

# Fire Safety Study

Revision 05

14 March 2025

**Upper South Creek – Advanced Water Recycling Centre**





## Fire Safety Study

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## Executive Summary

Sydney Water is developing a modern, sustainable, and highly automated Advanced Water Recycling Centre (AWRC) and circular economy hub in Kemps Creek in Western Sydney. Located at the junction of Kemps Creek and South Creek, the AWRC will produce advanced quality recycled water suitable for release to the Nepean River in line with the Hawkesbury-Nepean nutrient removal framework.

The AWRC Foundation Plant will treat wastewater and produce high-quality water (close to drinking water standard) with flexibility to supply recycled water to future local customers, including residential, commercial and agriculture users in the Western Sydney Aerotropolis Growth Area (WSAGA) and South-West Growth Area (SWGA). The Jacobs and GHD Design Joint Venture (DJV) are designing the Upper South Creek AWRC.

The SSI -8609189 Minister's Conditions of Approval (CoA), condition E135(b) requires for the facility that a Fire Safety Study (FSS) is undertaken for the development.

The hazard identification process identified two (2) hazards which posed an increased risk to the facility and require further review as part of this study. These being;

- Vapour Cloud Explosion (VCE) and flashfire at the biogas holders, and
- Jet flame at the gas flares.

Main findings of the FSS can be summarised in Table 1, 2, and 3.

In accordance with HIPAP 2 (Department of Planning, 2011) Section 3.3, this FSS has been developed in consultation with the design team, enabling the integration of the measures described below, as the design has progressed. Therefore, the recommendations made by this report are being implemented as part of the construction of the facility, and the operational recommendations are to be implemented by the operator. Detailed implementation of the design parameters are included in Appendix E.

**Table 1** *Biogas holders' prevention and mitigation measures*

Parameter	Prevention and Mitigation Measures
Gas fittings, piping, and valves	All gas piping's and fittings shall be designed and installed in accordance with <i>AS/NZS 5601</i> The relief devices shall be designed and installed in accordance with <i>AS 1271—2003</i>
Electrical equipment	All electrical equipment used for operations and monitoring for the digester within the hazardous area zone, is required to comply with <i>AS/NZS 60079.14</i> . Electrical bonding and earthing of isolated equipment will be required in accordance with <i>AS/NZS 1020</i> in hazardous areas.
Methane detection	A methane detector (indicated in Figure 20) is provided downstream of the biogas holders. The detector will be exposed to clean air. In the event of membrane failure, the instrument shall be checked and re-calibrated. <ul style="list-style-type: none"> <li>– The detector will be configured to a threshold of 20% LFL (Lower Flammability Limit).</li> <li>– An uninterrupted power supply (UPS) is provided for all critical safety elements including the methane detector and programmable logic controller (PLC).</li> </ul>
Minimising ignition sources	<ul style="list-style-type: none"> <li>– Duty and standby fans that are used to inflate the outer membrane are recommended to be designed to prevent frictional sparking risks</li> <li>– Flame arrestors will be installed in various locations across the digester (detailed in Figure 23)</li> <li>– Lightning protection to be available in this area (detailed in Figure 24)</li> </ul>
Excess digester gas	Surplus methane produced in the digester shall be combusted and not accumulated. The waste gas burner shall operate when the level or pressure in the gas holder reaches the set point from the transmitter. Supervisory Control and Data Acquisition (SCADA) is recommended to monitor gas levels in the digester and control the amount of gas flared
Operational procedures	Procedures shall be developed to include the required steps to prevent and monitor a tear in the inner membrane during different stages of the digester - commissioning, maintenance and operation.

Parameter	Prevention and Mitigation Measures
	Procedures shall reflect the requirement to maintain sufficient gas in the digester headspace to keep the membrane at least 20% above “empty level” during operation.
Maintenance procedure	A maintenance procedure shall be developed and implemented as per the suppliers’ recommendations to ensure fittings and the associated pipework is appropriately maintained.
Bushfires	It is recommended that a bushfire management plan be developed and implemented to reduce the total flammable gas stored or produced in the digester.
First aid fire fighting	Hydrant coverage will be provided to the digester, and fire extinguishers will be provided to areas surrounding the digester pipework at ground level

**Table 2 Gas flare prevention and mitigation measures**

Parameter	Prevention and Mitigation Measures
Gas piping and fittings and valves	<ul style="list-style-type: none"> <li>– Appropriate standards for gas piping and fittings shall be used (<i>AS 4041</i> and Section 2 of <i>AS/NZS 5601</i>).</li> <li>– Safety shut off valve system shall exhibit minimum requirements as stipulated by <i>AS 3814-2018</i>. This being that two valves in series are required with the valves to be class 1 automatic valves.</li> </ul>
Burners	<ul style="list-style-type: none"> <li>– Flame detector shall be installed for both the main burner and pilot burner may require a detector.</li> <li>– A pilot turndown test is required to be completed at a period defined by the supplier.</li> </ul>
Operating system	<p>Flame Safeguard System or Burner Management System shall be designed and installed in accordance with <i>AS 3814 -2018</i>.</p> <ul style="list-style-type: none"> <li>– The Flame Safeguard System or Burner Management System shall also be calibrated to a flame failure response time of 3 seconds.</li> <li>– An interlock system to shut off the bio gas fuel supply separate to the flame safeguard system or burner management system is recommended</li> </ul>
Lock out systems	<p>Flare operation dependent on flow shall be fitted with lockout features to activate when:</p> <ul style="list-style-type: none"> <li>– The device is not confirmed to be in a “no flow” state before ignition.</li> <li>– Loss of flow occurs during operation.</li> </ul>
Operational procedures	Operational procedures for reignition attempts after flame failure shall conform to Section 3.5.5 <i>Automatic reignition attempt on flame failure of AS 3814 -2018</i>

**Table 3 Fire Services requirements**

Parameter	Fire Services Requirements
Fire Water Supply and Demand	Total fire water demand for the site is 288,000 L. There are no additional fire water demand from the special fire hazard scenarios assessed.
Fire Water Supply	The primary fire-fighting water supply to the site is currently proposed to be provided by the town’s ring main.
Bushfire Firefighting Water	Bushfire fire water is not included in the overall water requirement of the site as they are a separate consideration. Please see bushfire assessment report for further details (Reference No: AWRC-DJV-RPT-GEN-0501-0019, Revision 01, dated 28 July 2023)
Stormwater System	The proposed stormwater drainage system for the site has been designed to capture a 1 in 20 year rainfall event. This equates to a capacity of approximately 489 kL. Therefore, the design is capable of capturing the full 288,000 L of potentially contaminated fire water run off as a result of the fire hydrants operating on site, inclusive of standard rain events.
First Aid Protection	First aid protection primarily comprises of fire hose reels and fire extinguishers as summarised in Section 6.3. No additional requirements for special hazard scenarios.

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## Acronyms and abbreviations

Acronym	Full name
ADGC	Australian Dangerous Goods Code
APZ	Asset Protection Zone
AS	Australian Standards
AWRC	Advanced Water Recycling Centre
AWTPRO	Advanced Water Treatment Plan Reverse Osmosis
BAL	Bushfire Attack Level
BCA	Building Code of Australia
CoA	Conditions of Consent
DG	Dangerous Good
DJV	Design Joint Venture
DN	Nominated Diameter
DPHI	Department of Planning, Housing and Industry
ERPG	Emergency Response Planning Guideline
FDCIE	Fire Detection Control and Indicating Equipment
FHA	Final Hazard Analysis
FRNSW	Fire and Rescue New South Wales
FSS	Fire Safety Study
HIPAP	Hazardous Industry Planning Advisory Paper
HV	High Voltage
IBC	Intermediate Bulk Container
ISO	International Organization for Standardization
LEL	Lower Explosive Level
LFL	Lower Flammability Limit
LPG	Liquified Petroleum Gas
MBR	Membrane Bioreactor
NCC	National Construction Code
NZS	New Zealand Standards
P&ID	Piping & Instrumentation Diagram
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment

Acronym	Full name
RDT	Rotary Drum Thickener
RFS	Rural Fire Service
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheet
SWGA	South-West Growth Area
SWS	Sydney Water Specification
VCE	Vapour Cloud Explosion
WAS	Waste Activated Sludge
WSAA	Water Services Association of Australia
WSAGA	Western Sydney Aerotropolis Growth Area
UPS	Uninterrupted Power Supply
VOC	Volatile Organic Compounds

# 1 Introduction

Sydney Water is developing a modern, sustainable, and highly automated Advanced Water Recycling Centre (AWRC) and circular economy hub in Kemps Creek in Western Sydney. Located at the junction of Kemps Creek and South Creek, the AWRC will produce advanced quality recycled water suitable for release to the Nepean River in line with the Hawkesbury-Nepean nutrient removal framework.

The AWRC Foundation Plant will treat wastewater and produce high-quality water (close to drinking water standard) with flexibility to supply recycled water to future local customers, including residential, commercial and agriculture users in the Western Sydney Aerotropolis Growth Area (WSAGA) and South-West Growth Area (SWGGA). The Jacobs and GHD Design Joint Venture (DJV) are designing the Upper South Creek AWRC.

The SSI-8609189 Minister's Conditions of Approval (CoA), condition E135(b) for the facility requires that a Fire Safety Study (FSS) is undertaken for the development and submitted to the NSW Department of Planning, Housing and Industry (DPHI) prior to the commencement of construction of the AWRC development (except for construction of those works that are outside of the scope of the hazard studies) or within such further period as the Planning Secretary may agree.

## 1.1 Purpose of the Report

The purpose of this report is to provide a FSS of the AWRC development in accordance with the requirements of SSI-8609189 CoA E135(b), as quoted below:

*E135(b) - a Fire Safety Study for the AWRC development. This study must cover the relevant aspects of the Department's Hazardous Industry Planning Advisory Paper No. 2, 'Fire Safety Study Guidelines' (Department of Planning, 2011) and the New South Wales Government's Best Practice Guidelines for Contaminated Water Retention and Treatment Systems (HMPPCC, 1994). The study must meet the requirements of Fire and Rescue NSW.*

## 1.2 Scope

The scope of the FSS will include the following:

- Identification of fire hazards
- Analysis of consequences of potential fire incidents
- Fire prevention strategies and measures
- Analysis of requirements for fire detection and protection
- Detection and protection measures to be implemented
- Firefighting water demand and supply
- Containment of contaminated firefighting water
- First aid fire protection arrangements and equipment

## 1.3 Limitations

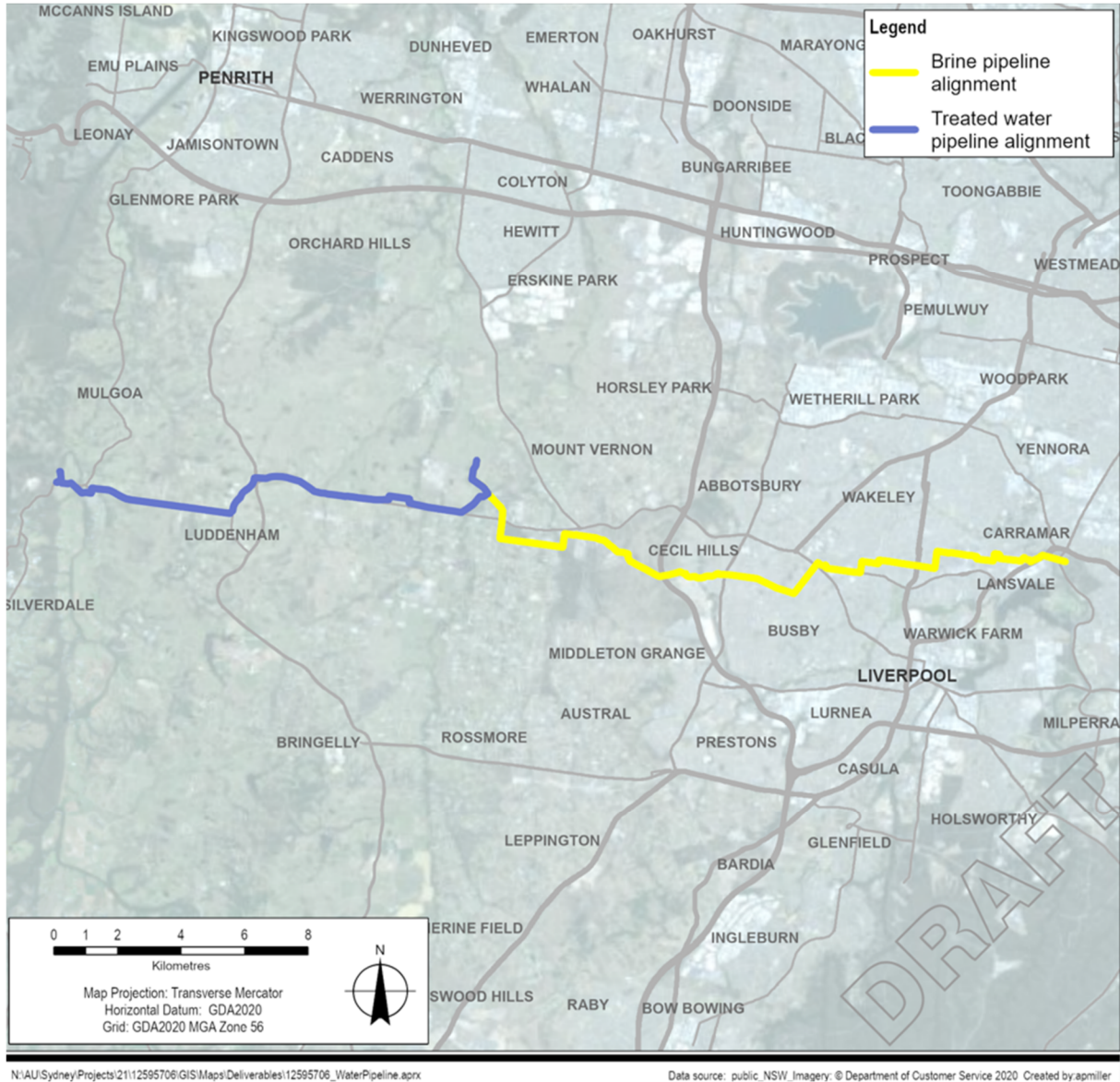
This report is limited to assessing the adequacy of fire protection measures for fire hazard scenarios identified as having an increased level of consequence to infrastructure and the environment. This report does not address the fire protection measures for areas of site that have not identified as an increased level of risk, which are assumed to be provided with fire protection measures in accordance with the National Construction Code (NCC) and the relevant standards.

The following limitations are applicable in the preparation of this report:

1. *Any information relied upon and presumed accurate in preparing the report (i.e. client and/or third party information)*
2. *Where data in the report was derived from (i.e. information sourced from the client and/or public domain)*
3. *The report has been prepared exclusively for Jacobs' client and no liability is accepted for any use or reliance on the report by third parties.*
4. *The report be read in full, with no excerpts to be representative of the findings*

## 2 Description of the Facility

The site is a greenfield development located at the junction of Kemps Creek and South Creek, west of Sydney and will be known as the Upper South Creek Advanced Water Recycling Centre (AWRC). This facility will have an ultimate capacity of 70 ML/d and a Stage 1 capacity of 35 ML/d.



**Figure 1** Location Map

The AWRC site is approximately 78 hectares in size and is bordered by South Creek to the west, Kemps Creek to the northeast, and the proposed M12 Motorway to the south. The site design is shown in Figure 2.

The key project components in the operational area include:

- The AWRC itself, including associated buildings, infrastructure, and equipment
- Ancillary infrastructure, including pumping stations, administration building, carparking, internal roads, renewable energy generation, onsite detention basins, chemical storage, and switch rooms.

It will operate 24 hours a day and seven days a week.

Future stages of the AWRC development site are proposed to have a green space area along the north and west of the site, adjacent to the waterways.

