 Table C.6:11	110	112	103	97	97	95	90	103
	Tipper lorry	BS 5228-1:2009 Table C.8:20	116	110	102	102	102	101	98	107
	Wheeled backhoe loader	BS 5228-1:2009 Table C.4:66	100	91	95	95	91	90	84	97
Piping, tubing and cabling between major equipment	Mobile telescopic crane (100t)	BS 5228-1:2009 Table C.4:41	101	99	96	98	94	91	82	99
	Telescopic handler (4t)	BS 5228-1:2009 Table C.4:54	107	101	94	93	106	94	82	107
	Semi-trailer delivery	BS 5228-1:2009 Table C.11:11	124	107	103	107	110	108	100	114
	Tracked excavator (20t)	BS 5228-1:2009 Table C.6:11	110	112	103	97	97	95	90	103

Activity	Equipment	Source	63	125	250	500	1k	2k	4k	Calculated Lw dB
	Angle grinder	BS 5228-1:2009 Table C.4:93	85	79	80	88	98	105	101	109

NOTES: [1] See below for duration adjustments

F4 Duration adjustments

The duration of noise sources refers to the percentage of time a particular item of equipment would be in operation in any given 15-minute assessment period. Duration adjustments for sources in the model are described below.

Table 30: Adjustments for duration of noise sources

Source	Duration adjustment	Notes
Buses	-11.5dB	Buses assumed to travel along access road at 25 km/h.
Semi-trailer deliveries	-11.5dB	Trucks assumed to travel along access road at 25 km/h.

Appendix J Traffic Assessment

ttm

Traffic Impact Assessment

Western Sydney Green Gas Project

Eco Logical Australia

Revision Record

No.	Author	Reviewed/Approved	Description	Date
1.	Baqir Husain		Draft	31/10/2019
2.	Baqir Husain		Rev00	07/11/2019
3.				
4.				

Level 5, Suite 501, 174 Pacific Highway, Greenwich. PO Box 5238 Greenwich NSW 2065

Contents

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1 Introduction

1.1 Background

TTM Consulting was engaged by Eco Logical Australia to prepare a traffic impact assessment report for proposed development works at Horsley Park high pressure gas facility. The existing gas facility comprises of a number of pressure let down and pipeline pigging facilities. The proposal includes undertaking a Power to Gas project at Horsley Park site to transform electrical energy into Hydrogen. The proposed facility will be referred to as the Western Sydney Green Gas Project (WSGGP).

1.2 Scope

This report investigates the traffic aspects associated with the proposed development. The scope investigated includes:

- Review of the concept design plans;
- Assessment of the proposed development layout of the site with respect to Council, Traffic, Access, Parking and Servicing requirements;
- Swept path analysis for proposed design
- Determination of the likely traffic generation for the proposed development and identification of potential traffic impacts on the local road network

The development plans have been assessed against the following:

- Fairfield City Wide DCP 2013;
- Australian Standards (AS 2890); and
- RTA (RMS) Guide to Traffic Generating Developments.

1.3 Site Location

The proposed facility will be located at 194 – 202 Chandos Road in Horsley Park, NSW within the Western Sydney Parklands and on site of the existing gas facility. The site context is shown in Figure 1.1 and site location map view and aerial view are shown in Figure 1.2 and Figure 1.3.

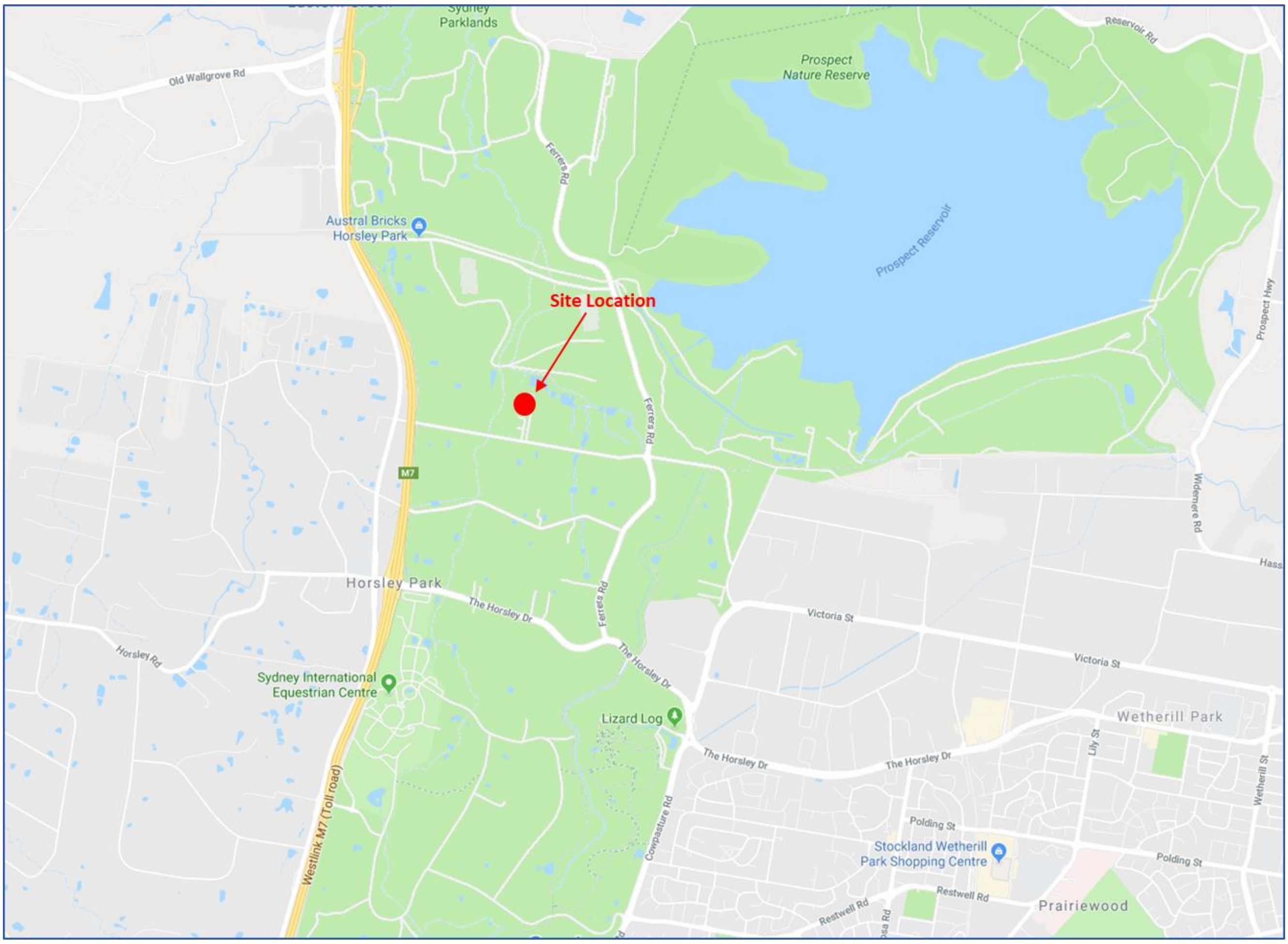


Figure 1.1: Site location context

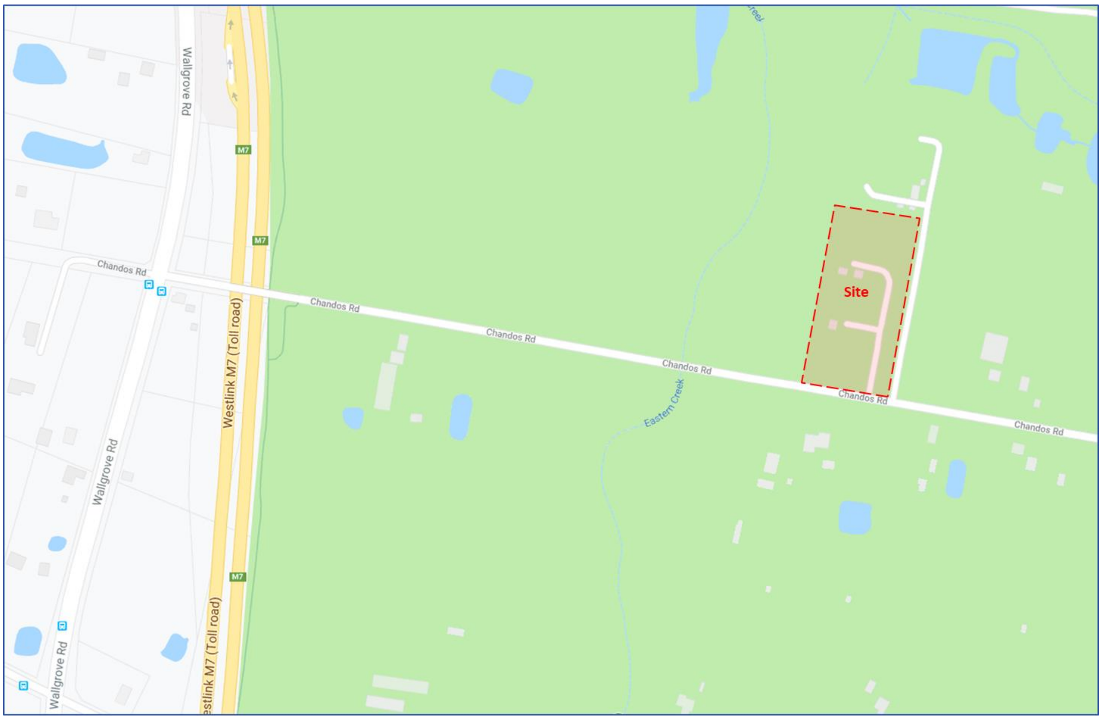


Figure 1.2: Site location map view

Figure 1.3: Site location aerial view

1.4 Development Profile

The client proposes to undertake a Power to Gas, or P2G, project, at the Horsley Park site to transform electrical energy into a combustible gas, hydrogen, which is injected into the Sydney secondary gas distribution network or supplied to an adjacent hydrogen bus refuelling facility.