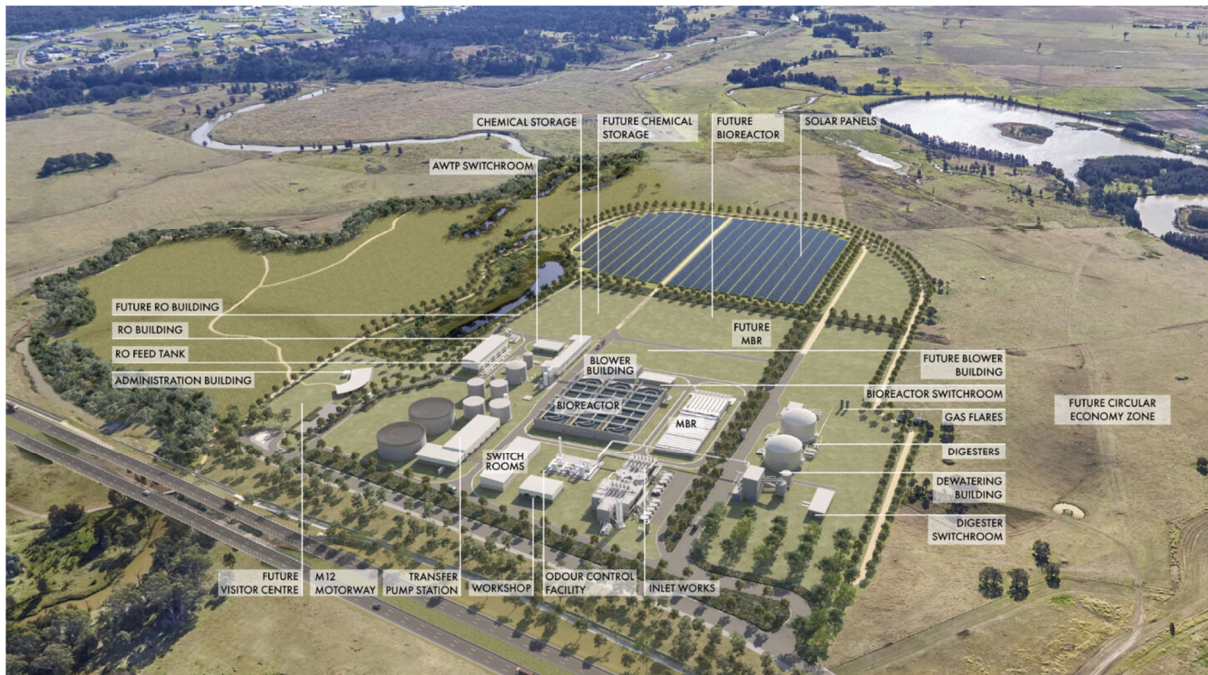


Figure 2 Regional Plan – Stage 1 render

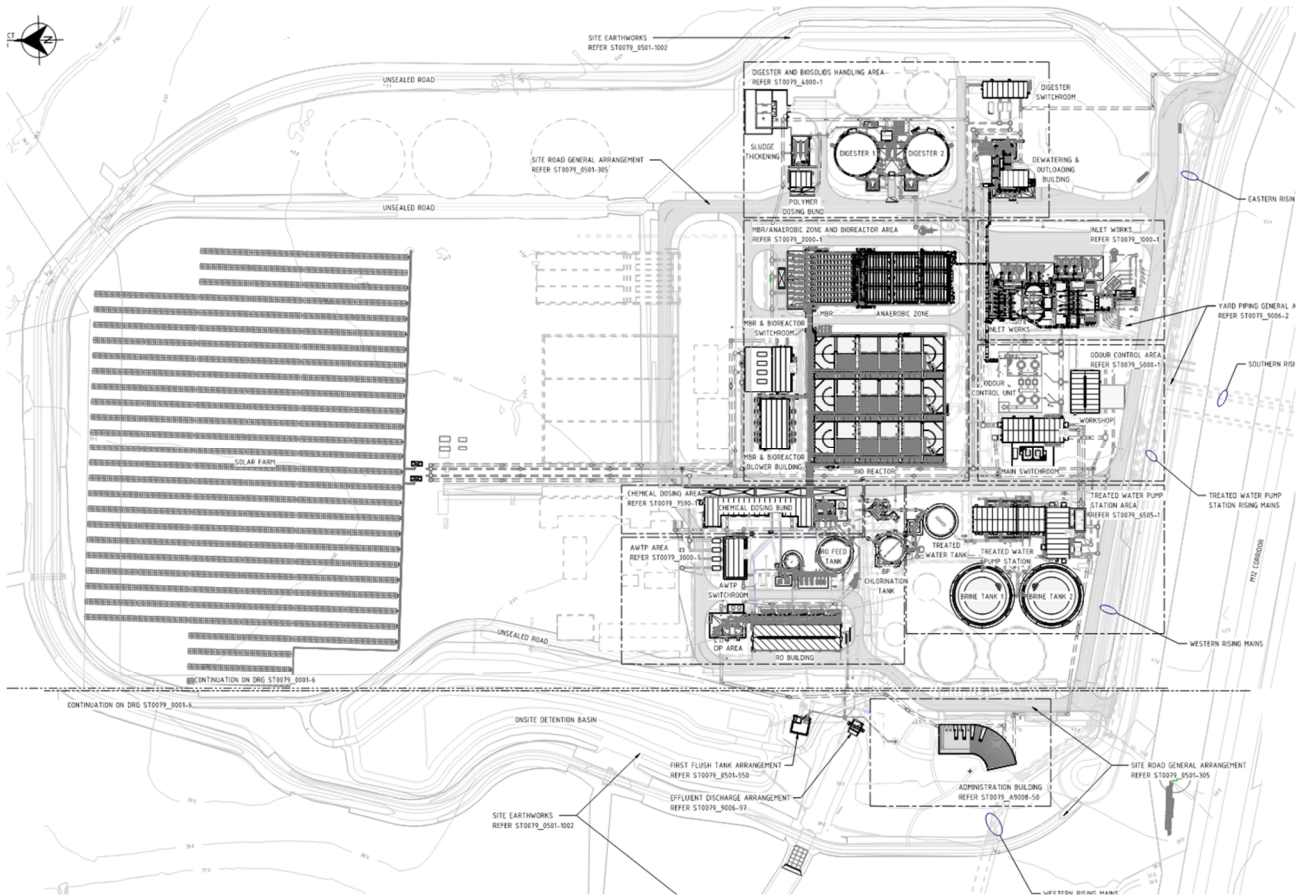
## 2.1 Site Layout

The AWRC Plant and equipment will include:

- Inlet works
- Anaerobic Tanks and Bioreactor
- Membrane Bioreactor (MBR)
- Waste Activated Sludge (WAS) Thickening
- Anaerobic digesters
- Biogas Pipework, energy recovery and hot water systems, including gas flare
- Dewatering centrifuges
- Biosolids (Dewatered Sludge) conveyors
- Digesters and Dewatered Sludge Silo
- Biosolids truck out loading building
- Advanced Water Treatment (Reverse Osmosis Membranes)
- Treated water and brine tanks and pumpstation, connected to a 24km brine pipeline to Malabar system
- Chemical dosing and storage

These plant areas are depicted in Figure 3.

The same figure also shows a proposed solar farm located to the North of the primary processing facility, which is largely part of a separate set of works.



**Figure 3 Site Plan**

Plant and equipment forming part of the water recycling process are located both externally in the open air (i.e. digesters) as well as within buildings (i.e. reverse osmosis technology).

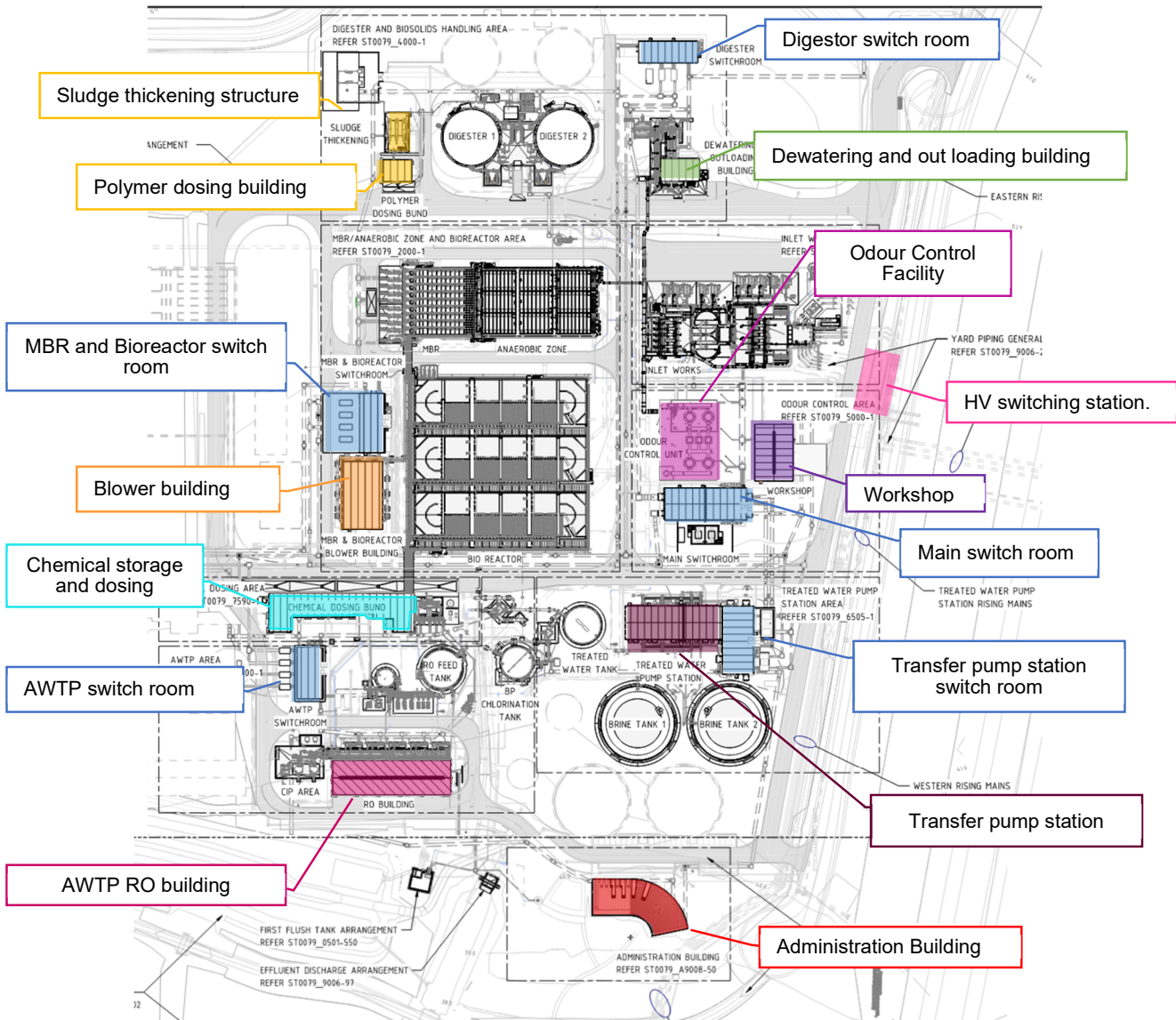
Where located within a building, the fire protection requirements are driven by the National Construction Code (NCC). Unless the specific building forms part of the infrastructure identified as a potential area with increased fire risk/consequence, the fire protection measures for these buildings are to be provided in accordance with the requirements of the NCC.

Details regarding the onsite buildings subject to NCC fire safety requirements are outlined further in Section 2.2.

## 2.2 On site infrastructure

The key component of a FSS is to analyse all potential special fire hazards on site. However, for an onsite building that presents no, or limited special fire hazards, the building is subject to standard NCC requirements regarding fire safety.

Fire Hydrants, although not required by the NCC for a building with a fire compartment less than 500 m<sup>2</sup>, will still be provided to all buildings. Essentially all buildings on site will be provided with hydrant coverage from the sitewide hydrant system – this was determined based upon the results of this FSS and from the perspective of asset protection. Below is a comprehensive analysis of all buildings on site and all other required fire services.



**Figure 4 Building Locations**

Fire protection systems required for each building are triggered by either the NCC 2019 Amendment 1 or a Sydney Water Specification (SWS). The compliance triggers of each building for different fire safety requirements are outlined in Table 5.

Building Code of Australia (BCA) reports prepared by Matt Shuter & Associates are the basis of Table 5. It is to be noted that the BCA reports were initially one document, however as the design progressed the BCA reports have been separated per building as follows:

**Table 4 BCA Reports**

Building	Report Number	Rev	Status	Date
Dewatering and out loading building	MSA2550_BCA_DEW_1	1	Draft 80%/IFC Design Review	16 February 2024
AWTP Switch Room	MSA2550_BCA_AWTPSW_1	1	Draft 80%/IFC Design Review	30 January 2024
Digester Switch Room	MSA2550_BCA_DIGSW_1	1	Draft 80%/IFC Design Review	30 January 2024
MBR and Bioreactor Switch Room	MSA2550_BCA_MBRS_1	1	Draft 80%/IFC Design Review	30 January 2024

Building	Report Number	Rev	Status	Date
Main Switch Room	MSA2550_BCA_MSW_1	1	Draft 80%/IFC Design Review	30 January 2024
Sludge thickening structure	MSA2550_BCA_UPP_2	2	50% Design Review	19 July 2023
Polymer Dosing Building	MSA2550_BCA_UPP_2	2	50% Design Review	19 July 2023
Blower room	MSA2550_BCA_BLO_1	1	Draft 80%/IFC Design Review	30 January 2024
Workshop	MSA2550_BCA_WRK_1	1	Draft 80%/IFC Design Review	30 January 2024
Chemical storage and dosing building	MSA2550_BCA_CDB_1	1	Draft 80%/IFC Design Review	30 January 2024
AWTP RO building	MSA2550_BCA_ROB_1	1	Draft 80%/IFC Design Review	30 January 2024
Transfer pump station	MSA2550_BCA_TRT_1	1	Draft 80%/IFC Design Review	30 January 2024
Admin building	MSA2550_DDA_ADM_1	1	Draft 80%/IFC Design Review	30 January 2024

**Table 5 Compliance triggers for each building**

Building	Automatic fire detection and alarm system	Building occupant warning system	Fire Hose reels	Portable fire extinguishers and fire blankets
Dewatering and out loading building	✓ NCC/SWS	✓ NCC	-	✓ NCC
Odour Control Facility	-	-	-	-
Switch Rooms	✓ SWS	✓ NCC	-	✓ NCC
Polymer dosing building	✓ SWS	✓ NCC	-	✓ NCC
Sludge thickening structure	-	-	-	-
Blower room	✓ SWS	✓ NCC	-	✓ NCC
HV Switching station	✓ SWS	✓ NCC	-	✓ NCC
Workshop	✓ SWS	✓ NCC	-	✓ NCC
Chemical storage and dosing building	✓ SWS	✓ NCC	✓ NCC	✓ NCC
AWTP RO building	✓ SWS	✓ NCC	✓ NCC	✓ NCC
Transfer pump station	✓ SWS	✓ NCC	✓ NCC	✓ NCC
Admin building	✓ SWS	✓ NCC	✓ NCC	✓ NCC

### 2.2.1 Dewatering and out loading building (WL 15)

The dewatering and outloading building houses essential process equipment involved in water removal from sludge. This equipment includes sludge centrifuges and conveyor belts.

Following an assessment of the BCA report prepared by Matt Shuter & Associates (*reference: MSA2250\_BCA\_DEW\_1, Rev: 1, Date of issue: 16<sup>th</sup> February 2024*) and taking into account stakeholder feedback, it has been identified that two (2) instances of non-compliance with the National Construction Code (NCC) require attention through fire engineering performance solutions.

The performance solutions are being addressed by DJV Fire Engineering and encompass addressing a non-continuous non-fire isolated stair and decreased fire rating of internal beams and columns within the building.

It is to be noted that WL 15 also contains polymer powder that is used during the process. However, the Hazardous Area Classification report (GHD & Jacobs, 2024) does not consider polymer powder storage to be hazardous as the area is inherently free from combustible dusts.

Due to the dewatering building containing sludge, a limited quantity of flammable vapours produced by the sludge can be considered hazardous as determined in the Hazardous Area Classification report (GHD & Jacobs, 2024). The quantity of flammable vapours produced by the sludge is limited, and is controlled via industry best practise. Further information on these controls are available in Section 3.3.4. As a result, the FSS has deemed the fire hazard risk in WL15 to be suitably mitigated through these practices. Subsequently, the building can be taken to have a minimal fire hazard profile.

Irrespective of these performance solutions, and minimal fire hazards, the dewatering and out loading building is subject to compliance with fire safety regulations as stipulated by NCC. These regulatory requirements, in addition to other NCC specifications, are catalogued in Table 6.

**Table 6** *Dewatering and out loading building description*

<b>NCC detail</b>	<b>Description</b>
Classification	Class 8
Rise in stories	3
Construction type	Type B
Fire Engineering	Non-compliant to NCC 2019 Amendment 1 Clause D1.9 and C1.1
Fire services	<ul style="list-style-type: none"> <li>- Automatic Fire detection</li> <li>- Occupant warning</li> <li>- Fire Extinguishers</li> <li>- Hydrant coverage</li> </ul>

## 2.2.2 Odour control facility

The odour control facility captures foul air from the following sources, to treats the air with a two-stage bio-trickling filter and activated carbon filter process:

- Inlet works channels
- Inlet works screenings sluicing launders
- Inlet works equipment and bins
- Inlet works wastewater pump station
- Bioreactor flow splitter structure
- Bioreactor anaerobic zones
- Sludge thickening equipment
- Biosolids dewatering equipment
- Biosolids conveyors (belt and screw)
- Biosolids storage silo
- Biosolids truck outloading bay
- Solids handling return pump station.

Discharge of treated air will be via a discharge stack, located locally to the odour treatment facility. Overall, the odour control facility extracts odorous and hazardous gases from the process throughout the plant to a centralised location for treatment using biological and physical processes.

Since the facility involves the extraction of Volatile Organic Compounds (VOC), the odour control facility is considered hazardous as determined in the Hazardous Area Classification report (GHD & Jacobs, 2024). However, the quantity of VOCs accumulated is limited and is controlled via industry best practise. Further information on these controls is available in Section 3.3.5.

As a result, the FSS has deemed the fire hazard risk in the odour control facility to be suitably mitigated through these practices. Subsequently, the building can be taken to have a minimal fire hazard profile.

The odour control facility is also not classified as a building and is therefore not subject to compliance with fire safety regulations as stipulated by the NCC.

### 2.2.3 Switch rooms

All switch rooms on site serve as the housing for essential electrical switching and distribution equipment dedicated to a specific building or area. Switch rooms on site include:

- Digester switch room
- MBR and Bioreactor switch room (WL07c)
- Main switch room (WL23a)
- AWTP switch room (WL23c)
- Transfer pump station switch room (WL10)

The precise location of these switch rooms in this facility is depicted in Figure 4. It is noteworthy that these switch rooms house sensitive electrical equipment that may present an ignition risk. However, it is worth emphasizing that they are comprehensively governed by regulations, including the National Construction Code (NCC) and industry standards like AS/NZS 61439. As a result, they are deemed to have foreseeable risks and are free from any exceptional fire hazards.

Consequently, their compliance responsibilities are exclusively tied to adhering to the fire safety regulations outlined in the NCC. These regulatory requirements, along with other pertinent NCC specifications, are detailed in Table 7.

**Table 7** Switch room building description

NCC detail	Description
Classification	Class 8
Rise in stories	1
Construction type	Type C
Fire services	<ul style="list-style-type: none"> <li>- Automatic Fire detection</li> <li>- Occupant warning</li> <li>- Fire Extinguishers and Fire Blankets</li> <li>- Hydrant coverage</li> <li>- Fire Hose Reel (Transfer Pump Station Switch Room)</li> </ul>

### 2.2.4 Sludge thickening structure

The sludge thickening area is a non-enclosed structure consisting of process equipment such as rotary drum thickeners on an open air gangway. The area contains three (3) rotary drum thickeners (duty/assist/standby) used to thicken waste activated sludge.

The Hazardous Area Classification report (GHD & Jacobs, 2023) considers the rotary drum thickeners to be non-hazardous. Further information is provided in Section 3.3.6.

The structure is thus free from any distinctive fire hazards and it is to be noted that as the structure is a Class 10b structure, no fire protection measures are necessary under the NCC.

**Table 8** Sludge thickening structure

NCC detail	Description
Classification	Class 10b
Fire services	N/A

### 2.2.5 Polymer dosing building (WL13)

The area also contains a polymer storage and dosing space, where liquid polymer is introduced to the process. This particular area is known as the Polymer Dosing Building.

The Hazardous Area Classification report (GHD & Jacobs, 2023) does not consider the liquid polymer storage and dosing area as being a hazardous area. The area is non-hazardous as the processes involved are inherently free from flammable vapours and combustible dusts.