The hydrogen bus refuelling facility will include a hydrogen dispenser (on Jemena land) and turning circle to be located on Jemena land within the Jemena Horsley Park gas facility adjacent to the Western Sydney Parklands Trust (WSPT) lot.

The plans detailing the proposal are shown in Appendix A.

1.5 Access and Parking

The existing development has vehicular access from Chandos Road. Chandos Road provides an east-west link between Wallgrove Road and Ferrers Road. Wallgrove Road starts from Great Western Highway (A44) in the north and goes up to Elizabeth Drive to the south. It connects with M4 Motorway to the north and M7 Motorway to the south.

Access from Wallgrove Road to Chandos Road is restricted for vehicles having Gross Vehicle Mass (GVM) of 5 tonne and over.

The existing site does not have any dedicated parking spaces on site.

Existing site access from Chandos Road is shown in Figure 1.4.

Figure 1.4: Existing site access

2 Existing Transport Infrastructure

2.1 Road Network Details

The existing site has direct access from Chandos Road. Chandos Road provides an east-west link between Wallgrove Road and Ferrers Road. It is expected that the most likely path of access to the site will be from M7 followed by Wallgrove Road and Chandos Road.

Chandos Road is a local road administered by Fairfield City Council (FCC) whereas Wallgrove Road is under the authority of Roads and Maritime Services (RMS). The characteristics of roads near the site are shown below in Table 2-1.

Table 2-1: Road Characteristics

Road	Speed Limit	Lanes	Road Authority
Chandos Road	60kph	2 (undivided)	FCC
Wallgrove Road	80kph	2 (undivided)	RMS

Chandos Road is a 2-lane undivided street with a carriageway of approximately 8 metres. The road provides access to various residential, commercial and industrial property lots on either side.

Wallgrove Road is a 2-lane undivided street with a carriageway of approximately 12 metres including shoulders on either side. Wallgrove Road carries significantly higher volume of vehicles as compared to Chandos Road.

Chandos Road and Wallgrove Road intersect to form a four-legged stop-controlled intersection with Chandos Road being the minor road.

2.2 Public Transport

There are two bus stops present near the intersection of Wallgrove Road and Chandos Road on either side. The bus stop is serviced by one bus route (# 835) which runs between University of Western Sydney and Prairiewood.

The location of the bus stops are shown in Figure 2.1.

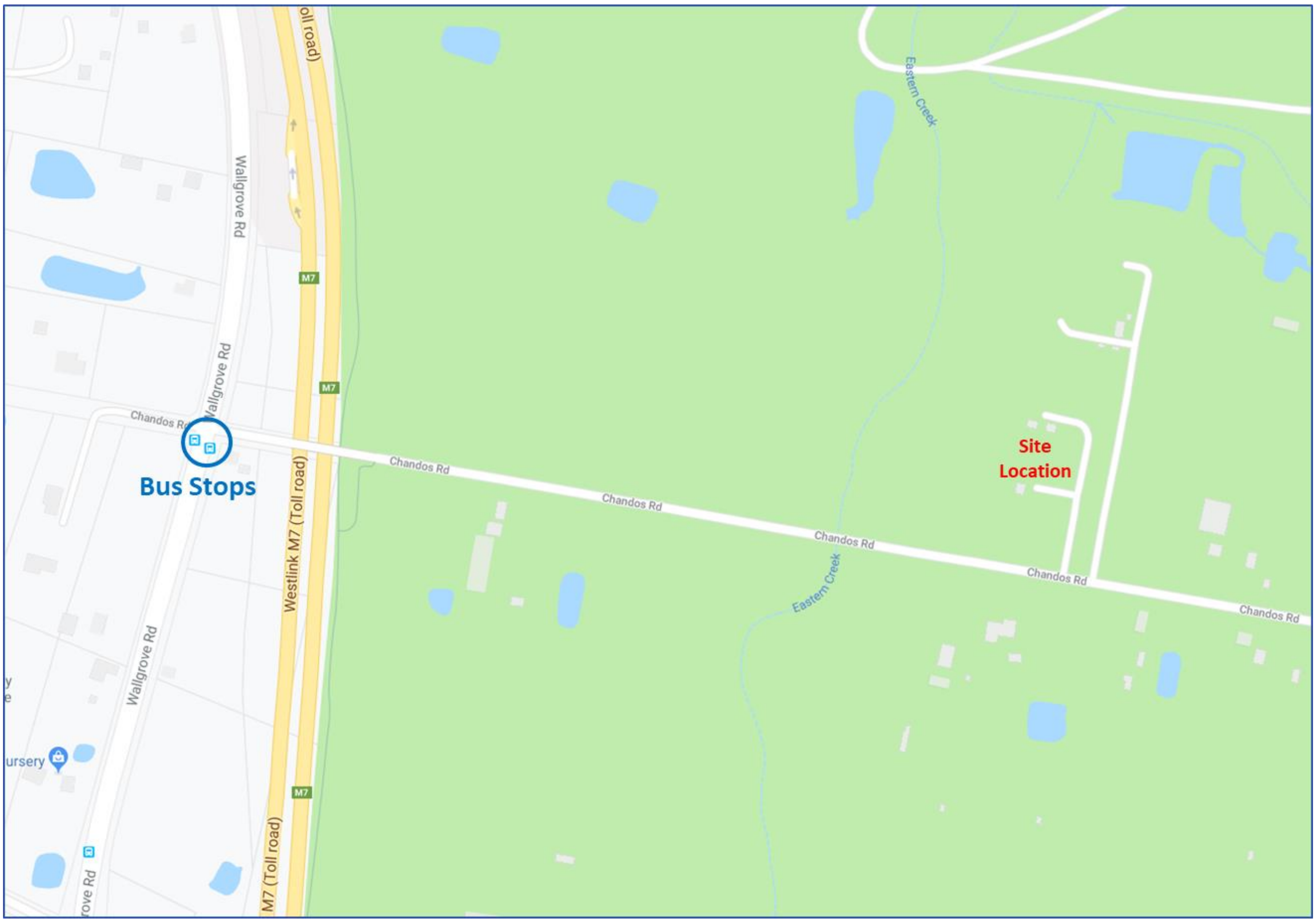


Figure 2.1: Location of bus stops

3 Expected Traffic Types and Volumes

3.1 Light Vehicles

The existing pressure gas facility is unmanned and requires only infrequent vehicular access. It is expected that the proposed facility will continue to have infrequent vehicular access as per existing conditions. Light vehicles currently accessing the site park in any of the open areas within the site boundary. Light vehicle access will increase during construction phases. Details of vehicle access during construction phases is presented in section 3.4.

3.2 Refuelling Buses

The proposed site will provide on-site hydrogen bus refuelling at the proposed hydrogen refuelling point. The expected number of buses utilising the refuelling facility will be a maximum of three busses per day.

The turning circle provides sufficient space to accommodate two buses waiting to refuel whilst a third is undergoing refuelling at the hydrogen dispenser. No buses are expected to park on site. Swept path analysis demonstrating buses accessing, refuelling and exiting the site are presented in Appendix B.

As per discussion with Fairfield City Council the need for refuelling buses to access the site through the safest route was identified. The shortest access route for the buses assuming arrival from M7 Motorway is to access Wallgrove Road, travel northbound turning right on to Chandos Road and ultimately turning left into the site access road. Fairfield City Council has raised safety concerns for buses making right turns toward Chandos Road considering the heavy traffic volumes on Wallgrove Road.

An alternative route identified is to exit on to Horsley Drive from M7 Motorway, travel eastbound turning left towards Ferrers Road, travel northbound on Ferrers Road turning left on to Chandos Road and ultimately turning right into the site access road. This route eliminates making a right turn across a high traffic volume road. Further, the Horsley Drive is a state road and Ferrers Road is a 19m B-double route with travel conditions[1]. Having reviewed the road network and geometry of intersections along the alternative route, it is recommended the buses adopt this path of travel for refuelling operations.

The shortest and alternative approach routes for refuelling buses is shown in Figure 3.1.

[1] NSW Combined Higher Mass Limits (HML) and Restricted Access Vehicle (RAV) Map

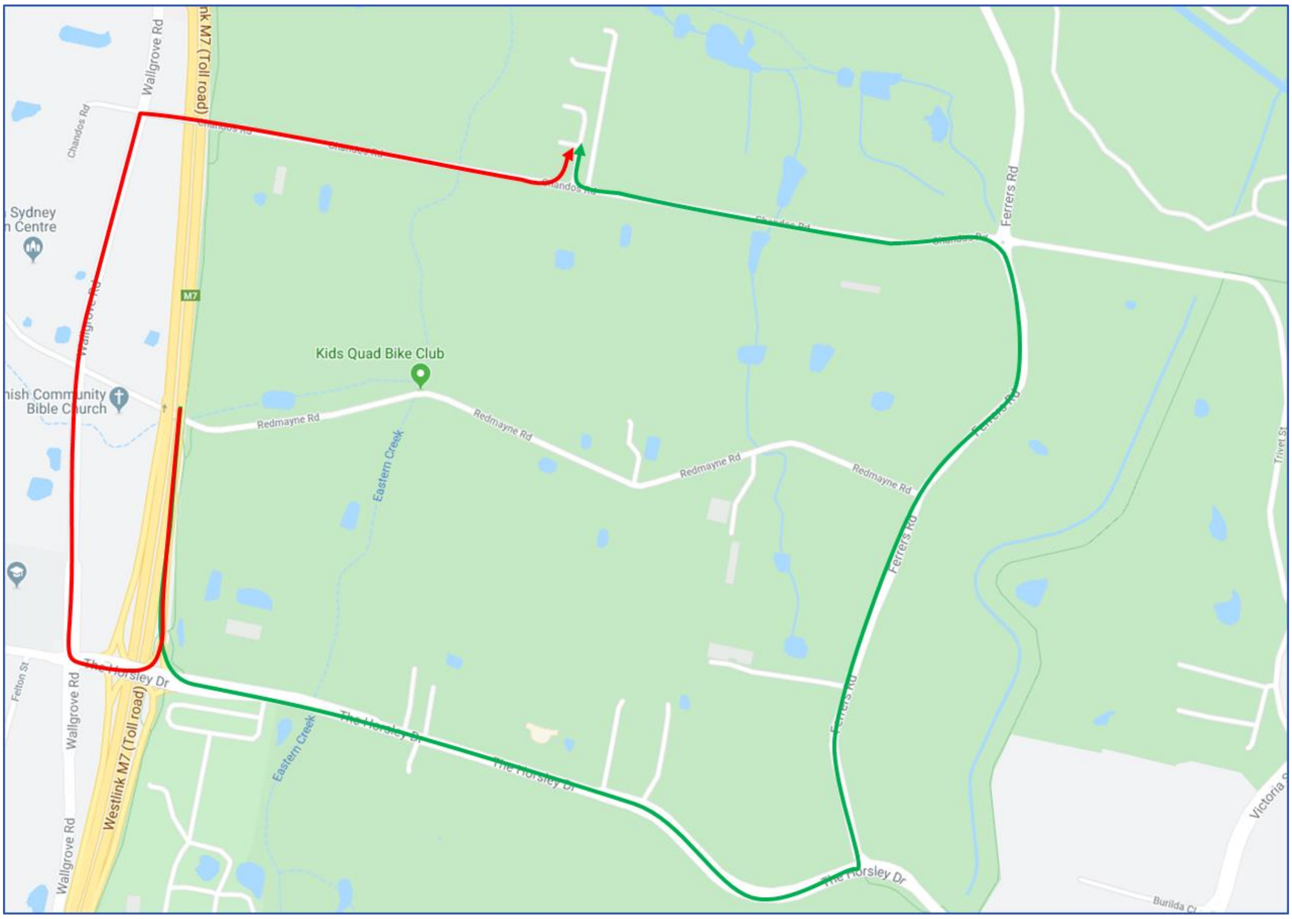


Figure 3.1: Shortest and alternative approach routes for refuelling buses

3.3 Trucks and Service Vehicles

The site will also be accessed by trucks for removing wastewater from the site. Wastewater removal truck is expected to be a vacuum loading truck with a capacity in the range of 3,000 to 8,000 litres from waste services such as Cleanaway, Veolia or Envirowaste. The wastewater removal truck will be smaller than a standard 12.5m Heavy Rigid Vehicles (HRV). It is expected that up to three trucks per month will access the facility.

The site will be accessed by oversized vehicles during construction phases. Details of vehicle access during construction phases is presented in section 3.4.

3.4 Construction Vehicles

The proposed facility will have increased vehicle activity during construction phases. This will include a mix of light vehicles and over-sized vehicles being used for equipment deliveries. It is expected that up to 10 contractor light utility vehicles will access the site during peak construction phase. Typical construction activities will generate between two to four light vehicle trips per day.

Various types of construction vehicles will visit the site during material delivery and construction phases. The maximum sized design vehicle will be a semi-trailer during equipment delivery phase.

The length of most other vehicles will be less than the standard heavy rigid 12.5 metre vehicle. Typical lengths are around 8 metres.

It is expected that the construction heavy vehicles will arrive at the site travelling from either M4 or M7 motorway, enter Wallgrove Road and either turn left or right from Wallgrove Road on to Chandos Road. Wallgrove Road is a state road and is an approved 19m B-double route.

Access from Wallgrove Road to Chandos Road is restricted for vehicles having Gross Vehicle Mass (GVM) of 5 tonne and over. Construction vehicles and refuelling buses will exceed the GVM limit. The Fairfield City Council has been consulted regarding this matter. The discussion with Council has been presented in Section 5 – Stakeholder and Community Consultation of the EIS (ELA 2019).

A construction traffic management plan will be prepared further detailing the impacts and management of construction vehicles for the project site.

3.5 Internal Road Layout

The internal road connecting Chandos Road to the site is approximately 5 metres in width. The internal road is an unsealed road with loose gravel occupying the length of the road.

The gravel access road will be layered with a base course up to the start of turning circle. The turning circle for the buses will be bituminised.

Table 3-1 identifies the characteristics of the internal road with respect to the Council/AS 2890 requirements. The last column identifies the compliance of each design aspect.

Table 3-1: Driveway design requirements and provision

Design Aspect	Council / AS 2890 Requirements	Existing/Proposed Provision	Compliance
Access Driveway Width – Private Vehicle – Commercial Vehicle (MRV)	6.0m to 9.0m 9.0m	9.0m	Compliant
Access Driveway Grade	First 6m from the property boundary shall be a maximum of 1:20 (5%)	First 6m from the property boundary has a maximum of 1:20 (5%)	Compliant
One-Way Road Width	3.0m (min) between kerbs	4.5m	Compliant

The project site is expected a maximum of three buses per day from a single bus company. The proposed turning circle is designed to accommodate up to 3 buses at a time with the third bus undergoing refuelling. It is highly unlikely to have more than one bus on site during refuelling. On the rare occasions where two or more vehicles will be required to pass each other, there is sufficient unsealed space on both sides of the road for vehicles to pass. Based on the expected traffic volume, the internal road layout is considered appropriate.

4 Impact of Proposed Development

The proposed facility will be unmanned and will require infrequent vehicular access during daily hours of operation. The maximum vehicular activity will take place during peak construction phase of the development. This will involve up to 10 light vehicles and potentially up to 8 heavy vehicles per day. This would result in a trip generation of up to 36 trips per day and would not forecast to occur for extended periods. This traffic generation is relatively minor and not of a level normally associated with unacceptable traffic implications in terms of road network capacity, efficiency or traffic related environmental effect.

Chandos Road is a sealed road with a maximum speed limit of 60 kilometres per hour. Vehicles both light and heavy accessing the site will either perform a left or right turn to access and egress the internal road leading towards the site. The access point off Chandos Road has adequate sight distances for vehicles to turn in and out of the internal road. Additional safety measures in terms of traffic controllers, truck crossing or entering signs etc. will be deployed during construction phases as part of the construction traffic management plan.

In terms of impact of construction and operational activities on roads, a dilapidation report will be submitted to the Council. The dilapidation report will be submitted prior to refuelling buses coming under operation.