The building is thus free from any distinctive fire hazards and consequently, it is solely subject to compliance with fire safety regulations as stipulated by NCC. These fire safety requirements, in addition to other NCC specifications, are catalogued in Table 9.

**Table 9** *Polymer dosing building description*

NCC detail	Description
Classification	Class 7b
Fire services	<ul style="list-style-type: none"> <li>- Automatic Fire detection</li> <li>- Occupant warning</li> <li>- Fire Extinguishers</li> <li>- Hydrant coverage</li> </ul>

## 2.2.6 Blower room (WL07c)

The blower building essential process equipment involved in the aeration of the sludge. The building is free from any distinctive special fire hazards, and consequently, the building is solely subject to compliance with fire safety regulations as stipulated by the NCC. These regulatory requirements, in addition to other NCC specifications, are catalogued in Table

**Table 10** *Blower rooms building description*

NCC detail	Description
Classification	Class 8
Rise in stories	1
Construction type	Type C
Fire services	<ul style="list-style-type: none"> <li>- Automatic Fire detection</li> <li>- Occupant warning</li> <li>- Fire Extinguishers</li> <li>- Hydrant coverage</li> </ul>

## 2.2.7 HV switching station

The High Voltage (HV) switching station houses for essential electrical switching and distribution equipment required for high voltage switching.

It is noteworthy that the HV station contains high voltage switching gear that may present an ignition risk. However, it is worth emphasizing that they are comprehensively covered in industry standards such as Sydney Waters' *Technical Specification - HV Switch rooms*, (ref: DOC0018, Version 3, dated: 20/02/2020). As a result, they are deemed to have foreseeable risks and are free from any exceptional fire hazards that require addressing in this FSS.

Consequently the High Voltage switching station, is solely subject to compliance with fire safety regulations as stipulated by NCC. These regulatory requirements, in addition to other NCC specifications, are catalogued in Table 11.

**Table 11** *HV switching station building description*

NCC detail	Description
Classification	Class 8
Rise in stories	1
Construction type	Type C
Fire services	<ul style="list-style-type: none"> <li>- Automatic Fire detection</li> <li>- Occupant warning</li> </ul>

NCC detail	Description
	<ul style="list-style-type: none"> <li>- Fire Extinguishers and Fire Blankets</li> <li>- Hydrant coverage</li> </ul>

### 2.2.8 Workshop (WL23d)

The workshop is expected to contain site specific tools and equipment, including lubricants solvents and other liquids. However, the Hazardous Area Classification report (GHD & Jacobs, 2023) does not consider the workshop as being a hazardous area as such, no special fire hazards exist. The workshop is thus solely subject to compliance with fire safety regulations as stipulated by the NCC. These regulatory requirements, in addition to other NCC specifications, are catalogued in Table 12.

**Table 12** Workshop description

NCC detail	Description
Classification	Class 8
Rise in stories	1
Construction type	Type C
Fire services	<ul style="list-style-type: none"> <li>- Automatic Fire detection</li> <li>- Occupant warning</li> <li>- Fire Extinguishers</li> <li>- Hydrant coverage</li> </ul>

### 2.2.9 Chemical storage and dosing building (WL18)

The chemical storage and dosing building will be storing the following chemicals:

- Powdered hydrated lime
- Sodium hypochlorite
- CO2
- Sodium hydroxide
- Sodium bisulphite
- Sulphuric acid
- Ferric chloride
- Citric Acid
- Sugar (as sucrose solution)
- Antiscalant

The Hazardous Area Classification report (GHD & Jacobs, 2023) does not consider the chemical storage dosing area as being a hazardous area. The area is non-hazardous as the processes and products involved have been concluded to be free from flammable vapours and combustible dusts. However, an interaction and compatibility analysis has been completed of the chemicals stored in this area (Appendix D).

The most credible causes of failure leading to the interaction of incompatible Dangerous Goods (DGs) include corrosion and leaks from the storage tanks. These interactions may lead to new substances which are corrosive, flammable, or explosive. Hence the tanks are to be segregated in accordance with the relevant Australian Standards, namely AS 3780 – *The Storage & handling of corrosive substances*. Further information is captured in the Final Hazard Analysis (FHA). (GHD & Jacobs, 2024)

Due to the mitigation of fire hazards caused by chemical interaction (via AS 3780 complaint separation distances) the building is only subject to compliance with fire safety regulations as stipulated by the NCC. These regulatory requirements, in addition to other NCC specifications, are catalogued in Table 13.

**Table 13** *Chemical storage and dosing building description.*

NCC detail	Description
Classification	Class 7b
Rise in stories	1
Construction type	Type C
Fire services	<ul style="list-style-type: none"> <li>- Occupant warning</li> <li>- Automatic Fire detection</li> <li>- Fire hose reels</li> <li>- Fire Extinguishers</li> <li>- Hydrant coverage</li> </ul>

### 2.2.10 AWTP RO building (WL08)

The Advanced Water Treatment Plant Reverse Osmosis (AWTP RO) building houses reverse osmosis membranes used for the removal of contaminants.

The Hazardous Area Classification report (GHD & Jacobs, 2023) does not consider the AWTP RO building as being a hazardous area. The area is non-hazardous as the processes involved are inherently free from flammable vapours and combustible dusts. As such, the building is free of special fire hazards. As such, the AWTP RO area is free from any special fire hazards. Consequently the building is thus solely subject to compliance with fire safety regulations as stipulated by the NCC. These regulatory requirements, in addition to other NCC specifications, are catalogued in Table

**Table 14** *AWTP RO building description*

NCC detail	Description
Classification	Class 8
Rise in stories	1
Construction type	Type C
Fire services	<ul style="list-style-type: none"> <li>- Occupant warning</li> <li>- Automatic Fire detection</li> <li>- Fire hose reels</li> <li>- Fire Extinguishers</li> <li>- Hydrant coverage</li> </ul>

### 2.2.11 Transfer pump station (WL10)

The transfer pump station is an area used to pump liquids to a required area. As such the building is expected to be free of any special fire hazards and is thus subject to the fire safety requirements stipulated by the NCC. Please see Table 15 for further details.

**Table 15** *Transfer pump station building description*

NCC detail	Description
Classification	Class 8
Rise in stories	1
Construction type	Type C
Fire services	<ul style="list-style-type: none"> <li>- Occupant warning</li> <li>- Automatic Fire detection</li> <li>- Fire hose reels</li> <li>- Fire Extinguishers</li> <li>- Hydrant coverage</li> </ul>

### 2.2.12 Admin building (WL22)

The Admin building is expected to have a low fire risk due to its contents mainly being for office use. As such, the building is free from any special fire hazards. Consequently, the building is solely subject to the fire safety requirements stipulated by the NCC. Please see Table for further details.

**Table 16** Admin building description

NCC detail	Description
Classification	Class 5
Rise in stories	1
Construction type	Type C
Fire services	<ul style="list-style-type: none"> <li>- Occupant warning</li> <li>- Automatic Fire detection</li> <li>- Fire hose reels</li> <li>- Fire Extinguishers and Fire Blankets</li> <li>- Hydrant coverage</li> </ul>

### 2.2.13 Solar Farm

The solar farm is indicatively located on the northern side of the site. With regards to the FHA, no hazards relevant to the AWRC were identified.

The solar farm does not include a battery energy storage system at this stage of the design.

## 3 Hazards Identified

### 3.1 Materials Identified

The following products in Table 17 have been identified in the FHA as being present in the design of the AWRC (refer to Figure 4 for the site plan). The FHA also captures the interactions between each chemical stored on site.

The most credible causes of failure leading to the interaction of incompatible DGs include corrosion and leaks from the storage tanks. These interactions may lead to new substances which are corrosive, flammable, or explosive. Hence the tanks are to be segregated in accordance with the relevant Australian Standards, namely *AS 3780 – The Storage & handling of corrosive substances*. Further information is captured in the FHA. (GHD & Jacobs, 2024).

It should be noted that the SEPP 33 Threshold Quantity considers the combined quantity of chemicals in each DG class and packing group (PG), not the individual chemicals.

Table 17 Screening for the storage of Dangerous Goods used at the facility

Product Name	UN No.	Class	PG	Anticipated Storage Quantity	Combined Storage Quantity per DG class and PG	Feed Material Form	Storage Type	SEPP 33 Threshold Quantity	Threshold exceeded	Separation distances from protected place and boundaries required as per AS 3780	Location	Description
Methane / (Biogas)	1971	2.1	N/A	3,800 m3	3,849 m3	Gas	Tank	10 t	No	N/A	Biogas holder, gas flare and pipework	Used for digester heating
Liquefied Petroleum Gas (LPG)	1075	2.1	N/A	90 kg or 49 m3		Gas	Bottles (2 x 45 kg bottles)	10 t	No	N/A	Digester Area – cylinders will be stored on a concrete slab close to the gas water heater with minimum 3.5m distance from potential source of ignition and in accordance with AS 4332 requirements	LPG storage is provided as a backup gas supply for the hot water heater, especially during the plant commissioning period when biogas production from the digesters may not be sufficient to continuously operate the gas heater using biogas alone. Due to the very low total stored quantity, this is not considered to present a special fire hazard.
Carbon Dioxide	1013	2.2	N/A	14 t	14 t	Liquid	Tank	N/A	N/A	N/A	Adjacent to Chemical Delivery and Storage Area	Used as pH correction / alkalinity addition
Sodium Hydroxide	1824	8	II	70 t	91 t	Liquid	Tank	25 t	Yes	8 m	Chemical Delivery and Storage area	Used for alkalinity correction and reverse osmosis cleaning in place
Sulphuric Acid	1830	8	II	19 t		Liquid	Tank			5 m	Chemical Delivery and Storage area	Used as a pH correction.
BIOMATE MBC 781	3265	8	II	2 t		Liquid	Tank			5 m	RO CIP area	Biocide Typically stored in Intermediate Bulk Containers (IBC)s

Product Name	UN No.	Class	PG	Anticipated Storage Quantity	Combined Storage Quantity per DG class and PG	Feed Material Form	Storage Type	SEPP 33 Threshold Quantity	Threshold exceeded	Separation distances from protected place and boundaries required as per AS 3780	Location	Description
Ferric Chloride	2582	8	III	130 t	222 t	Liquid	Tank	50 t	Yes	8 m	Chemical Delivery and Storage area	Used for chemical phosphorous removal and biogas odour control
Sodium Hypochlorite	1791	8	III	71 t		Liquid	Tank			5 m	Chemical Delivery and Storage area	Various including reverse osmosis system biofouling control, MBR membrane cleaning, advanced treated water breakpoint chlorination and disinfection of emergency overflows
Sodium Bisulphite	2693	8	III	14 t		Liquid	Tank			5 m	Chemical Delivery and Storage area	Used for de-chlorination
Ammonium Hydroxide	2672	8	III	7 t		Liquid	Tank			5 m	Chemical Delivery and Storage area	For forming chloramine for reverse osmosis biofouling control

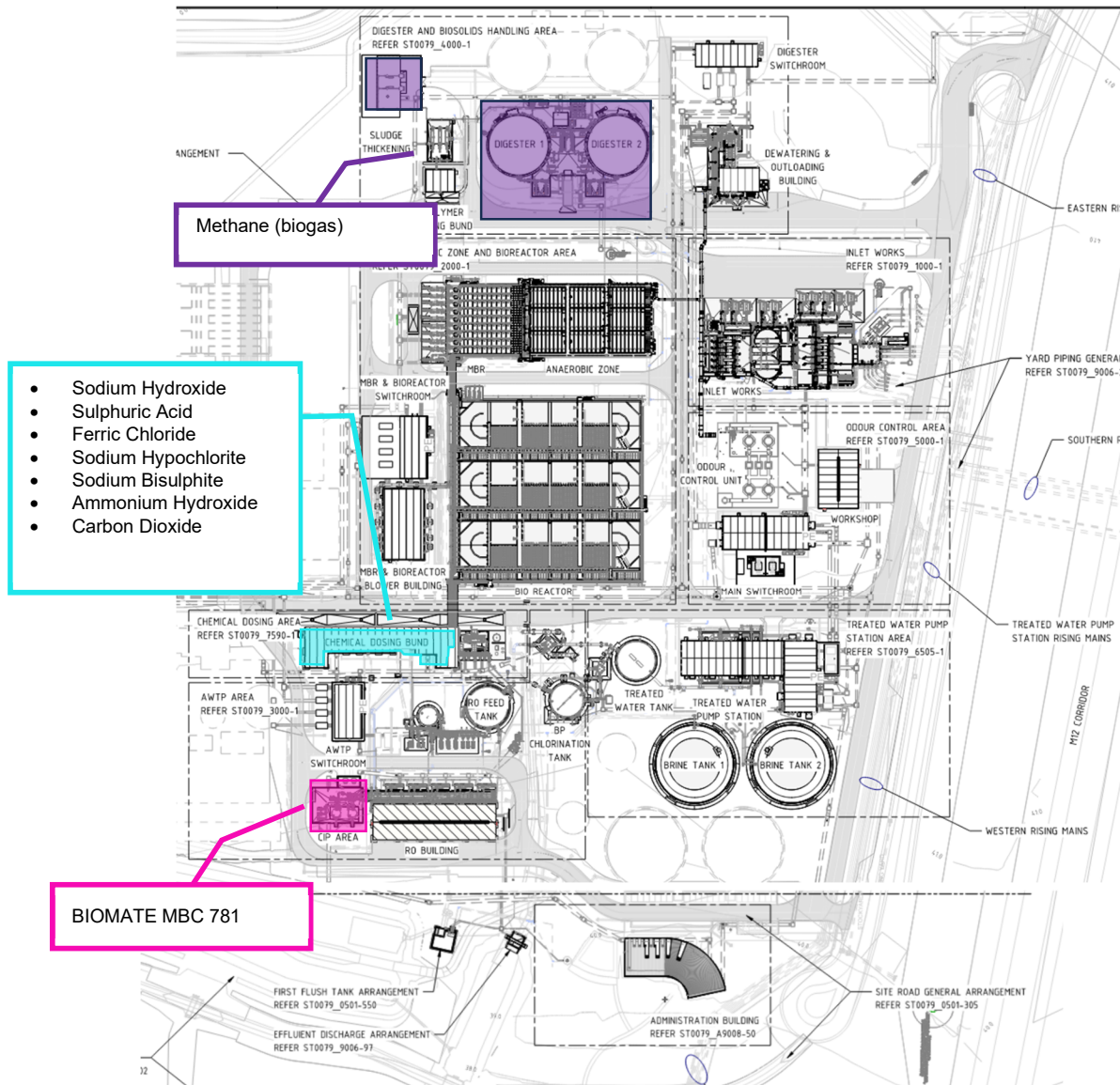


Figure 5 Building Locations with DGs

### 3.2 Hazardous incident scenarios

The hazard scenarios detailed in Table 18 have been identified in the FHA. The purpose of the FHA is to identify and model any hazards that have a potential for offsite consequences. From the FHA, three potential off-site impact events have been identified (refer to the FHA directly (GHD & Jacobs, 2024) for further information):

- Fire/ explosion in the digester gas holder
- Gas flare flame out and ignition; and fire/explosion
- Bushfire impacting the AWRC

As such, these potential events are further assessed in the FHA. The FHA has concluded that the events lead to no off-site impacts, however these are fire events that have the potential to impact the site locally, and are thus discussed in the FSS

In addition, the HAZID (Table 18) has also identified other fire and explosion hazards that have the potential to impact the site locally.

These events include:

- Fire/ explosion in the dewatering and out loading building and biosolids silo
- Fire/ explosion in the odour control facility (including inlet works and odour covers)
- Fire/ explosion in the rotary drum thickeners (inside flocculation tank, machine housing and thickened sludge hopper)
- Solar Farm fire, noting this hazard is limited to the solar farm area, not the AWRC area.

These events are further discussed in Section 3.3.4 and 3.3.5 and 3.3.6.

All remaining areas on site are considered to be free from any distinctive fire hazards. As such, these areas are subject to compliance with fire safety regulations as stipulated by the NCC. These areas have been detailed in Section 2.2, and are not pertinent to this FSS.