Figure 4.1: Chandos Road view towards East

Figure 4.2: Chandos Road view towards West

5 Summary & Conclusion

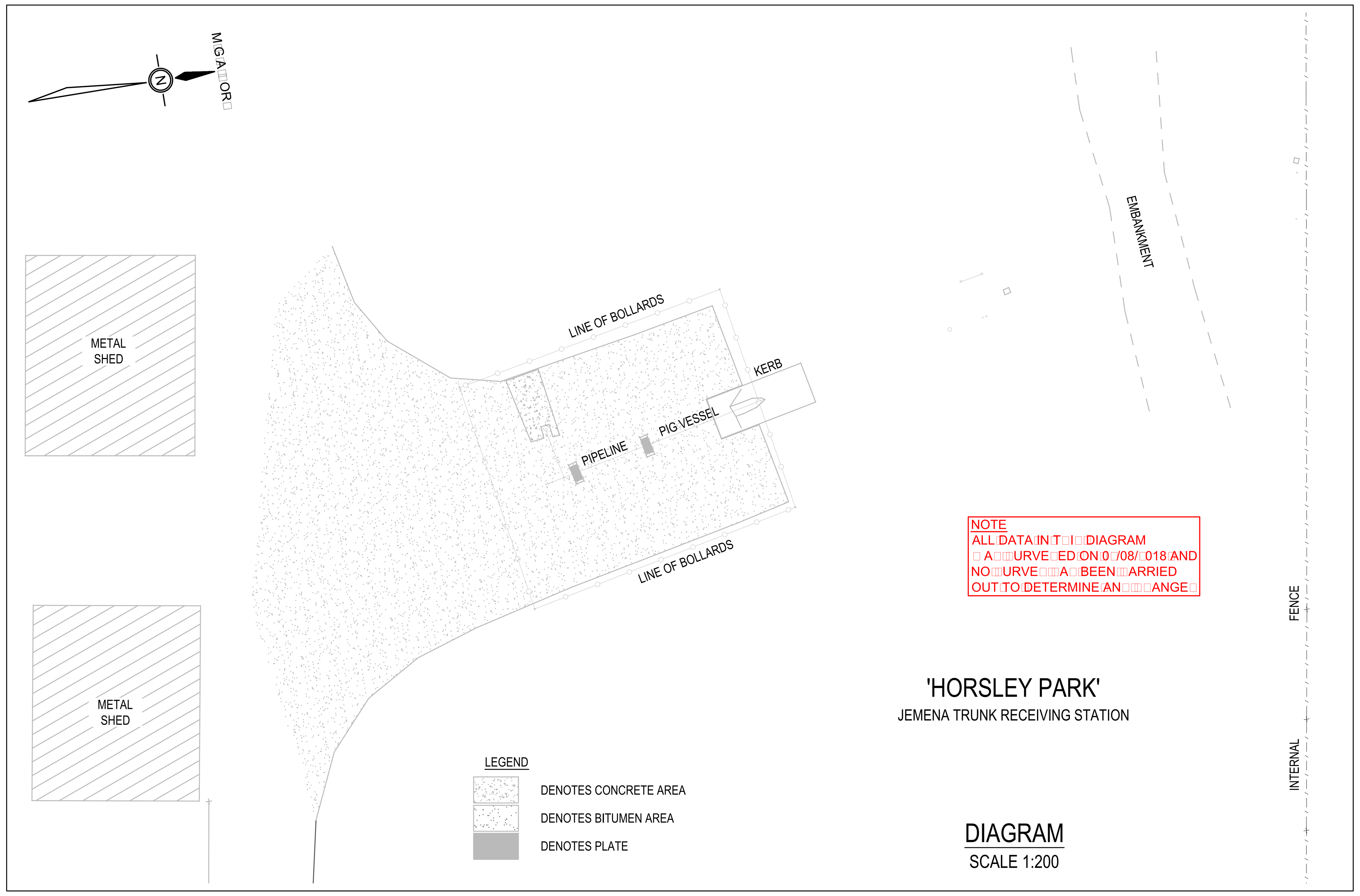
The proposed development involves undertaking a Power to Gas project at Horsley Park site to transform electrical energy into Hydrogen. The site will retain its access from Chandos Road.

The proposed development is expected to have infrequent access from staff and service vehicles. The development will have refuelling facility for buses with a maximum of three buses expected per day. The internal road layout including bus turnaround bay is considered acceptable as per bus swept paths. Safe and appropriate travel route has been identified for buses.

Peak traffic volumes for the development will occur during construction phase. Details of construction traffic will further be addressed in the construction traffic management plan.

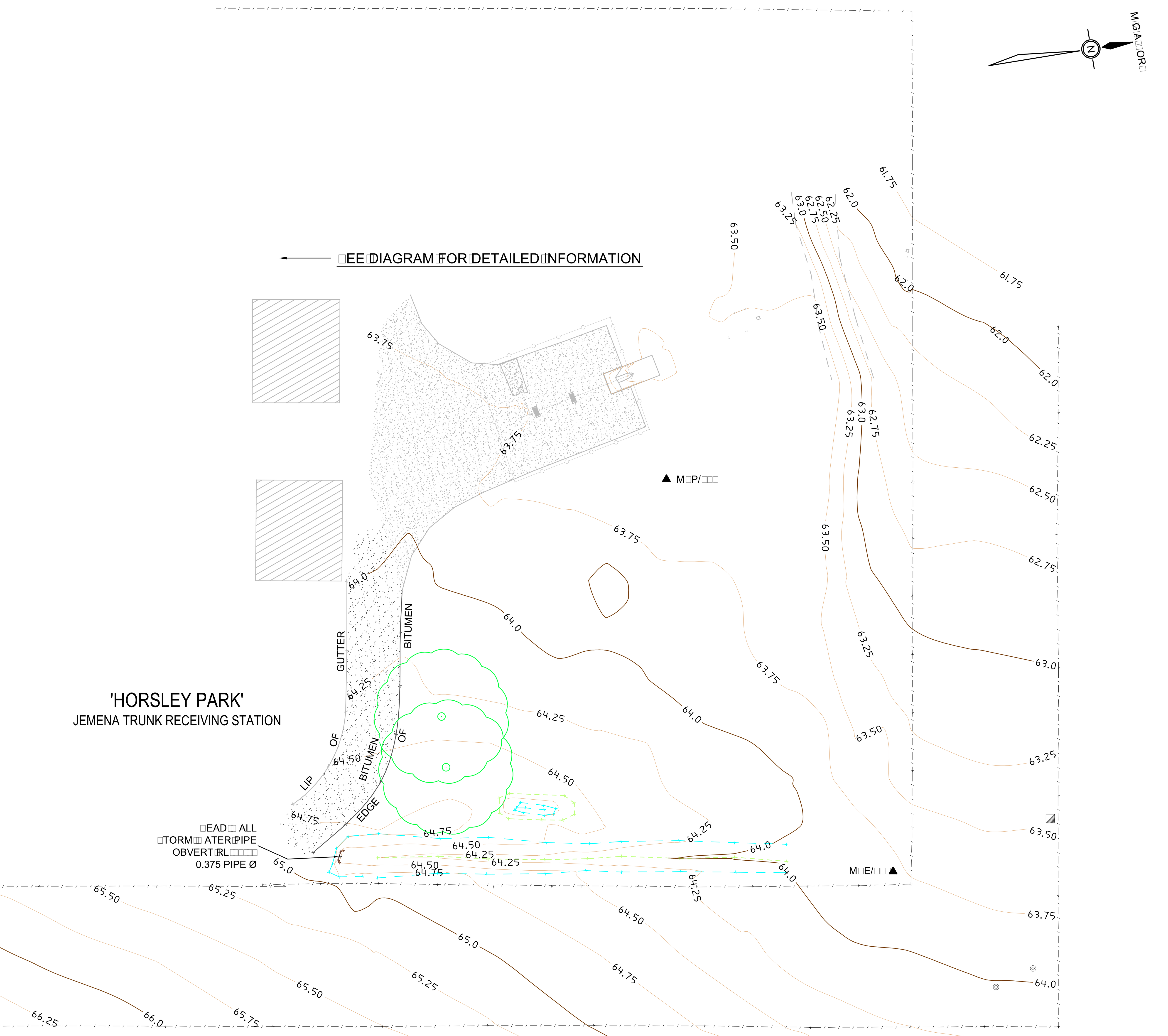
It is concluded that the proposed development will not have significant traffic impacts. TTM see no traffic engineering reason why the relevant approvals should not be granted.

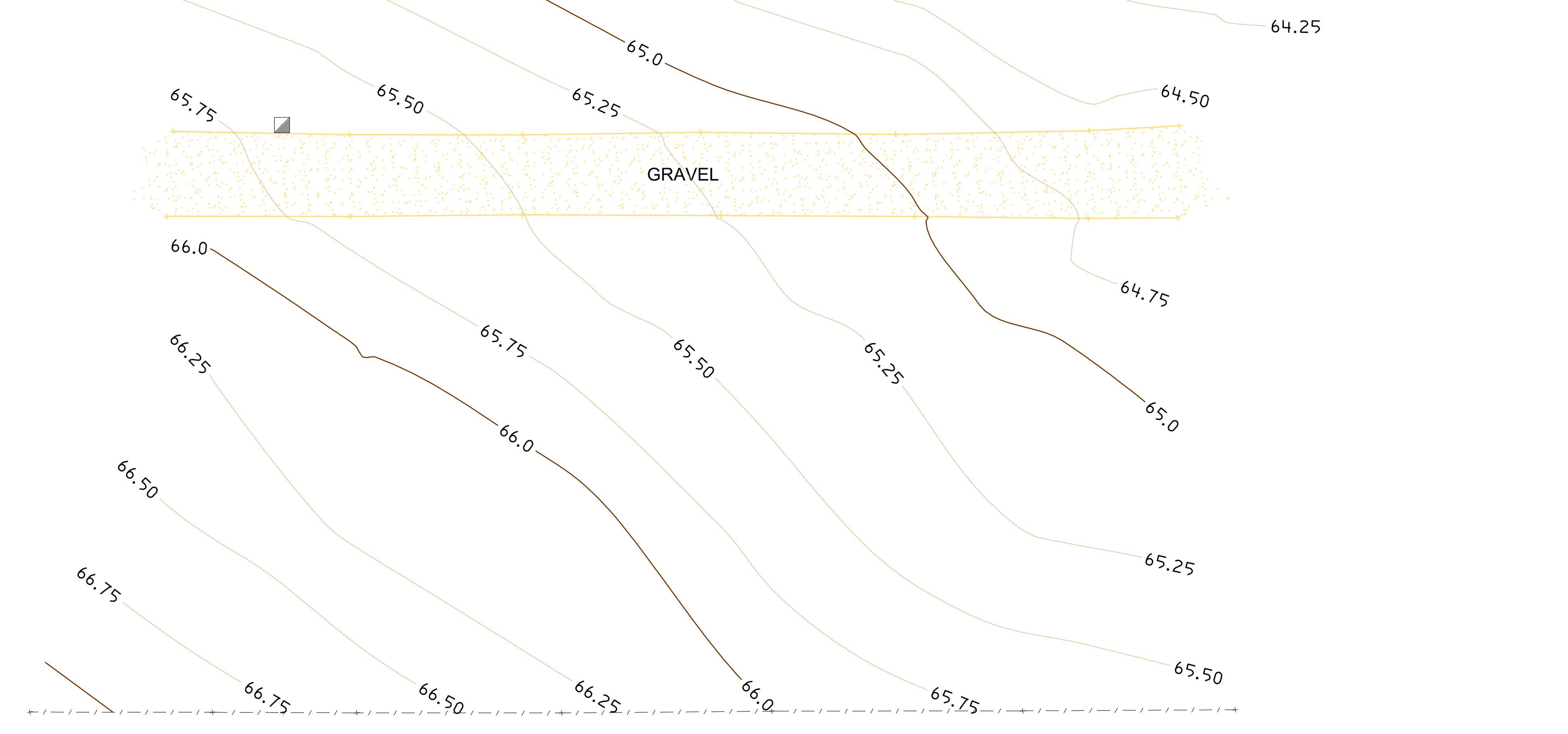
Appendix A Proposed Site Plan



DIAGRAM

SCALE 1:200





211761 CONTROL TABLE					
No.	Easting (MGA)	Northing (MGA)	Level (AHD)	Description/Name	Mark
502	302,381.140	6,254,455.362	63.558	MSP/966	STAR PICKET
503	302,425.404	6,254,472.147	63.842	MSE/967	SPIKE

LEGEND
- CONTROL POINT
- MONITORING STATION
- COMMUNICATION PIT
- FENCE VARIOUS MATERIALS
- TOP OF BANK
- BOTTOM OF BANK

EXPLANATORY NOTES

1. ONLY APPARENT SERVICES HAVE BEEN LOCATED BY SURVEY. NO SEARCH OF PUBLIC UTILITIES OR SUB-SURFACE INVESTIGATION HAS BEEN CARRIED OUT TO DETERMINE THE LOCATION OF ANY UNDERGROUND SERVICES SUCH AS TELSTRA, INTEGRAL ENERGY, GAS, WATER OR SEWER. SEE THE ATTACHED DIAL BEFORE YOU DIG CAUTION IN THIS PLAN SPACE. NO INVESTIGATION OF LOCATION OF ANY FOOTINGS OR FOUNDATIONS HAS BEEN CARRIED OUT.

2. SPOT LEVELS & CONTOURS REPRESENT GENERAL GROUND LEVEL ONLY. THEY GIVE AN APPROXIMATE REPRESENTATION ONLY OF THE SHAPE AND LEVELS OF THE GROUND SURFACE. CONTOURS DO NOT REPRESENT THE PRECISE LEVEL AT ANY PARTICULAR POINT EXCEPT WHERE A SPOT LEVEL IS SHOWN. SHOULD CRITICAL DESIGN FACTORS BE IN EXISTENCE THEN IT MAY BE NECESSARY TO OBTAIN SUPPLEMENTARY LEVELS TO CONFIRM DESIGN CONSTRAINTS OR PARTICULARS. (TO THIS EXTENT IT SHOULD BE NOTED THAT THE CONTOUR INTERVAL IS 0.25 m)

3. CONTOURS ARE INTERPOLATED FROM SPOT LEVELS AS SHOWN & SHOULD BE USED AS A GUIDE ONLY. DO NOT RE-INTERPOLATE CONTOURS.

4. PLEASE NOTE THAT NO BOUNDARIES ARE SHOWN ON THIS PLAN.

5. ORIGIN OF COORDINATES IS MGA AND ORIGIN OF LEVELS IS AUSTRALIAN HEIGHT DATUM (A.H.D.) BOTH OBTAINED BY CORS GPS).

6. WE HAVE NOT CARRIED OUT A TITLE SEARCH OF THE FOLIO IDENTIFIER AT THE OFFICE OF LAND REGISTRY SERVICES IN ORDER TO DETERMINE THE EXISTENCE OF EASEMENTS OR RESTRICTIONS THAT MAY AFFECT THE LAND. (ANY EASEMENTS SHOWN ARE TAKEN DIRECTLY FROM THE PLAN OF SUBDIVISION CREATING THE ALLOTMENT.)

7. THIS PLAN & ACCOMPANYING DIGITAL MODEL HAS BEEN PREPARED FOR GPA Engineering - ITS USE IS LIMITED TO SITE ANALYSIS MATTERS & MUST BE USED FOR NO OTHER PURPOSE OR BY ANY UNAUTHORIZED THIRD PARTY. THE CONTENTS REMAINS THE INTELLECTUAL PROPERTY OF LANDTEAM.

8. THIS PLAN IS TO BE READ IN CONJUNCTION WITH THE README FILE ON THE ACCOMPANYING DIGITAL TRANSFER AND THE PDF FILE ATTACHED.

SEE DWG DIGITAL FILE FOR LOCATION & LEVEL FOR ALL SPOT HEIGHTS

A1 SHEET

SCALE: 1:200 — 0 5 10 15 20 METRES

SCALE: 1:300 — 0 10 20 30 METRES

ISSUE	AMENDMENT	DRAWN	DATE
A	INITIAL ISSUE	?A?	1?/08/?018
B	ADDITIONAL DETAIL ADDED	DG	?/0?/?01?

LandTeam Australia Pty Ltd

LandTeam

GPA ENGINEERING

JEMENA TRUNK RECEIVING STATION, HANDOVER ROAD, HORSLEY PARK

LGA: FAIRFIELD CITY COUNCIL

PLAN SHOWING DETAIL & CONTOUR SURVEY PLAN
HORSLEY PARK JEMENA TRUNK RECEIVING STATION
HANDOVER ROAD, HORSLEY PARK

SCALE	1:200 A1 / 1:300 A1	DATUM	AHD	DATE	0?/08/?018 / 0?/0?/?01?