Table 18 Hazards Identification

Hazard scenario	Causes	Consequence	Potential for offsite impact	Identified safeguards
Methane (biogas) release	Tank, pipework or flange leak. Tear in digester membrane gas holder.	Explosion in digester tank / gas holder	Yes	<ul style="list-style-type: none"> <li>– Pressure and vacuum relief valves</li> <li>– Leak detection</li> <li>– Electrical equipment selected in accordance with the hazardous area classification</li> <li>– Comprehensive emergency plan and procedures provided for the site</li> <li>– Safety Data Sheets (SDSs) held for all materials</li> <li>– Personal Protective Equipment (PPE) provided</li> <li>– Annual fire and evacuation training to be conducted</li> <li>– Excess gas is flared when necessary (duty + standby waste gas burners / flares)</li> <li>– Both digesters are connected to a common pipe and gas can be transferred between them. Total storage volume is effectively 2 times the volume of what one digester can store.</li> </ul>
Gas flare flame out and ignition leading to an explosion	On-demand failure of the duty and standby gas flares, methane / biogas may be released into the air	Fire	Yes	<ul style="list-style-type: none"> <li>– Annual fire and evacuation training to be conducted</li> <li>– Comprehensive emergency plan and procedures provided for the site</li> </ul>
Explosive gas-air mixture forms beneath the odour covers at inlet works (zone 2 hazardous area)	Methane gas from organic content of sewerage, and flammable liquid contaminants mixed with incoming sewerage accumulating	Explosion at odour covers of inlet works	No	<ul style="list-style-type: none"> <li>– The area under the odour covers is constantly ventilated to try and stay below lower explosive limit (LEL)</li> <li>– Electrical equipment selected in accordance with Zone 2 hazardous area</li> <li>– Comprehensive emergency plan and procedures provided for the site</li> <li>– SDSs held for all materials</li> <li>– PPE provided</li> <li>– Annual fire and evacuation training to be conducted</li> </ul>
Explosive gas-air mixture forms in the inlet works foul air ducts, fans, filters, and exhaust stacks	Accumulation of flammable gas	Explosion	No	<ul style="list-style-type: none"> <li>– Electrical equipment selected in accordance with Zone 2 hazardous area</li> </ul>

Hazard scenario	Causes	Consequence	Potential for offsite impact	Identified safeguards
				<ul style="list-style-type: none"> <li>– Comprehensive emergency plan and procedures provided for the site</li> <li>– SDSs held for all materials</li> <li>– PPE provided</li> <li>– Annual fire and evacuation training to be conducted</li> </ul>
Explosive gas-air mixture may form in the rotary drum thickeners (inside flocculation tank, machine housing and thickened sludge hopper)	Waste activated sludge coming from an aerated process with a high sludge retention time has a low risk of methane generation. However, this machine does not have any ventilation, thus gas could accumulate in the housing of the machine.	Explosion	No	<ul style="list-style-type: none"> <li>– Comprehensive emergency plan and procedures provided for the site</li> <li>– SDSs held for all materials</li> <li>– PPE provided</li> <li>– Annual fire and evacuation training to be conducted</li> <li>– Waste activated sludge coming from an aerated process with a high sludge retention time has a low risk of methane generation. Automated duty rotation of rotary drum thickeners (RDT's) minimises time for sludge to remain static inside equipment. Minor natural ventilation is available through sludge hopper and RDT vents. Therefore, this area is classified as non-hazardous.</li> </ul>
Explosive gas-air mixture forms in the digested sludge centrifuge	With dewatering operations being near to continuous (20 hours or more), gas can realistically accumulate in the bowl of the machine. (inside bowl) Despite odour extraction on centrate and solids chute, gas can realistically accumulate in the housing of the machine. (inside machine outer housing)	Explosion	No	<ul style="list-style-type: none"> <li>– Electrical equipment selected in accordance with Zone 2 hazardous area</li> <li>– Comprehensive emergency plan and procedures provided for the site</li> <li>– SDSs held for all materials</li> <li>– PPE provided</li> <li>– Annual fire and evacuation training to be conducted</li> </ul>
Explosive gas-air mixture forms in the dewatered sludge belt and screw conveyors	Although sludge is stabilised, it is not uncommon for conveyors to be stopped without being cleared and for sludge to sit in position for 24hrs or more. Despite all screw and belt conveyors being fitted with odour extraction, gas can realistically accumulate in the housing of the machine.	Explosion	No	<ul style="list-style-type: none"> <li>– Electrical equipment selected in accordance with Zone 2 hazardous area</li> <li>– The area under the odour covers is constantly ventilated to try and stay below LEL</li> <li>– Comprehensive emergency plan and procedures provided for the site</li> <li>– SDSs held for all materials</li> <li>– PPE provided</li> <li>– Annual fire and evacuation training to be conducted</li> </ul>

Hazard scenario	Causes	Consequence	Potential for offsite impact	Identified safeguards
Explosive gas-air mixture forms in the dewatered sludge silo	Although sludge is stabilised, it is sitting for a significant period with minimal ventilation. Some amount of methane that is produced may accumulate. Small amounts of hydrogen sulphide (being heavier than air) could accumulate over time in the lower section of the silo away from extraction openings.	Explosion	No	<ul style="list-style-type: none"> <li>– Electrical equipment selected in accordance with Zone 2 hazardous area</li> <li>– The area under the odour covers is constantly ventilated to try and stay below LEL</li> <li>– Ventilation in the silo</li> <li>– Comprehensive emergency plan and procedures provided for the site</li> <li>– SDSs held for all materials</li> <li>– PPE provided</li> <li>– Annual fire and evacuation training to be conducted</li> </ul>
Explosive gas-air mixture forms in the odour control facility	The odour control facility extracts odourous and hazardous gases from the process throughout the plant. The facility involves the extraction of Volatile Organic Compounds (VOC) to the odour control facility.	Explosion	No	<ul style="list-style-type: none"> <li>– Electrical equipment selected in accordance with Zone 2 hazardous area</li> <li>– Comprehensive emergency plan and procedures provided for the site</li> <li>– SDSs held for all materials</li> <li>– PPE provided</li> <li>– Annual fire and evacuation training to be conducted</li> </ul>
Radiant heat or embers from a bushfire affecting infrastructure on site	Radiant heat or embers from a bushfire impacting fire sensitive areas i.e Digesters, Gas Flares, Bioreactor Switchroom, Administration building, Solar Farm	Explosion (at digester) or fire at other areas	Yes	<ul style="list-style-type: none"> <li>– Asset Protection Zone (APZ) – of at least 10 m around the AWRC facility (including the solar farm), to provide a maximum bushfire attack level (BAL) 29 rating.</li> <li>– The APZ may be maintained along the outside of the perimeter fence and include the perimeter access road.</li> <li>– Electricity services will all be underground.</li> <li>– Essential equipment housed in structures with a Fire Resistance Level of -/30/-. Vulnerable control equipment is to be suitably protected or enclosed in non-combustible ducts or sheathing</li> <li>– Administration buildings should be provided with compliant ember protection as stated in AS3959 (i.e. mesh screens applied to all vents, weep holes and access doors). Under the current layout, if the area between the administration and visitor centre and the outer edge of the fire trail is maintained as an APZ, the BAL is reduced to 12.5.</li> </ul>

Hazard scenario	Causes	Consequence	Potential for offsite impact	Identified safeguards
				<ul style="list-style-type: none"> <li>– Solar farm is to be on mown or dwarf grass substrates, maintained in a low fuel condition</li> </ul>
Release of corrosive material (e.g. sodium hydroxide)	Tank, Pipework or flange leak	Potential for injury or environmental release	No	<ul style="list-style-type: none"> <li>– Pallet bunds used for IBC Storage</li> <li>– Pallet bunds used for pail and drum storage</li> <li>– Pallet bunds used for diesel storage</li> <li>– Comprehensive emergency plan and procedures provided for handling corrosives</li> <li>– SDSs held for all materials</li> <li>– Emergency spill kits provided</li> </ul>
Release of sulphuric acid / 400kg or litres in 200 litre drums	Tank, Pipework or flange leak	Potential for injury or environmental release	No	<ul style="list-style-type: none"> <li>– Bulk storage provided in accordance with Dangerous Goods Storage requirements</li> <li>– Comprehensive emergency plan and procedures provided for handling corrosives</li> <li>– All chemical storage tanks banded</li> <li>– SDSs held for all materials</li> <li>– Emergency spill kits provided</li> </ul>
Interaction of incompatible dangerous goods stored together	Inadequate storage Corrosion and leaks from the storage tanks	Fire, toxic gas or potential for environmental release	Yes	<ul style="list-style-type: none"> <li>– Segregated in accordance with the relevant Australian Standards, AS 3780</li> <li>– SDSs held for all materials</li> <li>– Emergency spill kits &amp; PPE provided</li> </ul>
Production of hazardous materials from the interaction of chemicals (e.g., chlorine gas produced from interaction of citric acid and sodium hypochlorite)	Inadequate storage Corrosion and leaks from the storage tanks	Fire, toxic gas or potential for environmental release	Yes	<ul style="list-style-type: none"> <li>– Segregated in accordance with the relevant Australian Standards, AS 3780</li> <li>– SDSs held for all materials</li> <li>– Emergency spill kits &amp; PPE provided</li> <li>– Interlocks to prevent dosing incompatible chemicals simultaneously</li> <li>– Alarming of leak detection in common pipework dosing locations</li> </ul>
Release of firewater into the environment	Firewater encounters the incoming waste stream or processing areas and is contaminated	Potential for environmental release	Yes	<ul style="list-style-type: none"> <li>– The stormwater system is designed to allow for sufficient capacity to contain the firewater in the event of a fire and retain it until testing confirms it is safe for release</li> </ul>

Hazard scenario	Causes	Consequence	Potential for offsite impact	Identified safeguards
Release of brine into the environment	Tank, Pipework or flange leak	Potential for environmental release	Yes	<ul style="list-style-type: none"> <li>– Design and operational measures in place to reduce the likelihood of a pipeline failure or leak</li> <li>– Systems to detect pipeline failure or leak</li> </ul>
Fire at the solar farm	Solar farm is indicatively located on the northern side of the site	Fire Personal injury/fatality Asset Damage Plant shut down	Yes	<ul style="list-style-type: none"> <li>– Location of the solar photovoltaic panels is outside the hazardous area classifications</li> <li>– Correct installation and maintenance procedure</li> </ul>

### 3.3 Special Fire hazard scenarios

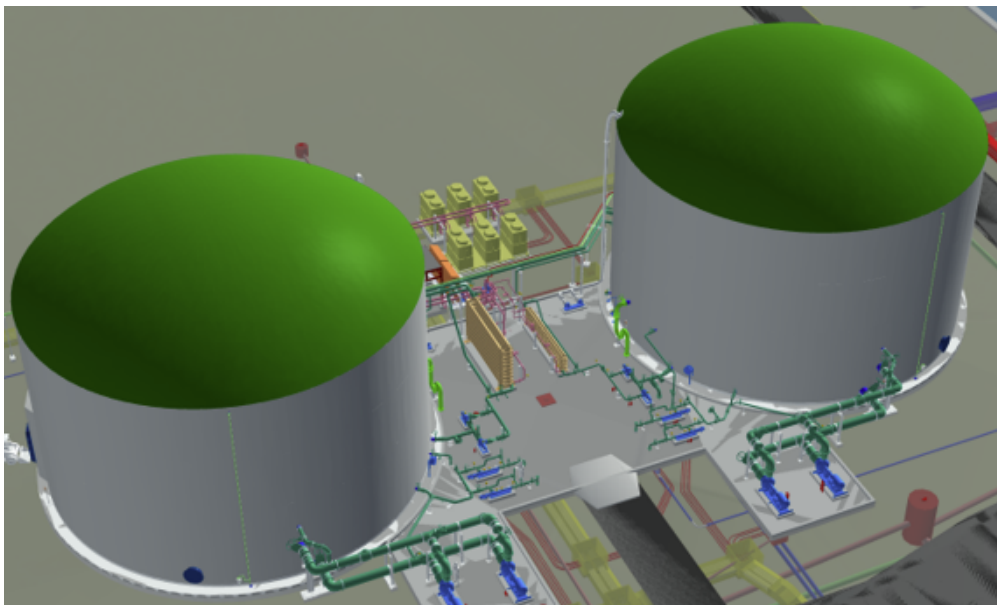
As discussed in Section 3.2, the HAZID has identified the following fire hazards for the AWRC facility:

- Fire/ explosion in the digester gas holder
- Gas flare flame out and ignition; and fire/explosion
- Bushfire impacting the AWRC
- Fire/ explosion in the dewatering and out loading building and biosolids silo
- Fire/ explosion in the odour control facility (including inlet works and odour covers)
- Fire/ explosion in the rotary drum thickeners (inside flocculation tank, machine housing and thickened sludge hopper)

#### 3.3.1 Biogas Holder

Biogas is produced in the digestion process and will be stored in the membrane gas holders fitted above each anaerobic digester as seen in Figure 6.

Methane is classified as a Class 2.1 dangerous good by the Australian Dangerous Goods Code (ADGC).



**Figure 6** *Biogas holders (green) atop of digesters*

Loss of containment from the biogas holders is most likely to be a result of a leak from the gas holders or associated pipework. A possible consequence of this release includes a flash fire or Vapour Cloud Explosion (VCE) due to a potential release of methane in conjunction with an ignition source.

Due to the large volume of methane stored in the digester, this scenario warranted consideration of potential off-site impacts and onsite impacts to fire safety. As a result, this scenario was included within the FHA's detailed consequence analysis. From the analysis it was found that a loss of containment of the methane within the biogas holder was not found to lead to potential off-site consequences (GHD & Jacobs, 2024). However, the loss of containment event has the potential to impact the site locally. As such further analysis of the biogas holder has been carried forward in this FSS.

Further details of the consequence analysis can be found in Section 3.4.2, 3.4.3 and 3.4.4.

#### 3.3.2 Gas Flare

When an excess of biogas accumulates within the inner membrane layer of the biogas holder, the surplus gas is directed to the flares, where it is combusted. In the event of an on-demand failure of the gas flare,

methane / biogas may be released into the air. This will form a vapour cloud and in the event of an ignition source being present, a jet fire may result.

This scenario has been concluded by the FHA (GHD & Jacobs, 2024) to not lead to potential off-site consequences. However, in the event of an on-demand failure the entrained methane has the potential to impact the site locally. As such further analysis of the gas flare has been carried forward in this FSS.

The details of this consequence analysis can be found in Section 3.4.5

### 3.3.3 Bushfire

The location of the AWRC site is deemed to be 'bushfire prone' and is required to comply with the aims and objectives of NSW Rural Fire Services document Planning for Bush Fire Protection.

The Bushfire Constraints and Opportunities Assessment (ref. 201323) completed for the facility states that the proposed AWRC can meet the general aims and objectives of Sections 1 and 8 of the Planning for Bush Fire Protection.

Therefore, this event is not carried forward for a detailed consequence analysis.

### 3.3.4 Dewatering and out loading building and biosolids silo

The dewatering and out loading building, as well as the biosolids silo, are involved in the process of removing water from the sludge and disposing of the solids. This removal of water is achieved via a centrifuge, where the dewatered cake is then directly dropped on to a reversible belt conveyor that enables direct out loading or transfer to the biosolids storage silo.

Although the sludge within the dewatering and out loading building is stabilised, there is a possibility of the methane being released, which if sufficient quantities were to occur, may create an explosive gas mixture. However, according to the site's Design Report (GHD & Jacobs, 2023) the maximum fugitive emissions of VOCs from the biosolids area is 13 ppm (0.0013 %), far less than the ISO 10156: 2010 Lower Explosive Level (LEL) of 5% for methane.

Currently, best practises have been employed within the area to mitigate the consequence of methane accumulation. These include:

- Odour Extraction fans to remove VOCs
- Electrical equipment selected in accordance with Zone 2 hazardous area
- Comprehensive emergency plan and procedures provided for the site
- SDSs held for all materials
- PPE provided
- Annual fire and evacuation training to be conducted

Due to the overall limited fire hazard in this area, further analysis of the dewatering and out loading building as well as the biosolids silo is not carried forward for a detailed consequence analysis.

### 3.3.5 Odour control facility (including inlet works odour covers)

The odour control facility is a critical component of the site as it removes and treats hazardous gases and odorous fumes from the process. Areas of extraction include the inlet works, the bioreactor, and the biosolids area. It is to be noted that the odour covers used in all of these areas (inlet, bioreactor and biosolids) are fitted with outlet ducts which are also connected to the odour control facility.

A potential hazard in this area is the formation of an explosive gas mixture due to the accumulation of flammable gases. Considering the odour control facility as a sum of its parts, the total accumulation of hazardous gases (specifically VOCs) is dependent on the flammable gases extracted from the inlet works, bioreactor and biosolids area.

According to the Design Report (GHD & Jacobs, 2023) the maximum emissions of VOCs from each area is as below:

- Inlet works – 9 ppm (0.0009 %)
- Bioreactor area – 7 ppm (0.0007%)

- Biosolids area – 13 ppm (0.0013%)

Subsequently the total cumulative VOCs within the odour control facility is approximately 0.0029%. Overall, the VOC's in both the inlet works, and odour control facility is significantly less than the ISO 10156: 2010 Lower Explosive Level (LEL) of 5% for methane.

In addition, best practises have been employed for areas undergoing extraction by the odour control facility and the odour control facility itself such as:

- Electrical equipment selected in accordance with Zone 2 hazardous area
- Comprehensive emergency plan and procedures provided for the site
- SDSs held for all materials
- PPE provided
- Annual fire and evacuation training to be conducted

Due to the overall limited fire hazard in this area, further analysis of the odour control facility, (including inlet works and odour covers) is not carried forward for a detailed consequence analysis.

### 3.3.6 Rotary drum thickeners

Three (3) rotary drum thickeners are a critical component of the sludge thickening process. During this stage, waste activated sludge, will operate to produce thickened sludge with a solids content of 3 – 6 %. Each rotary drum thickener has a dedicated hopper with a wide throat progressive cavity pump to directly transfer thickened waste activated sludge to the primary digester.

A potential hazard in this area is the accumulation and formation of an explosive gas mixture in the housing of the machine. However, according to the Hazardous Classification Report (GHD & Jacobs, 2023), deems the area to be non-hazardous. The report concludes that waste activated sludge coming from an aerated process with a high sludge retention time has a low risk of methane generation. To further combat the risk of methane generation, automated duty rotation of the thickeners minimises the time for the sludge to remain static inside the equipment.

In addition, best practises have been employed for rotary drum thickeners such as:

- Comprehensive emergency plan and procedures provided for the site
- SDSs held for all materials
- PPE provided
- Annual fire and evacuation training to be conducted

Due to the non-hazardous atmosphere, as deemed by the Hazardous Classification Report (GHD & Jacobs, 2023), there are suitably limited fire hazards in the area, the rotary drum thickeners are not carried forward for a detailed consequence analysis.

## 3.4 Consequence of Incidents

The consequence of the special fire hazard scenarios detailed in Section 3.3 are further discussed. The purpose of this section is to expand on the consequence analysis undertaken as part of the FHA, which primarily focuses on offsite impacts. The assessment will consider on site implications such as secondary fires as a result of the event.

The risk contours from the FHA will be drawn upon for the assessment.

### 3.4.1 Relevant Risk Criteria

#### 3.4.1.1 Heat Radiation Criteria

The effects of various heat radiation levels used in this assessment are summarised in Table 19 as per the NSW HIPAP No. 4.

**Table 19**      **Radiation Heat Criteria**

Heat radiation (kW/m <sup>2</sup> )	Effect
2.1	– Occupants can traverse without impact
3	– Threshold used for firefighter’s operation. The value is derived from Fire Brigade Intervention Model (AFAC, 2020)
4.7	– Will cause pain in 15-20 seconds and injury after 30 seconds of exposure (at least second-degree burns will occur)
12.6	<ul style="list-style-type: none"> <li>– Significant chance of fatality for extended exposure. High chance of injury</li> <li>– Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure</li> <li>– Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure</li> </ul>
23	Likely fatality for extended exposure and chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure <ul style="list-style-type: none"> <li>– Unprotected steel will reach thermal stress temperatures which can cause failure</li> <li>– Pressure vessel needs to be relieved, or failure would occur</li> </ul>
35	<ul style="list-style-type: none"> <li>– Cellulosic material will pilot ignite within one minute’s exposure</li> <li>– Significant chance of fatality for people exposed instantaneously</li> </ul>

### 3.4.1.2 Explosion Overpressure Criteria

The effects of various explosion overpressures used in this assessment are summarised in Table 20 as per the NSW HIPAP No. 4.

**Table 20** *Effects of explosion overpressure*

Explosion overpressure (kPa)	Effect
3.5	– 90% glass breakage
7	<ul style="list-style-type: none"> <li>– Damage to internal partitions and joinery but can be repaired</li> <li>– Probability of injury is 10%</li> <li>– No fatality</li> </ul>
14	– House uninhabitable and badly cracked
21	<ul style="list-style-type: none"> <li>– Reinforced structures distort</li> <li>– Storage tanks fail</li> <li>– 20% chance of fatality to a person in a building</li> </ul>
35	<ul style="list-style-type: none"> <li>– House uninhabitable</li> <li>– Wagons and plants items overturned</li> <li>– Threshold of eardrum damage</li> <li>– 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open</li> </ul>

### 3.4.2 Biogas holder – Vapour Cloud Explosion (VCE)

The VCE scenario involves a loss of containment event. Methane is released from the digester gas holder and forms a gas cloud, mixing with air in an optimal stoichiometric ratio for combustion. This occurs in the digester gas holder annular area which has a volume of approximately 1,900 m<sup>3</sup>.

The consequence for this scenario is a direct result of the pressure waves generated from the blast. Results shown in Figure 7 and Figure 8 have been extracted from the FHA. Calculations theorems and assumptions utilised for this model is further detailed in Appendix B.

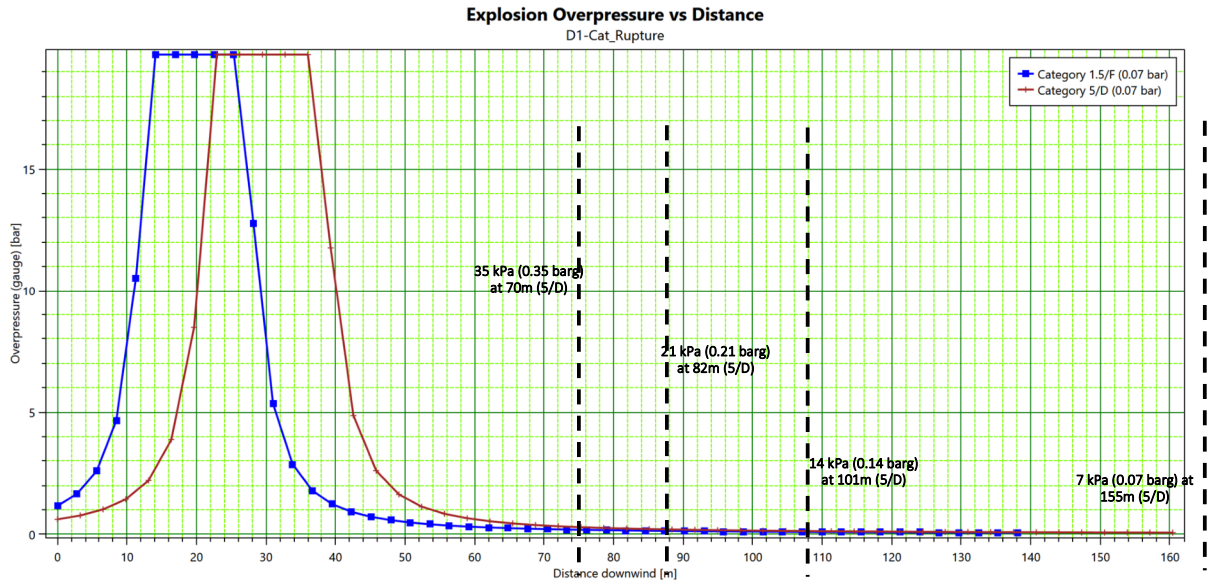


Figure 7 Gas holder VCE overpressure vs distance

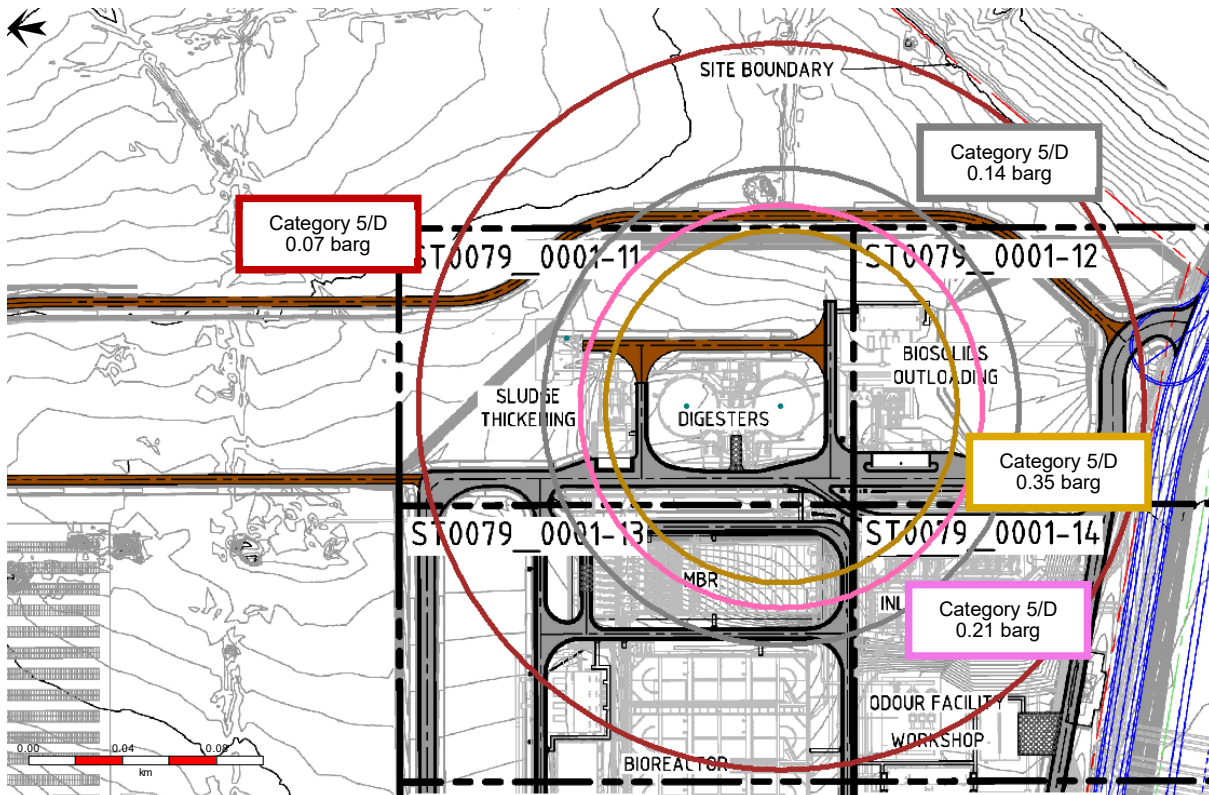


Figure 8 Gas holder VCE impact contours

### 3.4.3 Secondary Fires from VCE

The area subject to the largest pressure waves are located within 70 m radii from the blast epicentre. Infrastructure within this range is subject to 0.35 bars or 35 kPa. However, according to HIPAP 4, and as replicated in Table 20, at 0.21 bars or 21 kPa, the following is expected to occur:

- Reinforced structures distort
- Storage tanks fail
- 20% chance of fatality to a person in a building

This pressure (0.21 bars or 21 kPa) was chosen as a threshold for secondary fires, as this is the pressure where fires caused by a loss of containment – due to the failure of storage tanks is most likely to occur.

In order to assess this potential, buildings, plant equipment and firefighting infrastructure located within this pressure region are required to be reviewed.

Aside from infrastructure located below the digester and the second digester, there are notably five (5) other buildings and/or equipment within the 82 m blast radii. These are:

- WL15 – Dewatering and out-loading building
- WL 13- Sludge thickening structure
- Biosolids switch room
- Bioreactor
- Firefighting Infrastructure

#### 3.4.3.1 Dewatering and outloading building

Polymer powder is stored in the building to assist with the sludge dewatering process. The powder does not burn readily when in storage, however as with many organic powders, flammable dust clouds may be formed in air. When in contact with an ignition source, this result may in a dust explosion.

It is to be noted, that the Hazardous Area Classification report (GHD & Jacobs, 2023) has not identified the polymer powder as a potential risk, and therefore, no hazardous classification is adopted has been adopted for the area.

The dewatering and out loading building is located within both the 21kPa and 35 kPa overpressure contours, as such the blast pressure has the potential to distort the building and overturn plant equipment.

The volume of polymer stored in the building is understood to be low, and is stored in a conical hopper. In the event of a VCE is it expected that the dewatering and out loading building may be significantly damaged and the conical hopper may be damaged and overturned.

From the SDS of the powdered polymer (Zetag 81XX Series), it has been stipulated that only through the fine grinding of the polymer, resulting in the accumulation of fine dust (420 micron or less) may burn rapidly if ignited, and have explosive potential. As such, the size of the polymer would have to undergo fine grinding to create an explosive atmosphere, if distributed in the air. No such grinding is planned for this facility, and therefore the particle sizes of the powder are larger than the 420 micron limits. Therefore, if during a VCE, the conical hopper is to be overturned/damaged, the powder is not sufficiently fine, and therefore the potential of a subsequent VCE of the powder is mitigated against.

In addition, in the extremely unlikely event that fines of the powdered polymer do manage to accumulate, and an ignition source is found, the polymer powder is now open to air due to the expected damage of the dewatering and out loading building. As a result, the “confined” space” required for an explosion is no longer applicable either.

It is also to be noted that the overall mitigation philosophy utilised for the fire safety measures regarding the digester is fire / explosion prevention. In essence, placing controls to prevent a VCE in the first place works to mitigate potential knock-on events, such as this.

As such, the likelihood for a secondary fire to occur at the dewatering and out-loading building due to the stored polymer powder is suitably low.

### 3.4.3.2 Sludge thickening Structure

There are no flammable chemicals or powders stored in the sludge thickening area. Furthermore, waste activated sludge from an aerated process has a high sludge retention time and has a low risk of methane generation (GHD & Jacobs, 2023). The sludge thickening process is also undertaken in a non-enclosed structure.

Damage caused by a 21 kPa pressure wave to the sludge thickening structure is unlikely to result in a secondary fire at this location.

### 3.4.3.3 Switch room

A blast pressure of 21 kPa has the potential to damage electrical equipment, causing short circuits or other electrical faults which could result in a fire. It is assumed that there are no automatic suppression systems provided to the switch rooms, and a fire event would require manual intervention to extinguish.

Should equipment at these areas be damaged due to the pressure wave, a secondary fire event may occur. Particularly in areas where there are combustible materials stored within them.

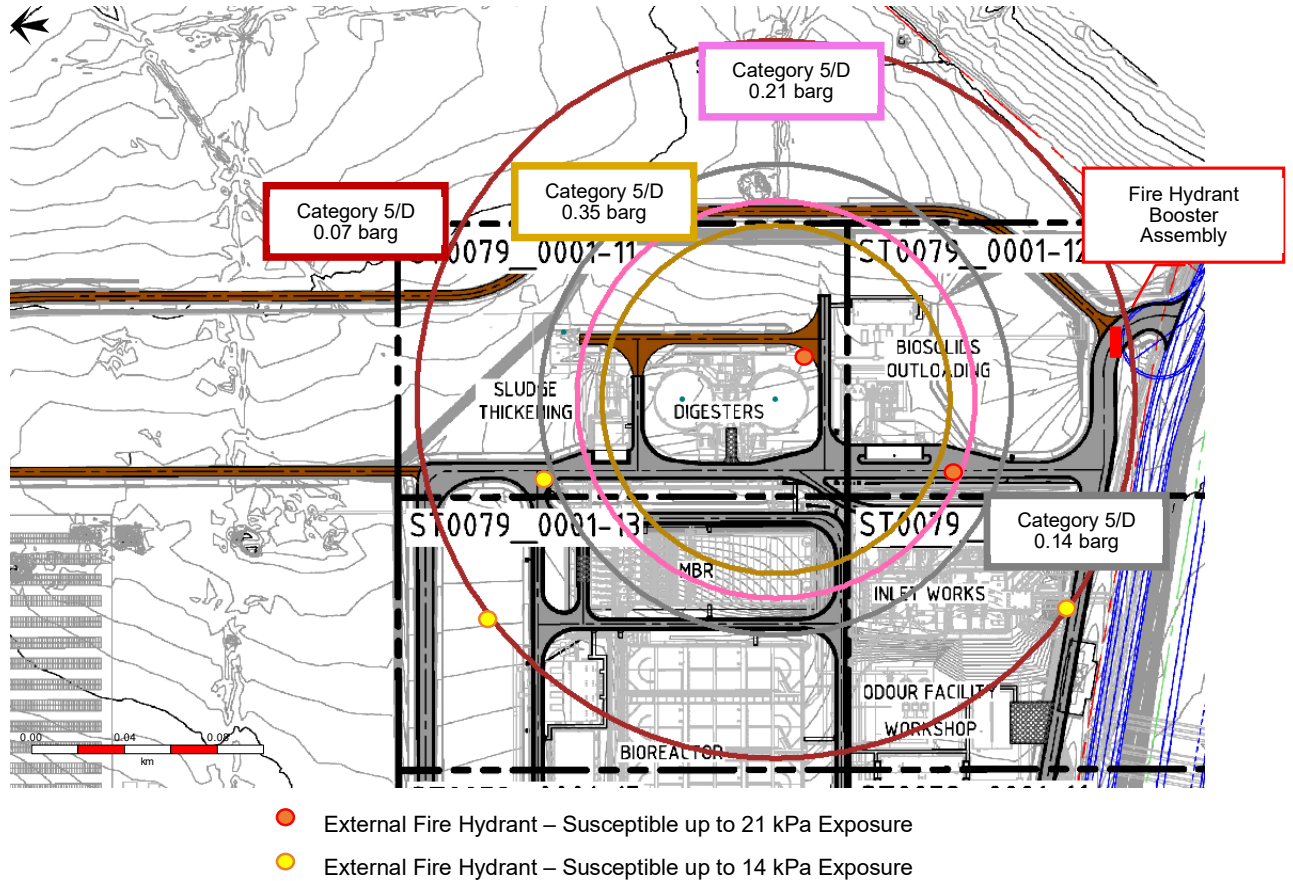
### 3.4.3.4 Bioreactor

There are no flammable chemicals or powders stored at the bioreactor area. The bioreactor supports a biologically active environment, allowing biomass to grow and consume some of the substances in raw wastewater. Typically, there is an absence of flammable or combustible elements in this area.

Damage caused by a 21 kPa pressure wave to the bioreactor area is unlikely to result in a secondary fire at this location. Note that only a portion of the area is within the 21 kPa pressure range.

### 3.4.3.5 Fire Fighting Infrastructure

There are two (2) external fire hydrants located within the 21 kPa blast range and several others located outside of this region, susceptible of up to 14 kPa pressure wave. Location of the hydrants are shown in Figure 9.



**Figure 9** Location of Fire Hydrants

In the unlikely event that a pressure wave from the digesters damage an external fire hydrant, with those within the 21 kPa zone having a higher likelihood, it is a reasonable expectation that intervention capabilities for the site remain largely available.

While some of the closer fire hydrants may be unusable, there are other fire hydrants located around the site that can be utilised for coverage with additional lengths of hose.

Furthermore, the fire booster assembly is located just within the confines of the outer most blast circle, receiving a pressure wave of up to 7 kPa. Such pressure levels are not expected to damage the booster assembly infrastructure. Therefore, fire hydrant pressure levels throughout the site are expected to be unaffected. Similarly, hardstands are expected to remain available throughout the site where connection to fire hydrants are required.

The Fire Detection Control and Indicating Equipment (FDCIE) is located in a location well away from the epicentre of a potential blast wave. It is housed within the administration building on the far side of the site as shown in Figure 10. Therefore, it is not expected to be impacted from a blast event, permitting its use for during intervention.

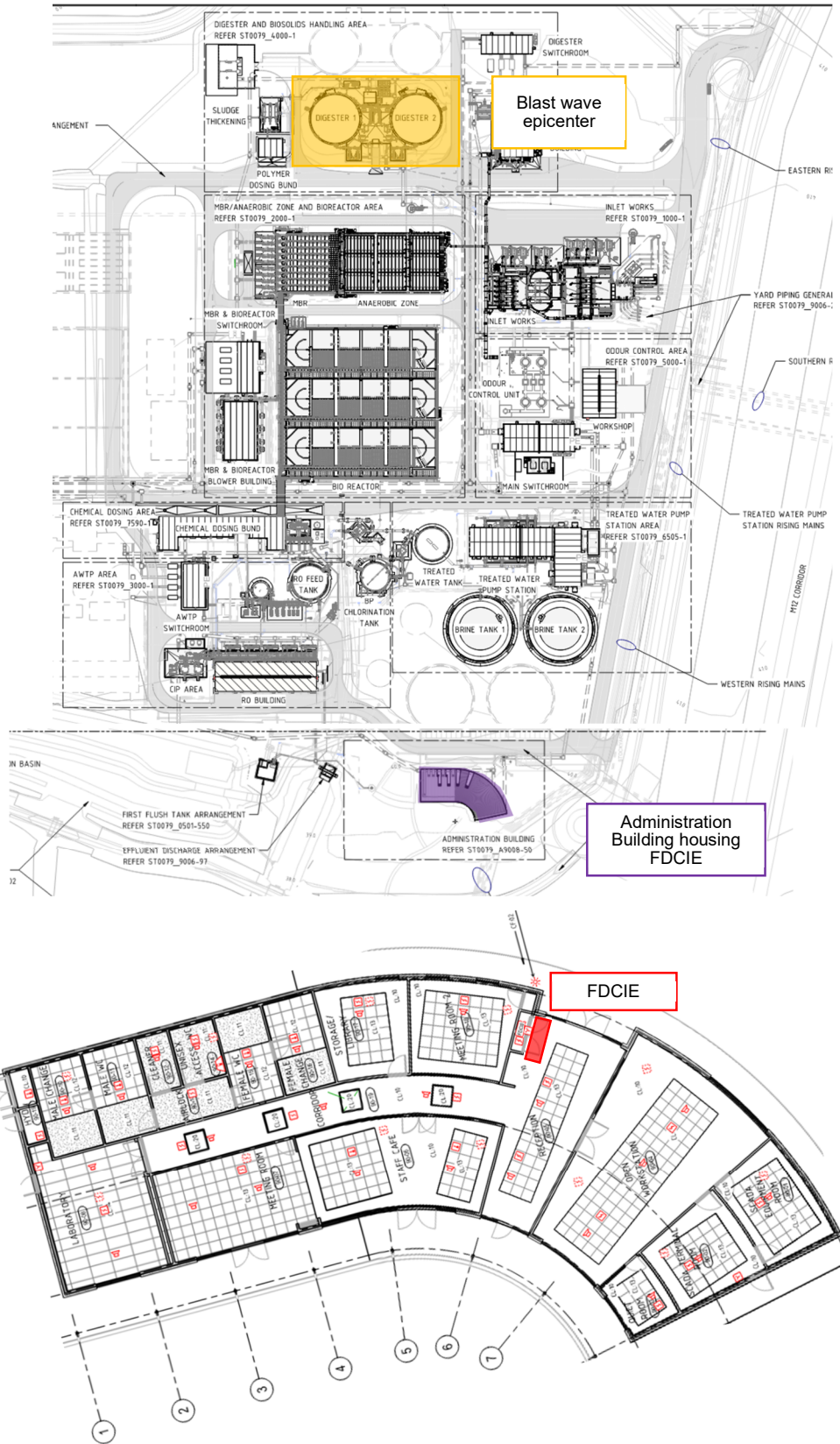


Figure 10 Location of FDCIE

### 3.4.4 Biogas holder – Flash Fire

The heat flux contours of a biogas flashfire event is shown in Figure 11. Calculations theorems and assumptions utilised for this model is further detailed in Appendix B.