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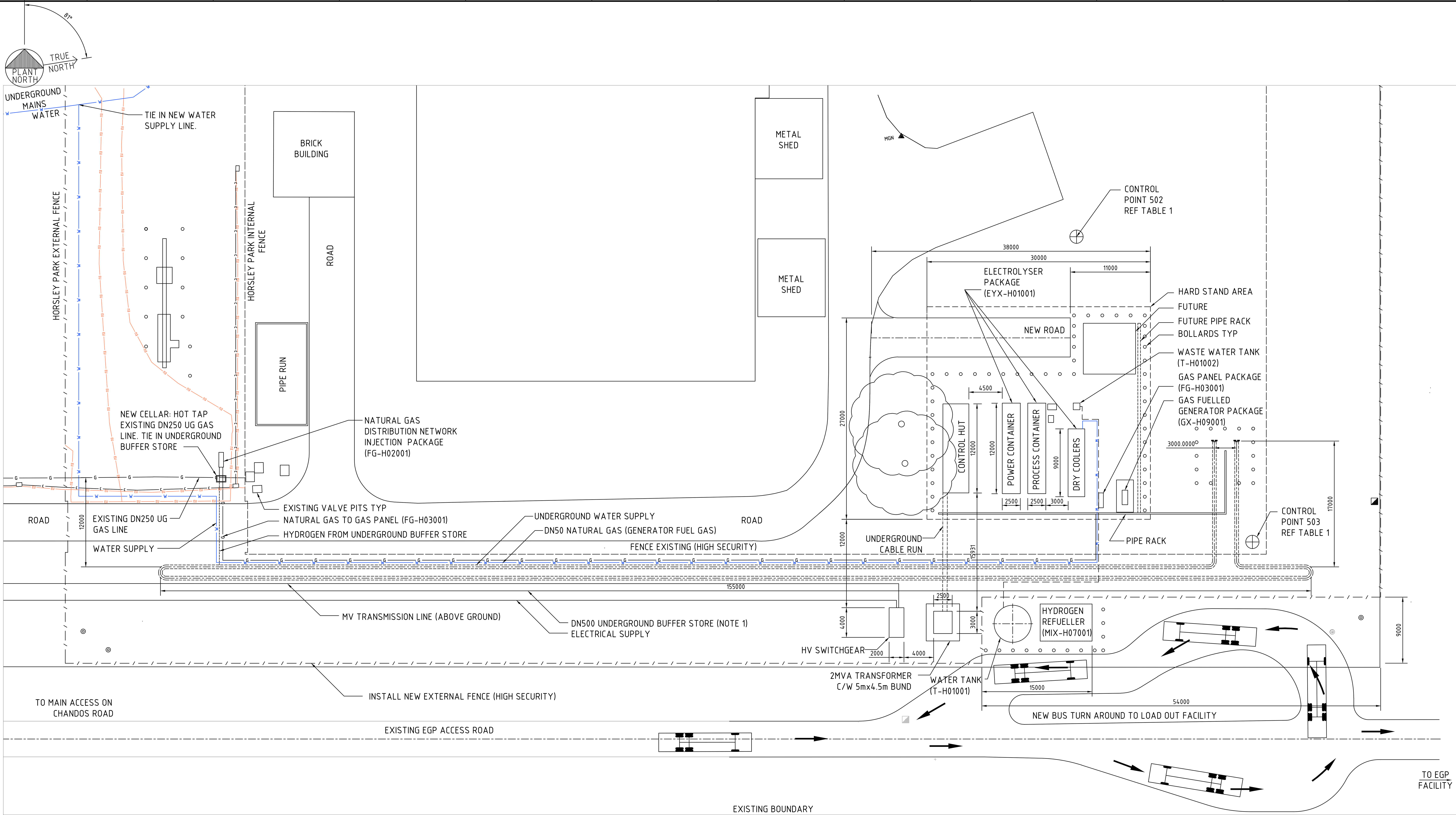
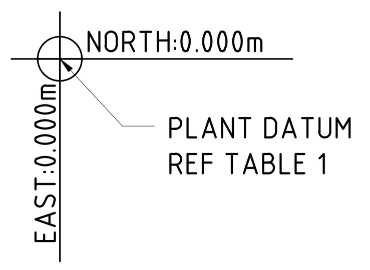
DRAWN: ?A?/DG
CHECKED: GG
ISSUE: B
DRAWING No: ?11??1?T?01
SHEET 1 OF 1 SHEETS





211761 CONTROL TABLE (TABLE 1)					
No.	Easting (MGA)	Northing (MGA)	Level (AHD)	Description/Name	Mark
502	302,381.140	6,254,455.362	63.558	MSP/966	STAR PICKET
503	302,425.404	6,254,472.147	63.842	MSE/967	SPIKE
PLANT DATUM PLANT N:000m PLANT E:0.000m	302,442.444	6,254,303.204	RL:HOLD	PLANT DATUM	-

NOTES

1. DEPTH OF COVER 900mm MINIMUM.
2. PIPELINE CLEARANCE FROM FENCE 8-10m.

LEGEND

- EU — ELECTRICITY UNDERGROUND
- C — COMMUNICATIONS UNDERGROUND
- G — GAS UNDERGROUND
- W — WATER UNDERGROUND
- / — FENCE (VARIOUS MATERIALS)

FOR INFORMATION ONLY

PRELIMINARY

SCALE 1:250 — 0 5 10 15 20 25 METRES

ASSET MANAGER
Jemena
Produced by
Jemena Asset Management (6) Pty Ltd
ABN 52 104 352 650

ASSET OWNER
Jemena
Jemena DDP(1) P/L
ABN 52 072 109 865
Jemena DDP(2) P/L
ABN 93 125 873 869
Jemena DDP(3) P/L
ABN 83 127 059 152

REV	DATE	DESCRIPTION	DRAWN	CHECKED	ENG CHK	APPRV
H	17/10/19	ISSUED FOR INFORMATION	GPA	DK	JW	IIK
G	08/10/19	ISSUED TO VENDOR	GPA	DK	JW	IIK
F	19/08/19	ISSUED POST HAZOP	GPA	DK	JW	IIK
E	23/07/19	ISSUED FOR HAZOP	GPA	DK	JW	IIK
D	10/04/19	ISSUED 30% DESIGN REVIEW	GPA	DK	JW	IIK

DRAWING No. | REFERENCE DRAWINGS

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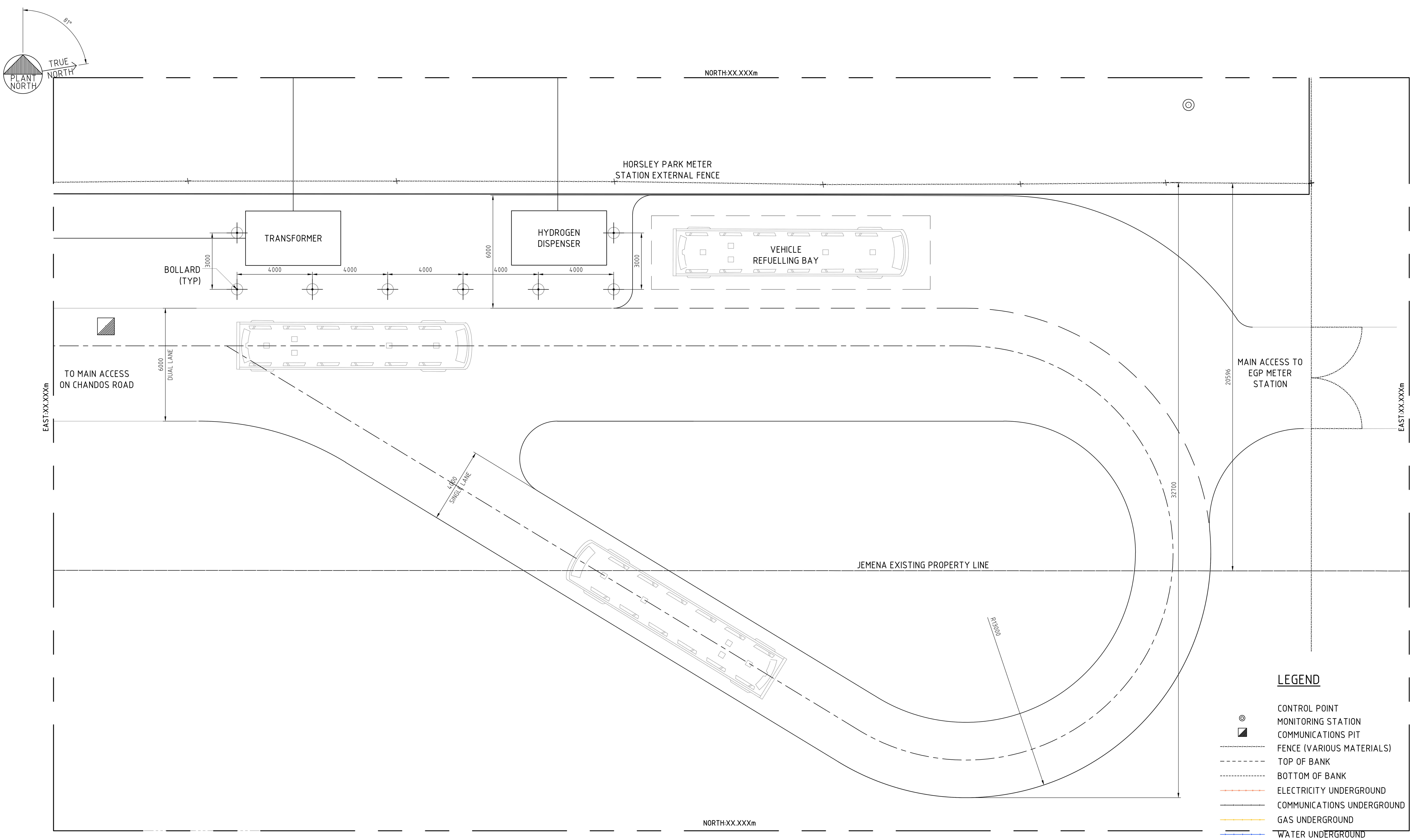
WESTERN SYDNEY GREEN GAS TRIAL
EQUIPMENT LAYOUT DRAWING

DRAWN	GPA		
DESIGN	GPA	SCALE	1:250
CHECKED	NK	SUPERSEDES	A1
APPROVED	JW	DRAWING NUMBER	
DATE	09/04/2019	P2G-2099-DW-CV-001	REV H



LEGEND

- CONTROL POINT
- MONITORING STATION
- COMMUNICATIONS PIT
- FENCE (VARIOUS MATERIALS)
- TOP OF BANK
- BOTTOM OF BANK
- ELECTRICITY UNDERGROUND
- COMMUNICATIONS UNDERGROUND
- GAS UNDERGROUND
- WATER UNDERGROUND

0 2.5 5.0 7.5 10
SCALE 1:100 METRES

NOTES

1. REFUELLING BAY BASED ON STANDARD 12.5m RIGID BUS.

HOLDS

1. FOOTPRINT AND LOCATION OF TRANSFORMER AND HYDROGEN DISPENSER TO BE CONFIRMED.
2. ROAD SURFACE OF TURNING CIRCLE MAY BE SEALED.
3. LOCATION OF EXISTING JEMENA PROPERTY BOUNDARY.
4. LOCATION OF EXISTING FIBRE OPTIC CABLE ALONGHORSLEY PARK METER STATION EXTERNAL FENCE LINE.