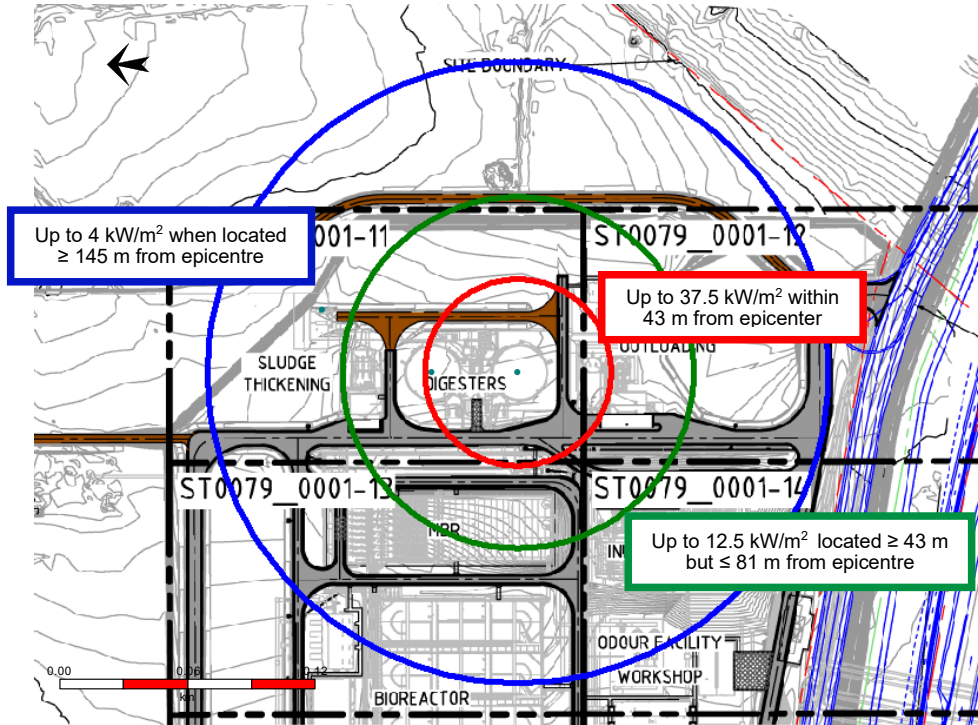


Figure 11 Gas holder intensity radii for flash fire effect contour

#### 3.4.4.1 Secondary Fires from Flash Fire

The radiant heat exposure from a significant fire or flashfire event may be sufficient to initiate secondary fires at other infrastructure in the vicinity, particularly those which house flammable or combustible materials. The radiant heat intensity contour shown in Figure 11 indicates that there are areas which exceed a heat flux of 35 kW/m², a level which is capable of igniting cellulosic material within a minute’s exposure. This indicates that the potential for secondary fires, at least in this region, is increased.

The heat flux intensity at various distances are summarised in Table 21.

Table 21 Summary of radiant heat exposure

Heat Flux Exposure	Location experiencing heat flux exposure
Up to 37.5 kW/m²	Within 43 m from epicentre
Up to 12.5 kW/m²	Located ≥ 43 m but ≤ 81 m from epicentre
Up to 4 kW/m²	Located ≥ 145 m from epicentre

Table 21 suggests that any buildings located within 43 m of the flashfire event, occurring at the digester gas holder, has a high potential to be involved in a secondary fire event. However, the elevation of the epicentre and the duration of the fire should be considered when identifying potential secondary fire locations.

The digester gas holders are located directly above the digesters, which themselves span a height of 13.6 m above grade. Therefore, a potential flashfire event at, or just beyond the gas holder is at least 13.6 m above the ground where any other infrastructure is positioned.

There are buildings on site which span a relatively tall height of 18 m, such as WL15 – dewatering and out loading building. And WL15 is partially located within the high exposure zone of the contour shown in Figure 11. Considering the height of the building and it being located at least 20 m away from the digesters, trigonometry suggests the building would be subject to the same 37.5 kW/m², given it is within the 43 m radii of the blast epicentre.

According to radiant heat exposure impacts detailed in HIPAP 4, and captured in Table 19, a heat flux of 35 kW/m<sup>2</sup> is capable of:

- Cellulosic material will pilot ignite within one minute's exposure
- Significant chance of fatality for people exposed instantaneously

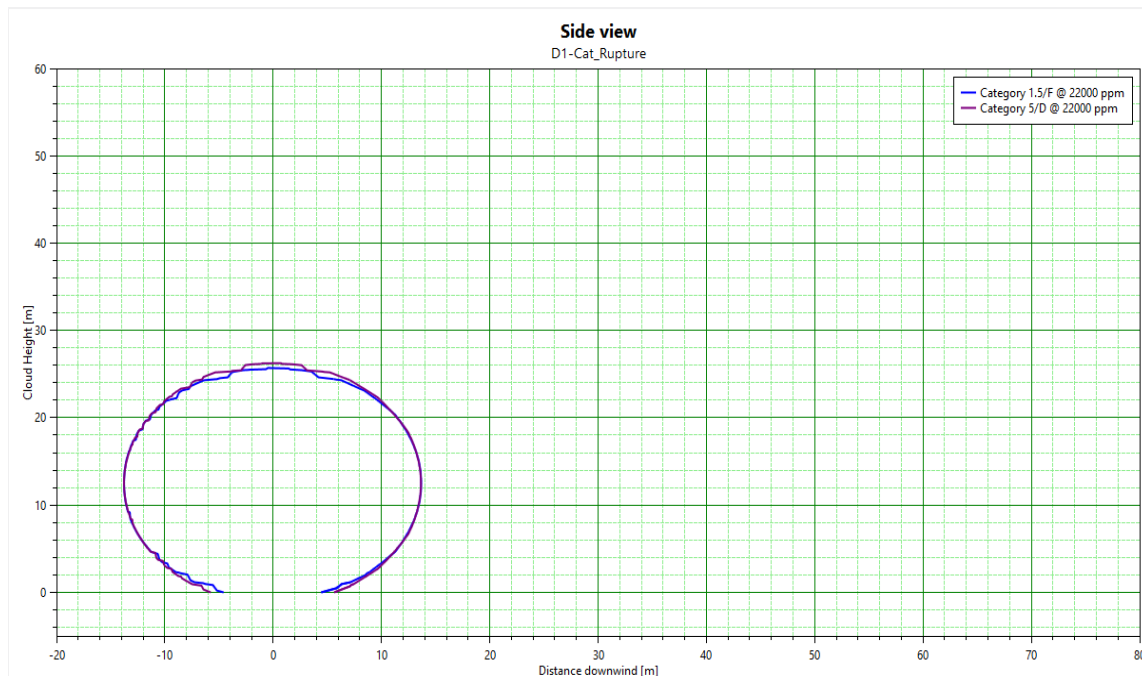
This level of heat flux is capable of resulting in secondary fires to infrastructure on site, however, the second proponent required to be considered following elevation is the duration of the exposure.

Flashfire events are known to be brief thermal hazards (Margolin, 2014). Once the flame front moves from the ignition point, through the fuel load, methane in this case, the fuel is consumed, and the event concludes.

The dispersion of methane in a catastrophic rupture was modelled by considering specific factors such as total amount of methane present within the biogas holder and prevailing wind conditions (following standard Pasquill conditions for day and night). A catastrophic rupture entails complete failure and represents a more conservative approach compared to modelling a loss of containment event.

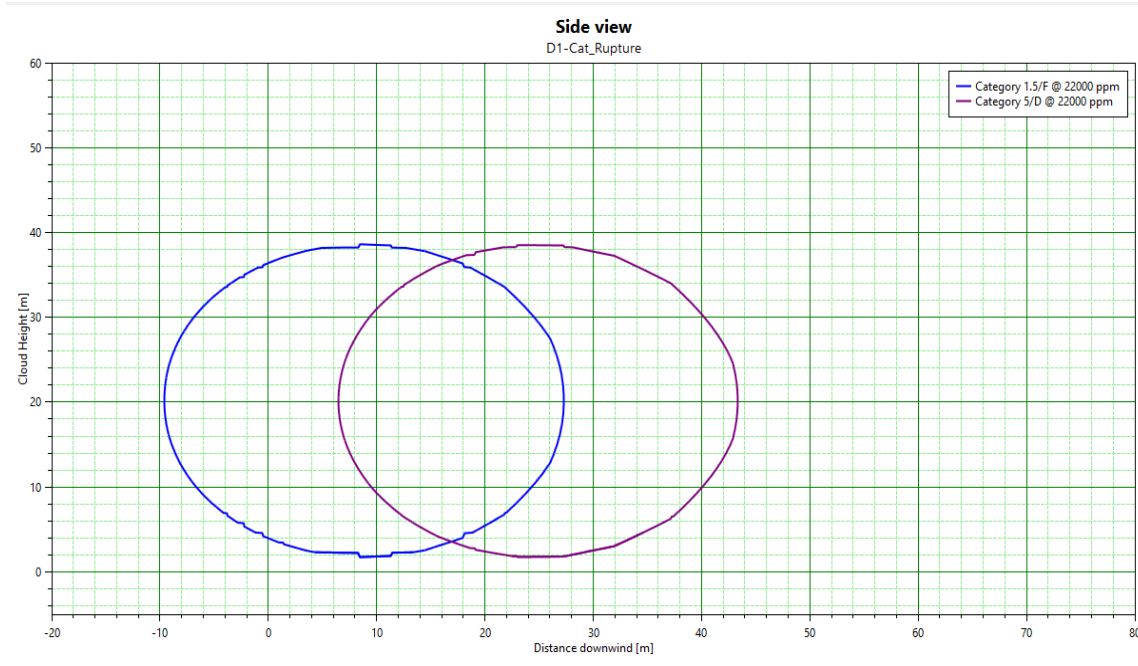
Figure 12 showcases that the total distance of methane dispersed during a catastrophic failure event is 24 m. Using a methane flame speed of 0.33 m/s (Chempedia.info, 2019), the total flash fire event can be calculated to last for a maximum of 72 seconds.

However, it is to be noted, that as the flame front moves through the fuel load, the methane is consumed. As such, for every metre the flame front moves through the fuel, the infrastructure at that location is exposed to 35 kW/m<sup>2</sup> for 3 seconds. To further emphasise the short duration of exposure, a building 10 m long will only be exposed to the fire event for 30 seconds.

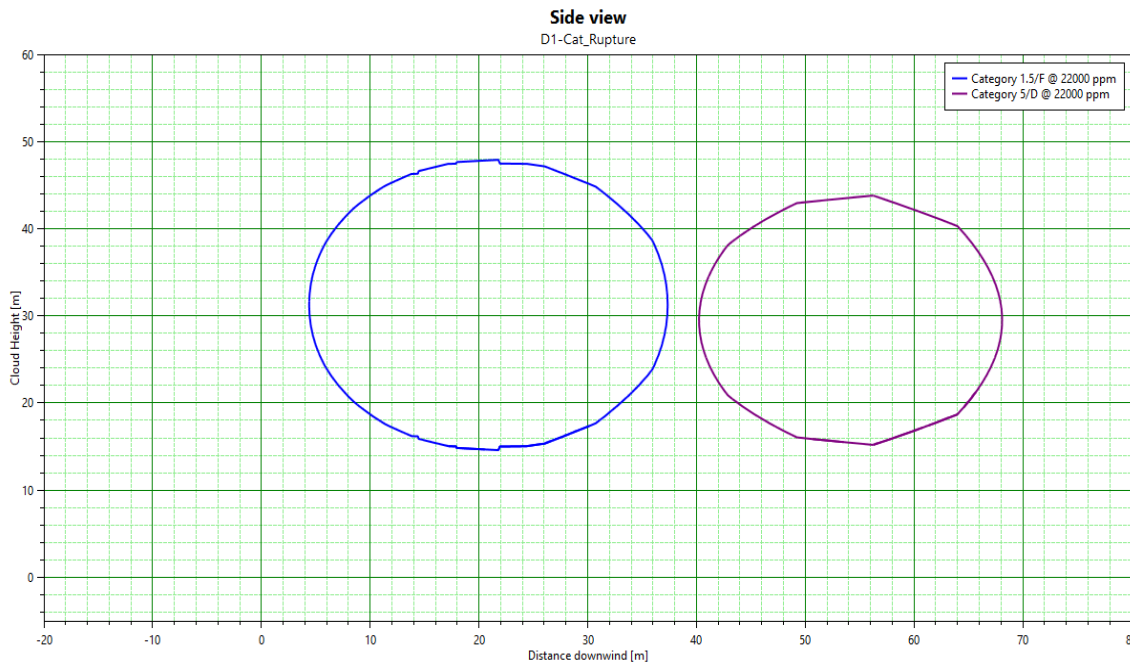


**Figure 12** *Methane Dispersion*

In addition, given methane gas is lighter than air, a loss of containment event would result in the gas dispersing into the atmosphere, typically in the upward direction. The dispersion of methane during a catastrophic failure was then modelled against wind conditions (Pasquill conditions for day and night) over a period of time.



**Figure 13** Methane Dispersion at 5 seconds



**Figure 14** Methane Dispersion at 10 seconds

Figure 13 showcases the dispersion cloud at 5 seconds after the catastrophic rupture, and Figure 14 showcases the dispersion cloud 10 seconds after the event. As detailed in both, the wind conditions do not move the methane downwards. Instead, as predicted, the methane rises and disperses upwards. In fact, 5D wind conditions, disperse the methane cloud at a faster rate than F1.5 conditions. Further detail regarding wind conditions is provided in Appendix B.

As a result, flames of the flashfire event would disperse at a high level, and no direct impingement is expected at lower-level infrastructure around site.

As previously detailed in HIPAP 4, a heat flux of 35 kW/m<sup>2</sup>, will pilot ignite cellulosic material within one minute's exposure. However, a flash fire occurring for a maximum of 3 seconds per metre is not expected to have the same effects as radiant heat exposure for 60 seconds. Based on the above, while the heat flux radiated from a methane flashfire event is relatively high, its short duration is unlikely to cause any secondary fires on the site, particularly to infrastructure located at grade.

Where concentrations are released from one digester is significant, and able to disperse in a manner where it reaches the second digester, and lower explosive limits are maintained, the flames from a flashfire event may cause a cascading effect to the second digester. This is due to the gas holder membrane being flammable and methane being housed beneath.

However, similar to the primary event, a flashfire at the second gas holder is unlikely to cause additional fires to other infrastructure on site given its altitude, the properties of methane, and flashfires being short-lived events.

### 3.4.5 Gas Flare – Jet Fire

As detailed in the FHA, the maximum process flow to the flare from both digesters is 120 m<sup>3</sup> / hr under process conditions.

Should a flame out occur, the biogas will entrain over time triggering a 15-minute site shutdown. In this time, a gas cloud of 0.1 m diameter may form. Further information regarding the assumptions, calculations, or modelling used to determine these values is detailed within the FHA (GHD & Jacobs, 2024) and summarised in Appendix B.

Figure 15, extracted from the FHA, shows a graph depicting an aerial view of the jet fires with different intensity radii. The sizes of these jet fires are reflected in the contours on the map in Figure 16. Calculations theorems and assumptions utilised for this model is further detailed in Appendix B.

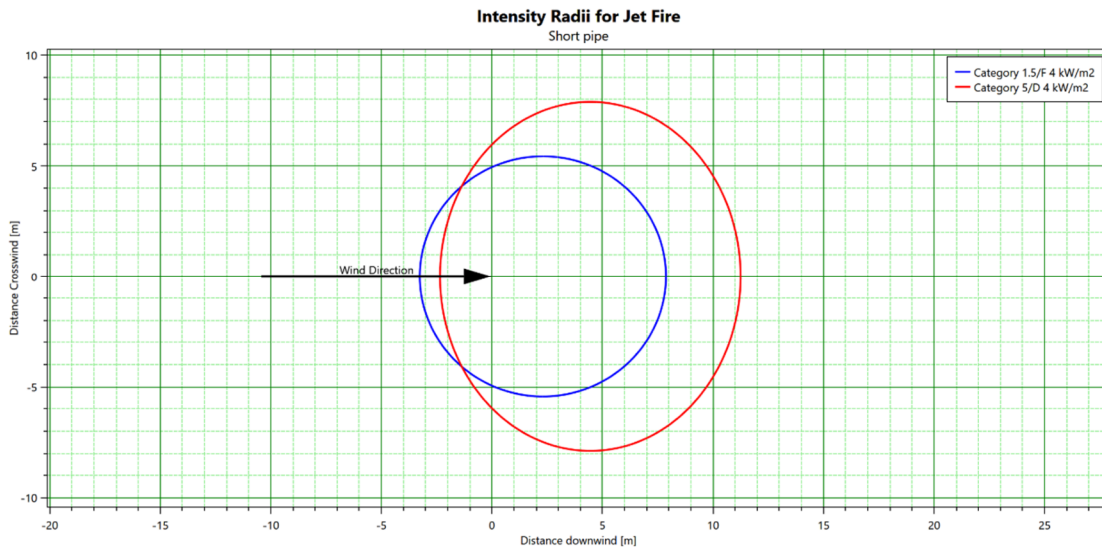


Figure 15 Gas flare – jet fire intensity radii

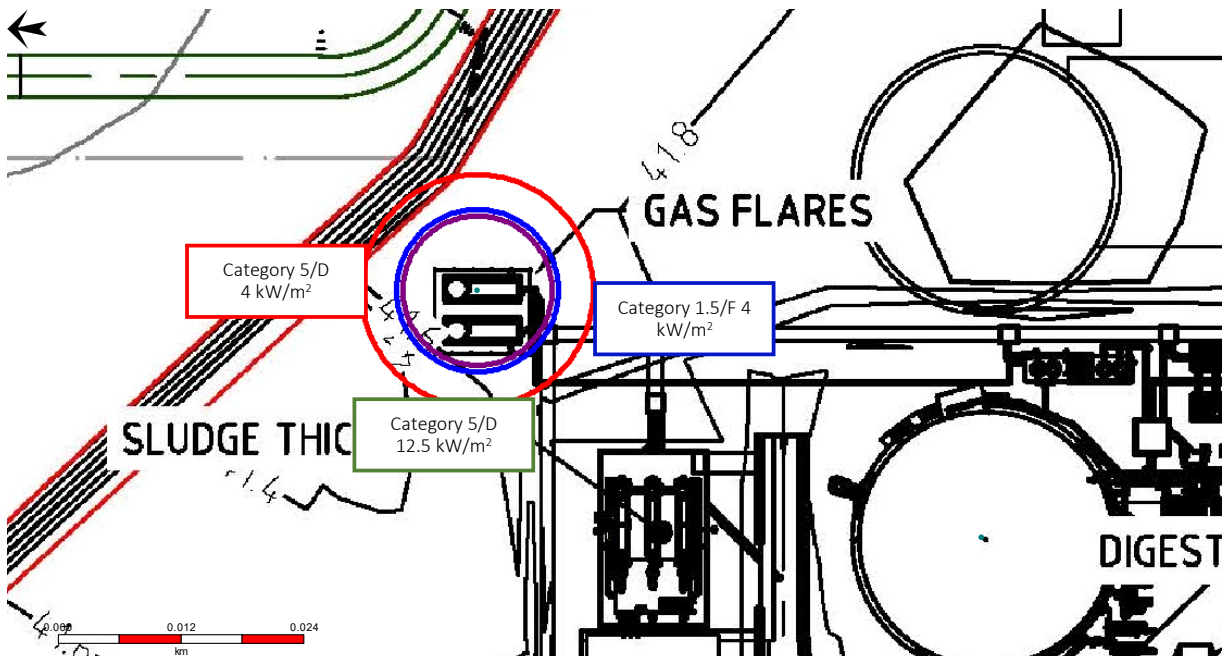


Figure 16 Gas flare intensity radii for jet fire contours

### 3.4.6 Secondary Fires from Jet Fire

There is limited infrastructure located in close proximity to the gas flare, and the contours shown in Figure 16 indicate that the heat flux exhibited to areas beyond a 7 m radii, and up to 11 m radii of the jet flame is subject to a heat flux up to 4 kW/m<sup>2</sup>. A heat flux of 4kW/m<sup>2</sup> approaches the threshold to cause pain if the exposure time is up to 15-20 seconds and injury after 30 seconds of exposure, however is unlikely to result in a secondary fire event.

## 4 Fire Prevention Strategies/Measures

Fire hazard scenarios identified as having significant impact/consequence to the site are further assessed, identifying means of minimising the likelihood of the event occurring and/or reduce their severity or extent.

The areas identified as potentially having a high impact are:

- Biogas Holder, and
- Gas Flare

As biogas holders reside directly above the anaerobic digesters, the protection requirements typically required of the latter are also discussed.

Currently, NSW regulatory bodies enforces many regulations in relation to gas distribution and utilisation such as the:

- *Gas and Electricity (Consumer Safety) Regulation 2018.*
- *Petroleum (Onshore) Regulation 2016*
- *Work Health and Safety (mines and petroleum sites) Regulation 2022*

However, these regulations do not currently have any enforceable or recommended protective measures on the production, storage, transport or use of biogas or the installation of Type B gas appliances (flares, boilers and cogeneration equipment) for biogas systems. Therefore, standards are used instead to provide guidance to help ensure safety and performance reliability through specifications and design procedures.

For instance, *NFPA 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities* stipulate the requirements for various parts of a wastewater treatment plant and is used as a reference for best practice design in the absence of local Australian Standards.

The fire protection requirements for the identified areas under NFPA 820 are summarised in Table 22.

**Table 22** *NFPA 820 requirements.*

Area	Characteristics	Fire Protection Requirements
Anaerobic Digester	Not enclosed in a building, open to atmosphere. Non-combustible construction	Fire Hydrants Fire Extinguishers
Biogas Holders	Not enclosed in a building Non-combustible, Limited combustion, Low flame spread index material	Fire Hydrants Fire Extinguishers
Gas Flare	No specific characteristics to note – may be candle stick, open or shrouded type burners	None required

The AWRC facility, specifically the anaerobic digester and gas flare, are proposed to be provided with the fire protection requirements stipulated under NFPA 820. While reference to NFPA 820 is applied for guidance, the suitability of the proposed fire protection equipment for areas such as the biogas holders shall be assessed further in Section 5, based on the characteristics of the design.

## 4.1 Biogas Holder (including anaerobic digester)

There are several risks presented at the Biogas Holder, these include the potential for Vapour Cloud Explosion (VCE) and a flash fire.

Although no specific standard exists for biogas holders, the Water Services Association of Australia (WSAA) publication entitled *Guidelines for Potentially Explosive Atmospheres* uses a variety of standards to provide guidance when addressing hazardous explosive environments and subsequent consequences. These standards include:

- *AS/NZS 60079.10.1- 2022: The foundation of area classification for flammable gases and vapour in Australia*
- *AS/NZS 60079.13-2022: Specifies the requirements for ventilation or pressurisation equipment when it is contained in a hazardous area.*
- *AS/NZS 60079.14-2022: Specifies the design, installation, and initial inspection of electrical equipment in hazardous areas (EEHA).*

From WSAA's *Guidelines for Potentially Explosive Atmospheres*, the parameters outlined, and the subsequent fire protective measures are outlined in Table 23.

**Table 23**      **WSAA requirements**

Parameter	Guideline from WSAA	Fire Protection Requirements
Methane threshold	Minimum of 5% LFL and a maximum of 40% LFL is recommended. <ul style="list-style-type: none"> <li>– Below 5% LFL, concentrations become difficult to measure accurately.</li> <li>– At 40% LFL, Australian industry experience is that the fire department will require notification to begin tracking the event.</li> </ul>	Sydney Water has adopted 20% LFL Methane as per Hazardous Area Classification Report (AWRC-DJV-RPT-PRO-0501-0001, Rev 2, 23 June 2023)  <b>A (Lower Flammability Limit) LFL of 20% will be used as a threshold for methane.</b>
Monitoring equipment	Table 3.1: High Level overview of different sampling technologies	<b>A methane detector on the air outlet of the gas membrane holder is required.</b> From the design of the process, throughout the life of the gas membrane holder, the detector will only be exposed to clean air and cannot be 'poisoned' until a membrane failure event occurs. If this did occur, the instrument could then be checked and re-calibrated
Benefit of Monitoring	Monitoring an LFL between 15% -26% provides a moderate benefit to mitigating a hazardous atmosphere.  Table 5.8: benefiting monitoring on mitigation of hazardous atmosphere.	The benefit of monitoring the threshold LFL (20%) of methane is confirmed to be moderate and should be implemented.  <b>Monitoring equipment will be configured to a threshold of 20% LFL to provide at least a moderate benefit in mitigating a hazardous atmosphere.</b>

In addition to WSAA's guidelines, *AS 1375 -2023 Industrial fuel-fired appliances* sets out the requirements for the design, installation and operation of industrial appliances that involve the combustion of gas and the generation of combustible vapours.

Although this standard is not specific to digestors, a primary hazard is the generation of combustible vapours (biogas/methane) within the digester. Therefore, this standard can be used as a reference. The parameters outlined and subsequent fire protection requirements are outlined in Table 24.

Table 24 AS 1375 -2023 requirements

Parameter	Guideline from AS 1375-2023	Fire Protection Requirements
Ignition Hazards	Electrical equipment and installations in hazardous areas shall comply with AS/NZS 60079.14	<b>All electrical equipment used for operations and monitoring for the digester, and biogas holder is required to comply with AS/NZS 60079.14</b>  This requirement has also been stipulated by the Hazardous Area Classification Report (AWRC-DJV-RPT-PRO-0501-0001, Rev 2, 23 June 2023)
	Mechanical equipment shall be designed to prevent frictional sparking risks.	<b>Duty and standby fans that are used to inflate the outer membrane are recommended to be designed to prevent frictional sparking risks</b>
	Static electricity charges may cause an explosion. Electrical bonding and earthing are required in accordance with AS/NZS 1020	<b>Grounding potentially isolated equipment is recommended in areas where flammable vapours are being produced</b>
Prevention of accidental fires	Appliances shall be designed such that accumulation of combustible waste, on a scale likely to cause accidental fires are prevented	<b>Surplus methane shall be vented/burned and not accumulated</b>
Gas piping's and fittings	For design pressures less than 200kPa: compliance with AS/NZS 5601 is required. For design pressures greater than 200kPa: compliance with AS 4041 is required	<b>Appropriate standards for gas piping and fittings shall be used dependant on digester design pressure</b>

Overall, all of the requirements listed above are either guidelines or extracted from a standard that has been extrapolated to include a biogas holder and digester.

As such, the proposed fire protection equipment for these areas shall be assessed further in Section 5, based on the characteristics of the design.

## 4.2 Gas Flare

The primary risk presented at the gas flare is a jet fire, caused by the on-demand failure of the flare and subsequent ignition of released biogas.

From the Hazardous Area Classification Report (AWRC-DJV-RPT-PRO-0501-0001, Rev 2, 23 June 2023), the gas flare is classed as a Type B appliance under AS/NZS 5601.1 - 2022. As such, AS/NZS 5601.1 stipulates that all Type B appliances shall conform to the requirements of AS 3814.

The parameters outlined and subsequent jet fire protection requirements from AS 3814 -2018 are outlined in Table 25.

**Table 25 AS3814 -2018 requirements**

Parameter	Guideline from AS 3814-2018	Jet Fire Protection Requirements
Gas Pipework	All pipework shall be in accordance with: <ul style="list-style-type: none"> <li>– AS/NZS 5601.1 (up to and including 200kPa)</li> <li>– AS 4041 and Section 2 of AS/NZS 5601 (over 200 kPa)</li> </ul>	<b>Appropriate standards for gas piping and fittings shall be used dependant on design pressure.</b>
Flow meters	Where the operation of the burner is dependant on flow, the flow measuring devices shall be fitted to cause lockout or prevent an ignition attempt if <ul style="list-style-type: none"> <li>(a) the device is not proven in the 'no-flow' state prior to the flow commencing; and</li> <li>(b) loss of flow occurs during operation.</li> </ul>	<b>Flare operation dependant on flow shall be fitted with lock out features.</b>
Flame detectors	A flame detector shall be accessible and be in accordance with: <ul style="list-style-type: none"> <li>- AS 4620 for the thermoelectric type.</li> <li>- AS 4625 for the electronic type; or</li> </ul> Where an intermittent or permanent pilot is used on atmospheric burner(s) exceeding 275 KW, either two electronic flame safeguard systems or two electronic flame detectors connected to one flame safeguard system shall be used.	<b>A flame detector(s) shall be installed to detect if the flame has ignited or extinguished.</b> <b>Dependant on burner design both the main burner and pilot burner may require a detector.</b>
Flame safeguard system	The function of this system is to shut off the fuel supply to the burner(s) in the event of ignition / flame failure.  Each burner shall have a flame safeguard system fitted as an integral part of the burner management system.	<b>Flame safeguard system shall be designed and installed in accordance with Section 2.25 of AS 3814 -2018.</b>
Pilot Burners	Where a pilot burner is fitted it shall be stable, supervised and provide the ignition energy necessary to— <ul style="list-style-type: none"> <li>(a) immediately ignite the main burner safely and reliably under all operating conditions.</li> <li>and</li> <li>(b) ignite the main burner safely and reliably when the pilot burner is turned down to the point where it will just actuate the flame safeguard system.</li> </ul>	<b>A pilot turndown test is required to ensure the main burner can safely and reliably ignite with the flame safeguard system activated.</b>
Flame failure response time	Fuel shut off after flame failure shall occur as quickly as possible after the detection of a loss of flare.  The flame safeguard system response time shall not exceed the following:	<b>Flame safeguard system should be calibrated to the appropriate flame failure response time.</b>

Parameter	Guideline from AS 3814-2018	Jet Fire Protection Requirements
	Atmospheric burner up to 140 KW - 45 s Atmospheric burner from 140- 275 KW – 15 s Atmospheric burner over 275 KW – 3 s Automatic burner – 3 s	
Safety shut off valve system	The main burner gas supply and the start gas supply shall be fitted with separate safety shut off valves. <ul style="list-style-type: none"> <li>- Valves shall be of Class 1 automatic shut off type.</li> <li>- Gas rate not exceeding 1.4MW the valves shall be two valves in series</li> </ul>	<b>Safety shut off valve system shall exhibit minimum requirements as stipulated by AS 3814-2018</b>
Relighting after flame failure	No attempt shall be made to re-ignite automatically after flame failure unless it can be shown that it is safe to do so.	<b>Reignition attempts after a flame failure shall conform to Section 3.5.5 Automatic reignition attempt on flame failure of AS 3814 -2018</b>

Based on the characteristics of the gas flare design, fire prevention strategies and mitigation measures are further discussed and justified in Section 5.

## 5 Detection and Protection to be Implemented

The detection and protection systems to be implemented for the various hazardous areas identified are captured and justified in this section of the report.

### 5.1 Biogas Holder

There are several risks presented at the Biogas Holder, these include the potential for Vapour Cloud Explosion (VCE) and a flash fire. The distinctive components leading to these events are the formation of a flammable vapour cloud via a loss of containment and an ignition source.

Due to the instantaneous nature of a VCE and flashfire, prevention strategies and measures based on preventing a loss of containment, flammable cloud formation and minimising ignition sources are the most important in relation to the fire and explosion protection.

#### 5.1.1 Loss of Containment Prevention

As extracted from the FHA, a loss of containment event is *“likely to be a result of a leak from the gas holders or associated pipework”*. To mitigate this risk, all gas piping’s and fittings shall be designed and installed in accordance with AS/NZS 5601 as the design pressure is expected to be approximately 2 - 2.5 kPa.

In addition, it is recommended for the site to **develop and implement a maintenance program as per the suppliers’ recommendations to ensure fittings and the associated pipework is appropriately maintained.**

As biogas holders are located directly above the anaerobic digesters, the protection requirements typically required of the latter are also discussed. AS 1210 -2010 mandates that every pressure vessel must be protected by a relief device that prevents the vessel pressure from rising more than 110% of the vessel’s design pressure to prevent a loss of containment event.

However, due to the dynamic inner membrane, the vessel is not considered to be a typical pressure vessel and can be instead classified as a tank. Nonetheless, as an added protection against overpressure, pressure relief devices have been installed in the digestors as indicated in Figure 17. **The relief devices shall be designed and installed in accordance with AS 1271—2003.** Although the digester is not expected to operate at high pressures, the incorporation of pressure relief valves reduces the likelihood of containment losses resulting from overpressure as far as reasonably practicable.

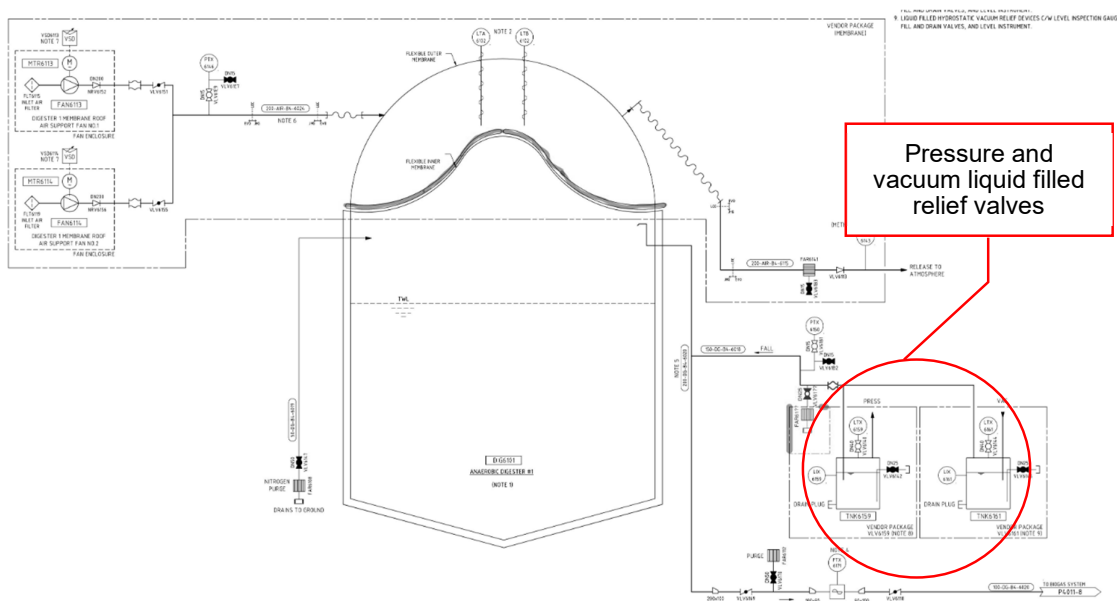
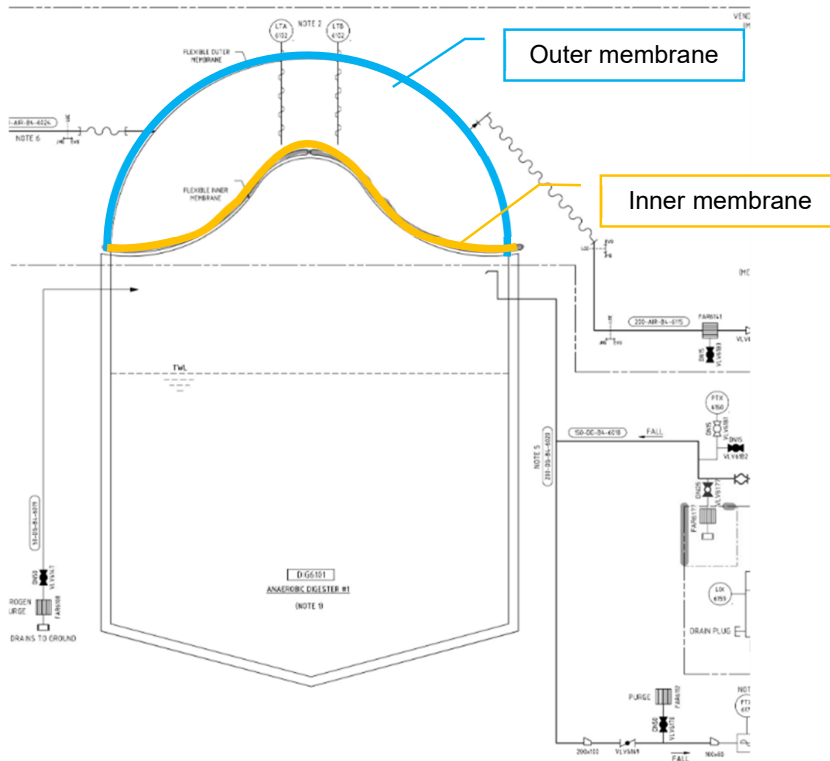