DRAWING No.	REFERENCE DRAWINGS

ASSET MANAGER
Jemena
Produced by Jemena Asset Management (6) Pty Ltd
ABN 52 104 352 650

ASSET OWNER
Jemena
Jemena DDP(1) P/L
ABN 52 072 109 865
Jemena DDP(2) P/L
ABN 93 125 873 869
Jemena DDP(3) P/L
ABN 83 127 059 152

REV	DATE	DESCRIPTION	DRAWN	CHECKED	ENG CHK	APPRV
A	10/04/19	ISSUED 30% DESIGN REVIEW	GPA	DK	JW	IIK

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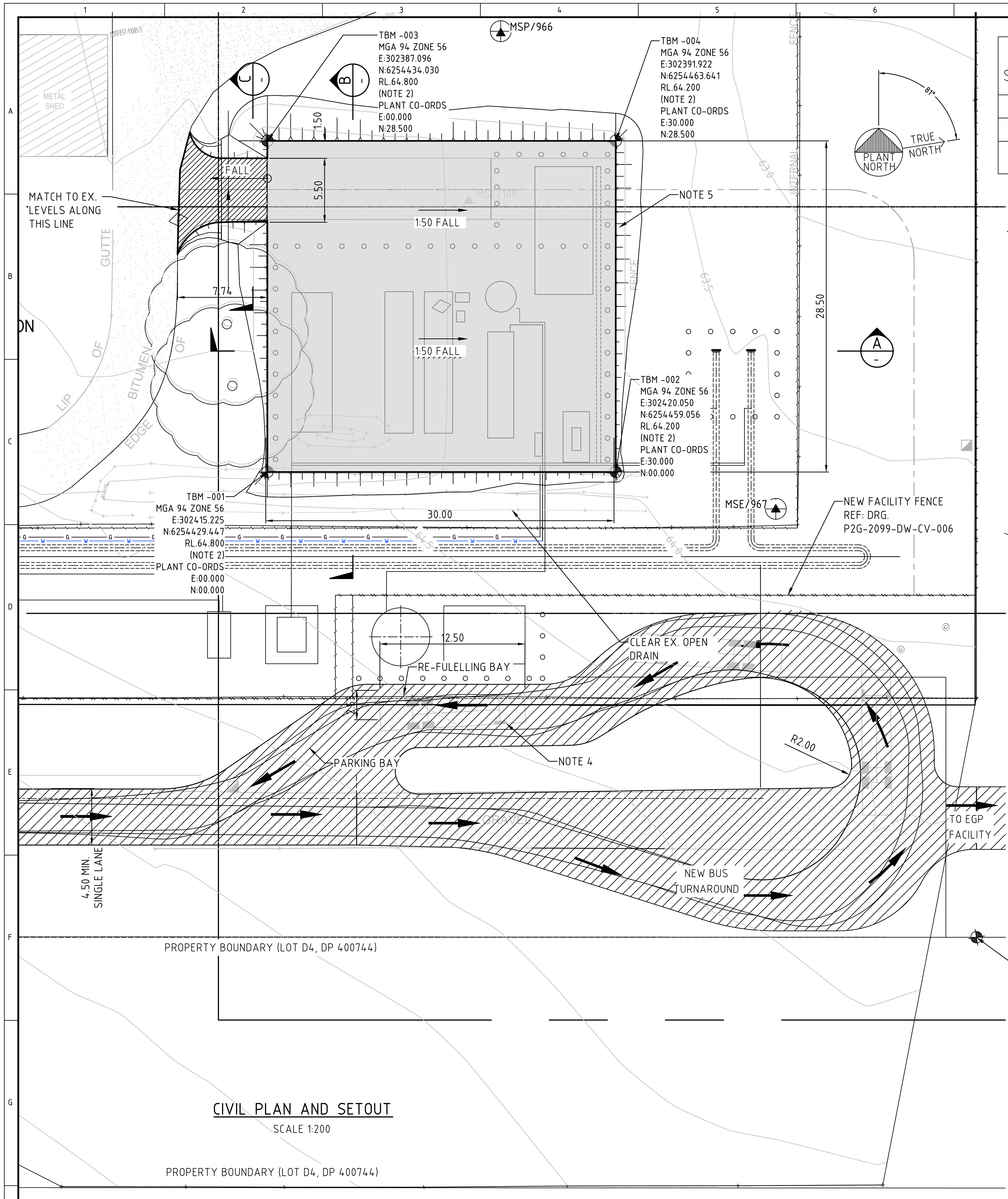
WESTERN SYDNEY GREEN GAS TRIAL
VEHICLE REFUELLING BAY
AND BUS TURN AROUND
PIPING PLAN

DRAWN	GPA		
DESIGN	GPA	SCALE	1:250
CHECKED	NK	SUPERSEDES	A1
APPROVED	JW	DRAWING NUMBER	REV
DATE	09/04/2019	P2G-2099-DW-CV-PI-008	A

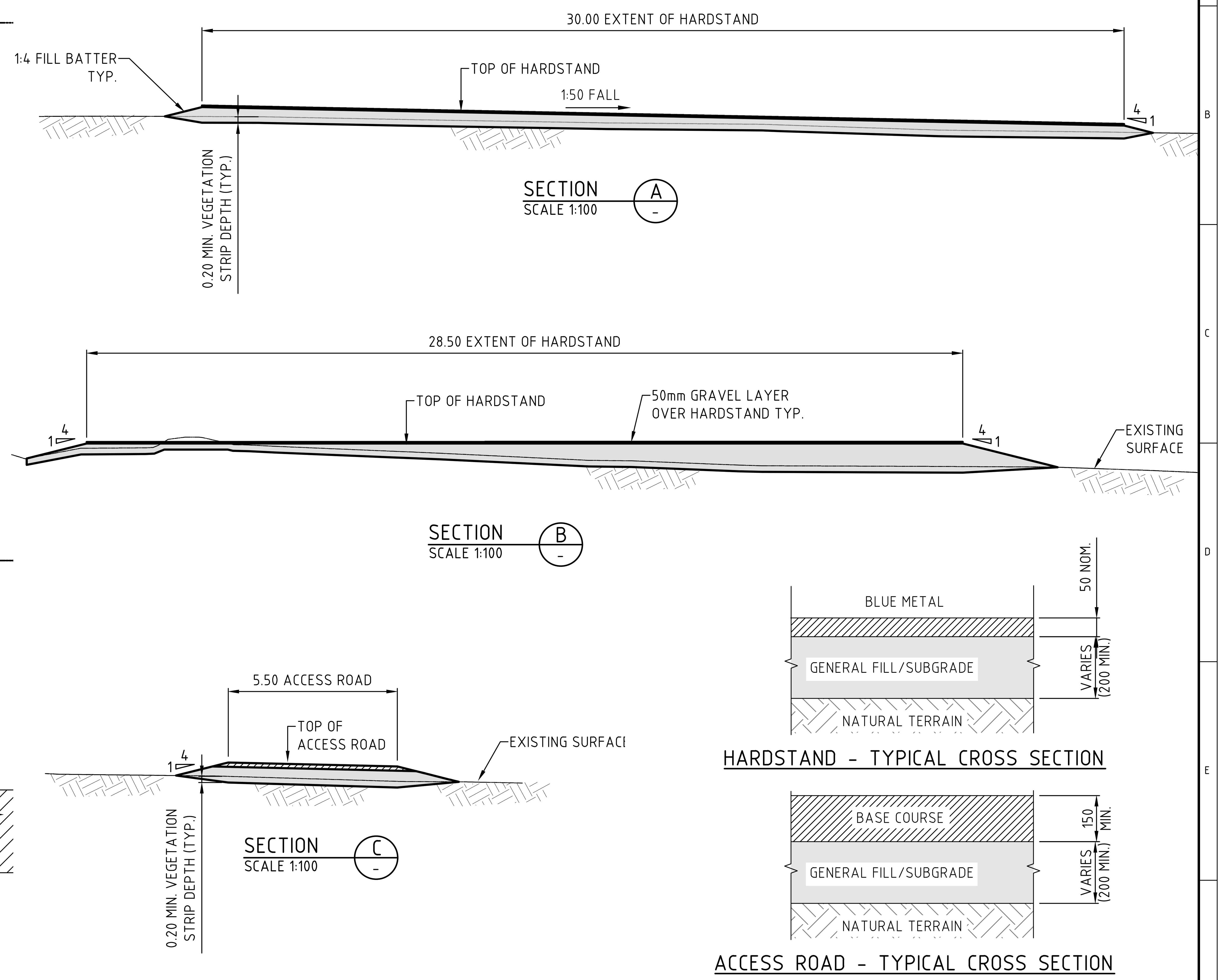


CIVIL PLAN AND SETOUT
SCALE 1:200

SITE CONTROL STATION/POINTS	EASTING (MGA)	NORTHING (MGA)	EL (AHD) (RL)	MARK
502 (MSP/966)	302,381.140	6,254,455.362	63.558	STAR PICKET
503 (MSE/967)	302,425.404	6,254,472.147	63.842	SPIKE
CONTOUR & FEATURE SURVEY DRG. NO. 211761-TS01				

NOTES

1. FOR GENERAL CIVIL & CONCRETE NOTES REFER TO DRG: P2G-2099-DW-CV-004-01 & 02.
2. ALL DIMENSIONS ARE IN METERS.
3. TEMPORARY BENCH MARKS (TBM) 4 OFF REQUIRED FOR SITE SETOUT AS NOTED ON THIS DRAWING.
4. VEHICLE TURNING RADIUS BASED ON 12.5m RIGID BUS.
5. TOP OF HARD STAND SHALL BE CAPPED WITH 50mm BLUE METAL TYPICALLY (EXCLUDING BATTERS).



LEGEND

(grey fill)	HARD STAND: GENERAL FILL NOTE B10.1 DRG: P2G-2099-DW-CV-004-01
(dense hatch)	ACCESS ROAD: ROAD BASE FILL NOTE B10.4 DRG: P2G-2099-DW-CV-004-01
(hatch)	ACCESS ROAD: BITUMEN, NOTE B10.5 DRG: P2G-2099-DW-CV-004-01
TBM/LM	TEMPORARY BENCH MARK/ LOCATION MARK

0 2.5 5.0 7.5 10
SCALE 1:100 METRES

0 5 10 15 20
SCALE 1:200 METRES

FOR REVIEW

NOT FOR CONSTRUCTION

DRAWING No. | REFERENCE DRAWINGS

ASSET MANAGER
Jemena
Produced by
Jemena Asset Management (6) Pty Ltd
ABN 52 104 352 650

ASSET OWNER
Jemena
Jemena DDP(1) P/L
ABN 52 072 109 865
Jemena DDP(2) P/L
ABN 93 125 873 869
Jemena DDP(3) P/L
ABN 83 127 059 152

REV	DATE	DESCRIPTION	DRAWN	CHECKED	ENG CHK	APPRV
A	25/06/19	ISSUED FOR REVIEW (18667)	GPA	AM	NKB	IIK

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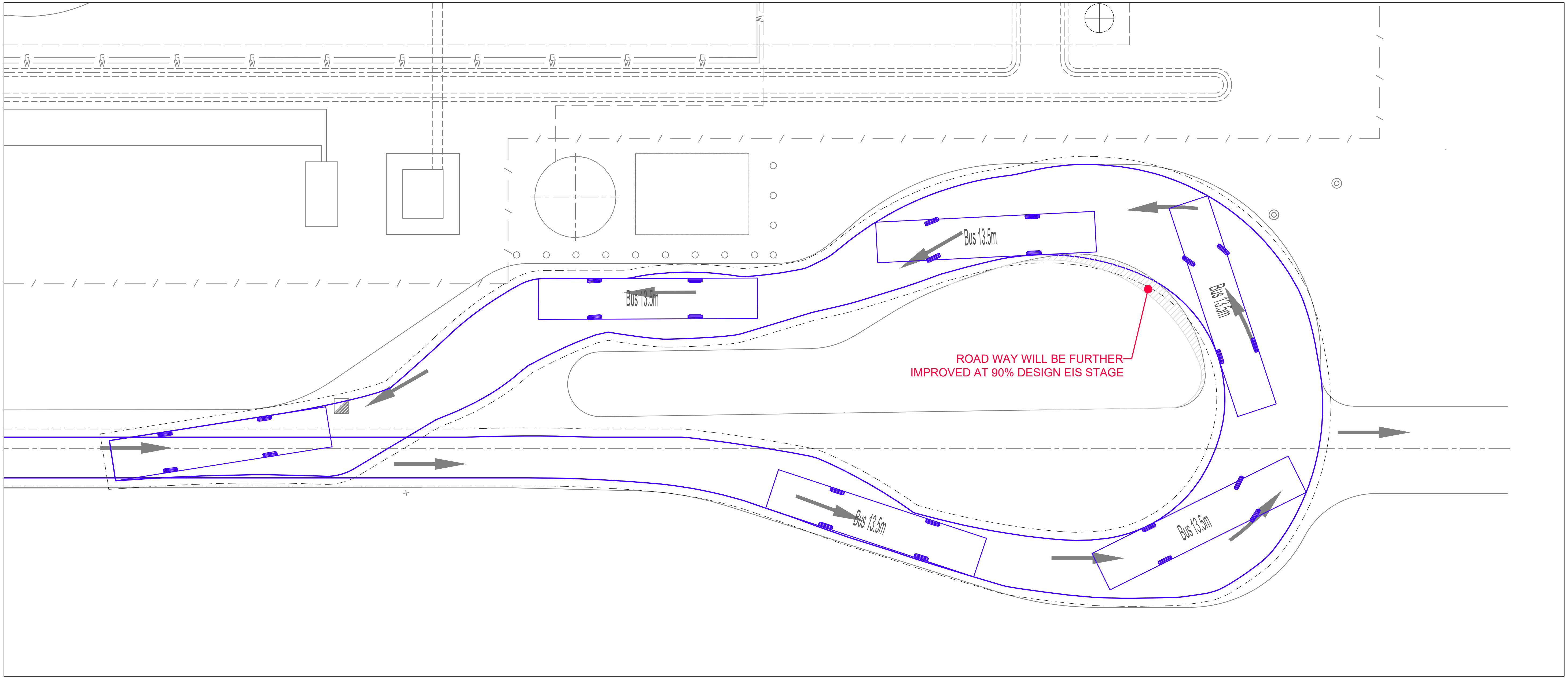
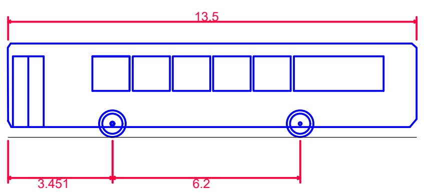
WESTERN SYDNEY GREEN GAS TRIAL
HORSLEY PARK
CIVIL EARTHWORKS
PLAN & DETAILS

DRAWN	GPA		
DESIGN	NKB	SCALE	1:200
CHECKED	AM	SUPERSEDES	A1
APPROVED	IIK	DRAWING NUMBER	REV
DATE	09/04/2019	P2G-2099-DW-CV-009	B

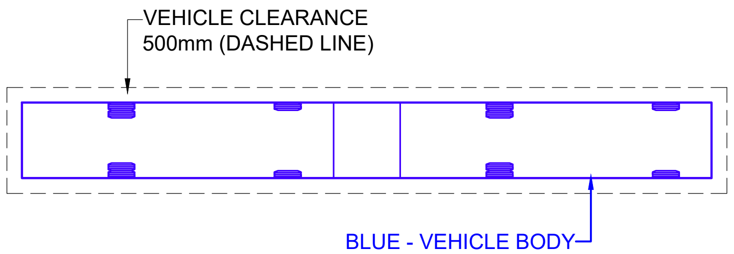
Appendix B Swept Path Analysis





Bus 13.5m

Overall Length	13.500m
Overall Width	2.500m
Overall Body Height	3.102m
Min Body Ground Clearance	0.337m
Track Width	2.500m
Lock-to-lock time	4.00s
Curb to Curb Turning Radius	12.410m



REV.	DATE	AMENDMENT DESCRIPTION	DRAWN	CHECKED	APPROVED
A	31-10-19	ORIGINAL ISSUE	LD	BH	BH

SCALE 0 2.5 5 7.5 10 12.5m
SCALE 1:250 AT ORIGINAL SIZE
NORTH
N

TTM CONSULTING PTY LTD
ABN 65 010 868 621
LEVEL 5, Suite 501, 174 Pacific Highway
Greenwich NSW 2065
T: (02) 9418 3033 F: (02) 9418 3112
E: ttmbris@ttmgroup.com.au W: www.ttmgroup.com.au

PROJECT
WESTERN SYDNEY GREEN GAS TRIAL HORSLEY PARK

DRAWING TITLE
SWEPT PATH ANALYSIS
DESIGN VEHICLE - 13.5m BUS

PROJECT NUMBER	ORIGINAL SIZE
19SYT0068	A3
DRAWING NUMBER	REVISION
18SYT0068-01	A
DATE	SHEET
31 Oct 2019	1 OF 1