Figure 17 Pressure relief valves (indicative of final design)

### 5.1.2 Flammable Vapour Cloud Prevention

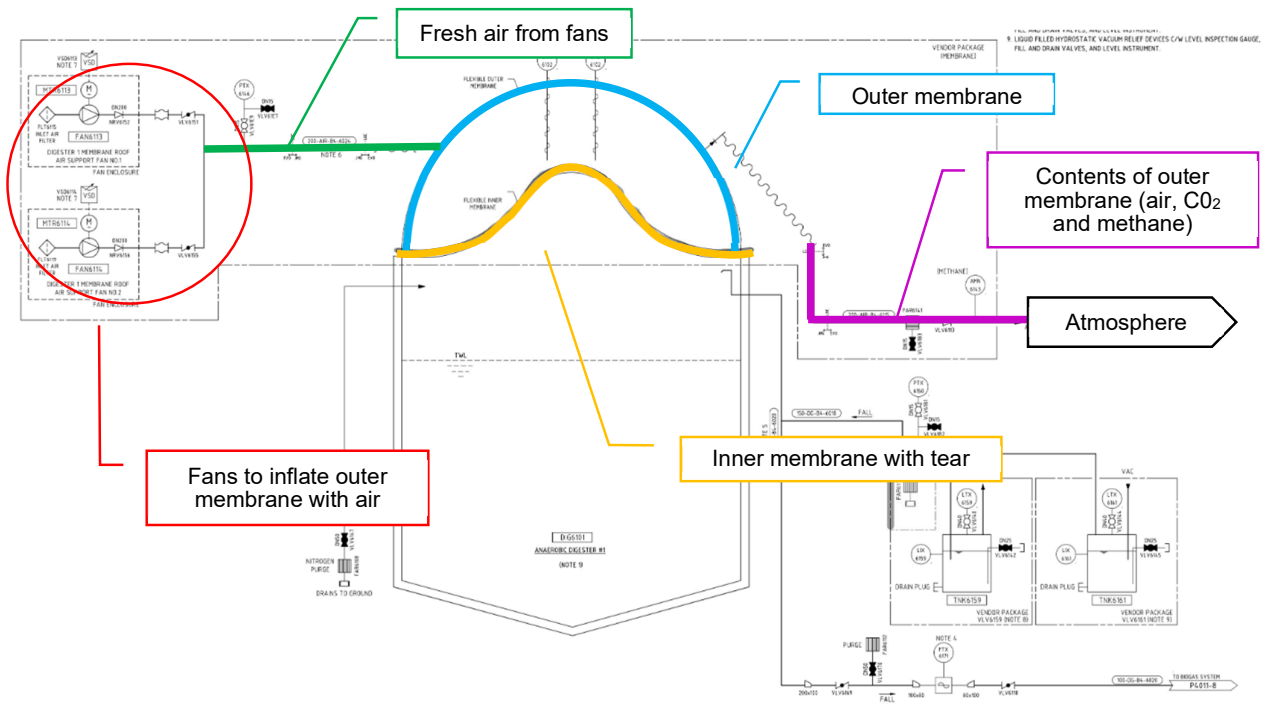
A loss of containment can occur from the inner membrane of the biogas holder to the outer membrane. The Piping and Instrumentation Diagram (P&ID) as shown in Figure 18 details the membrane layers. The outer membrane layer is continuously pressurised with air to maintain its inflation, while the inner membrane layer dynamically responds to the gas production within the digester, flexing and contracting in tandem with the gas levels.



**Figure 18** Outer membrane and inner membrane of biogas holders (indicative of final design)

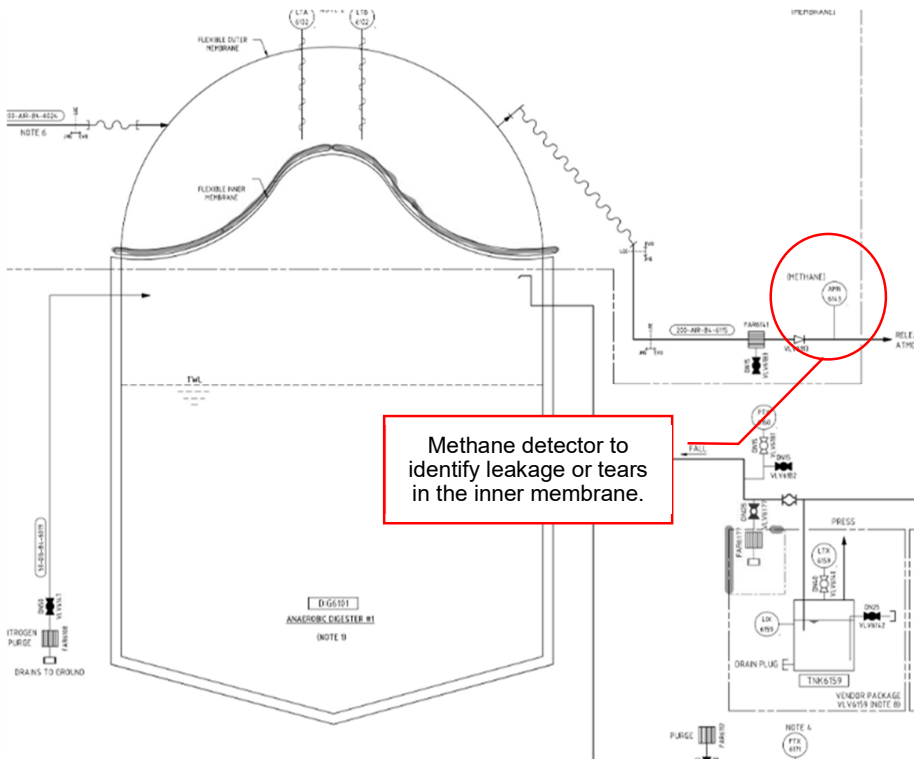
The outer membrane is continuously inflated with air via the operation of fans. A tear in the inner membrane is expected to leak digester gas into the outer membrane space, mainly because the weight of the inner membrane pushing down on the gas inside the digester headspace.

The differential pressure between the two zones is very small. However, any digester gas that escapes into the outer membrane space will mix with the air in the outer membrane, potentially forming a flammable vapour cloud. The flammable vapour can only exit via the air outlet valves. The passage of air and methane in the event of a methane leak is shown in Figure 19.



**Figure 19** Movement of air & methane in an inner membrane tear (indicative of final design)

Currently, if a loss of containment was to occur, a **methane detector (indicated in Figure 20) downstream of the biogas holders is expected to detect potential puncturing of the inner membrane**, raising an alarm where methane concentration levels exceed typical operating values.



**Figure 20** Methane detector downstream of digester (indicative of final design)

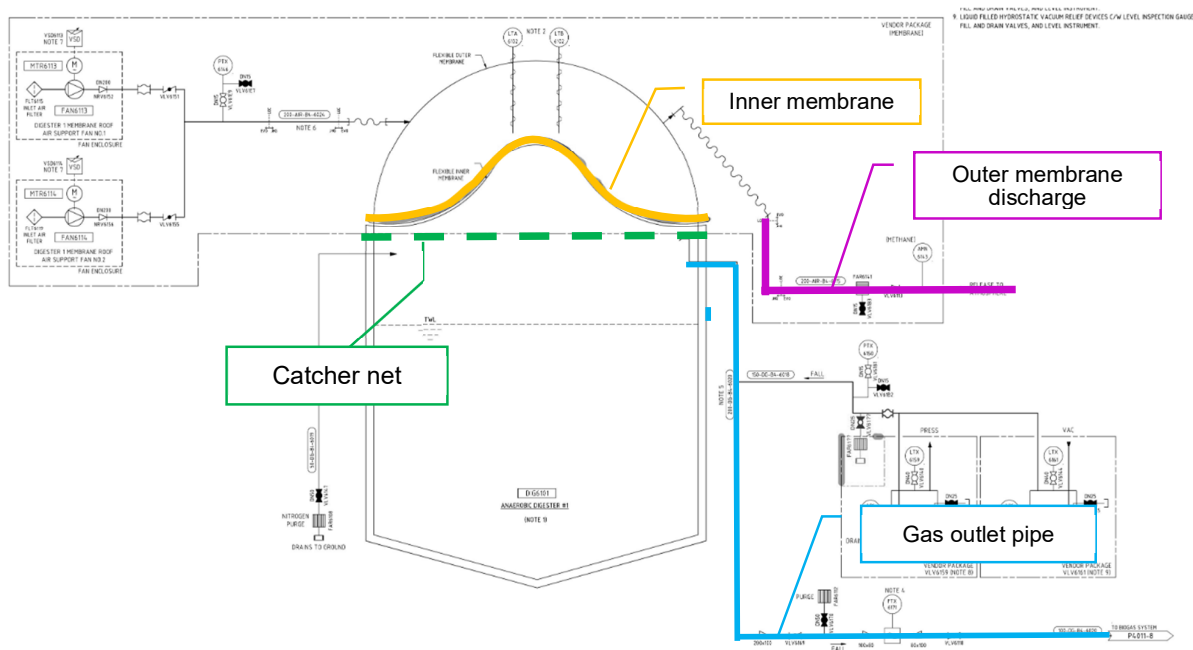
It is to be noted, that a single detector is not a safeguard against the loss of containment from the inner membrane, the detector merely serves to alert operators after a tear in the inner membrane has occurred.

The primary prevention of flammable gas formation in the outer membrane is to mitigate the risk of the inner membrane tearing.

A possible scenario that could result in tearing of the inner membrane is when the inflation fans push the inner membrane down onto the catcher net. This would be exacerbated if the pressure beneath the inner membrane was a slight vacuum due to over-extraction of gas from the digester. During normal operations, the inner membrane never comes to rest on the catcher net, as **operation procedures shall be required to keep sufficient gas in the digester headspace to keep the membrane at least 20% above “empty level”, thus keeping the inner membrane flexed.**

Furthermore, during operations, to prevent the over extraction of gas from the digester forming a vacuum and subsequently pulling the inner membrane onto the net, a **Supervisory Control and Data Acquisition (SCADA) is recommended to monitor gas levels in the digester and control the amount of gas flared.**

If during operation, the inner membrane was being pushed down onto the catcher and there was a tear in it, some air would be pushed into the digester headspace. The exit path for this air would thus be through the digester gas outlet pipe as indicated in Figure 21 and not via the outer membrane air discharge port. To ensure only methane is exiting via the gas outlet pipe, operators will monitor the differential pressure and if the outer membrane pressure is sufficiently greater than the pressure beneath the inner membrane an alarm would sound. **Overall, operational procedures shall be developed to include the required steps to prevent and monitor a tear in the inner membrane.**

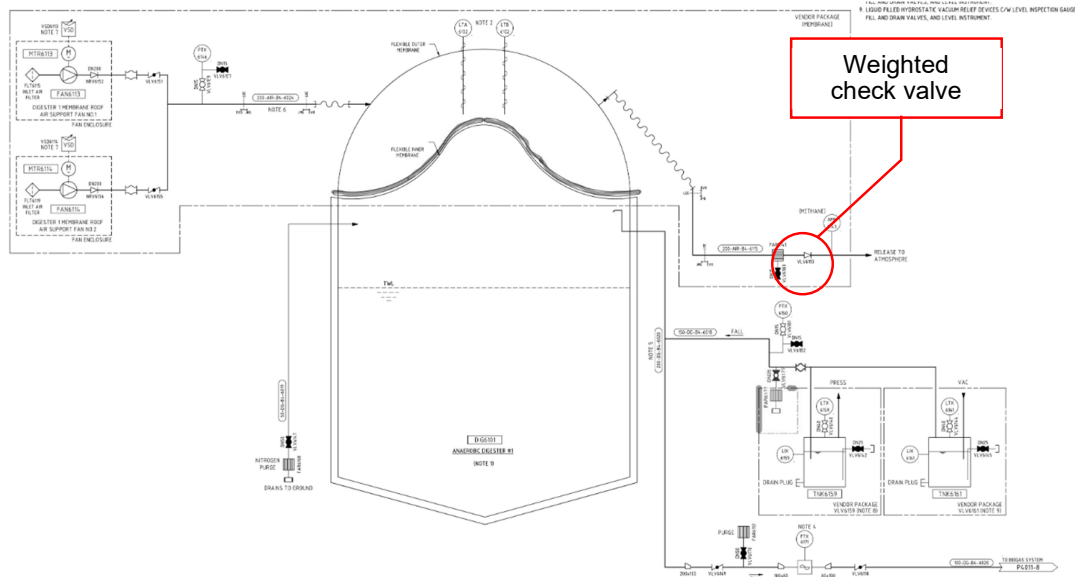


**Figure 21** Catcher net and digester gas outlet pipes (indicative of final design)

### 5.1.3 Power Failure

Currently, the worst-case scenario is the formation of a flammable vapour cloud in the outer membrane due to a tear in the inner membrane during a power failure event.

A weighted check valve as shown in Figure 22 is set during commissioning to provide back-pressure of 2 kPa when the inflation fan is running, and will close in the event of power failure to the fans to maintain outer membrane inflation.



**Figure 22** Weighted check valve (indicative of final design)

In the event of a leak from the inner membrane, accumulation of methane in the outer membrane is expected to occur. In addition, a power failure could compromise detection equipment used to measure methane. **To prevent the loss of detection, an uninterrupted power supply (UPS) is installed for all critical safety elements including the methane detector and programmable logic controller (PLC).**

In addition, to further prevent the accumulation of methane in the outer membrane, the fan on each digester will be connected to a separate power supply bus to minimise the chance of power failure to both fans simultaneously.

Furthermore, in the event of a power failure and an inner membrane leak, the fans that normally inflate the outer membrane come to a stop. This cessation of fan movement inherently removes the risk of frictional sparking. Consequently, this passive response diminishes the potential for ignition, thereby enhancing site safety by reducing the likelihood of a VCE or flashfire event.

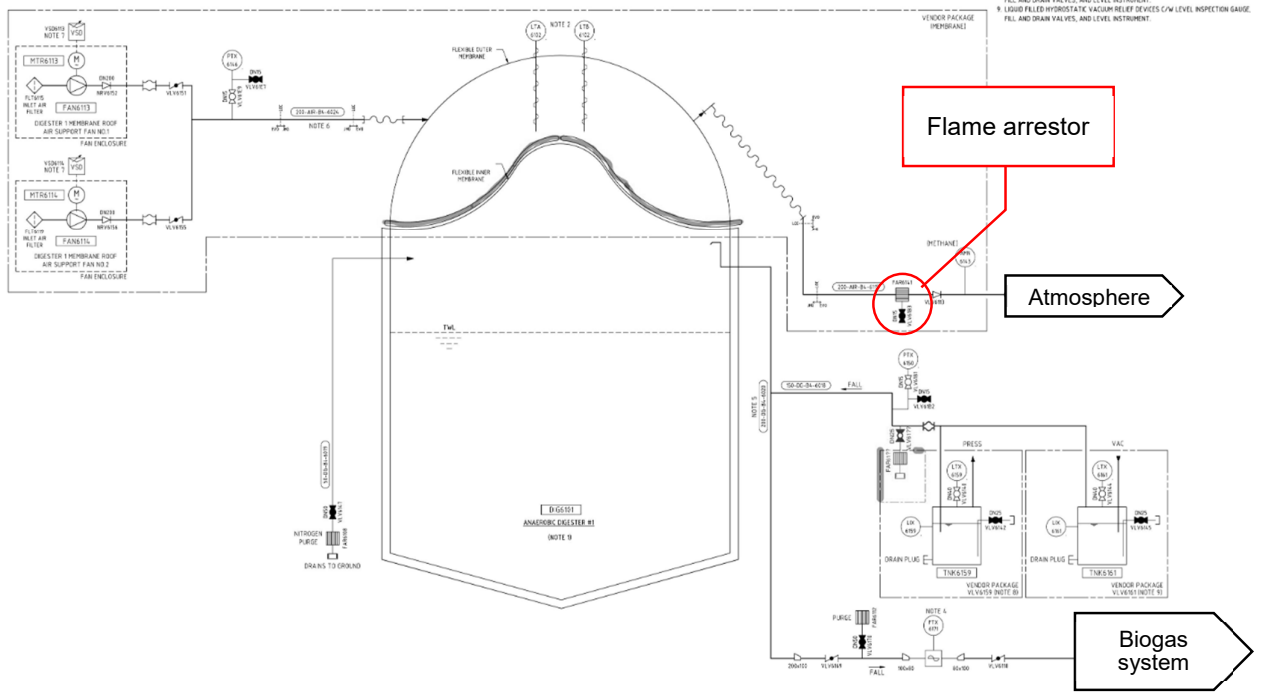
## 5.1.4 Minimising Ignition Sources

If a flammable vapour cloud was to form, an ignition source is the catalyst for a vapour cloud explosion or flash fire event. Although for modelling purposes, it is best practise to assume a flammable vapour cloud will “find” an ignition source, measures to mitigate ignition sources is recommended.

**Any instrumentation used within the hazardous area zone will be rated for and comply with AS/NZS 60079.14.** In addition, **to reduce static electricity charges, electrical bonding and earthing of isolated equipment will be required in accordance with AS/NZS 1020.**

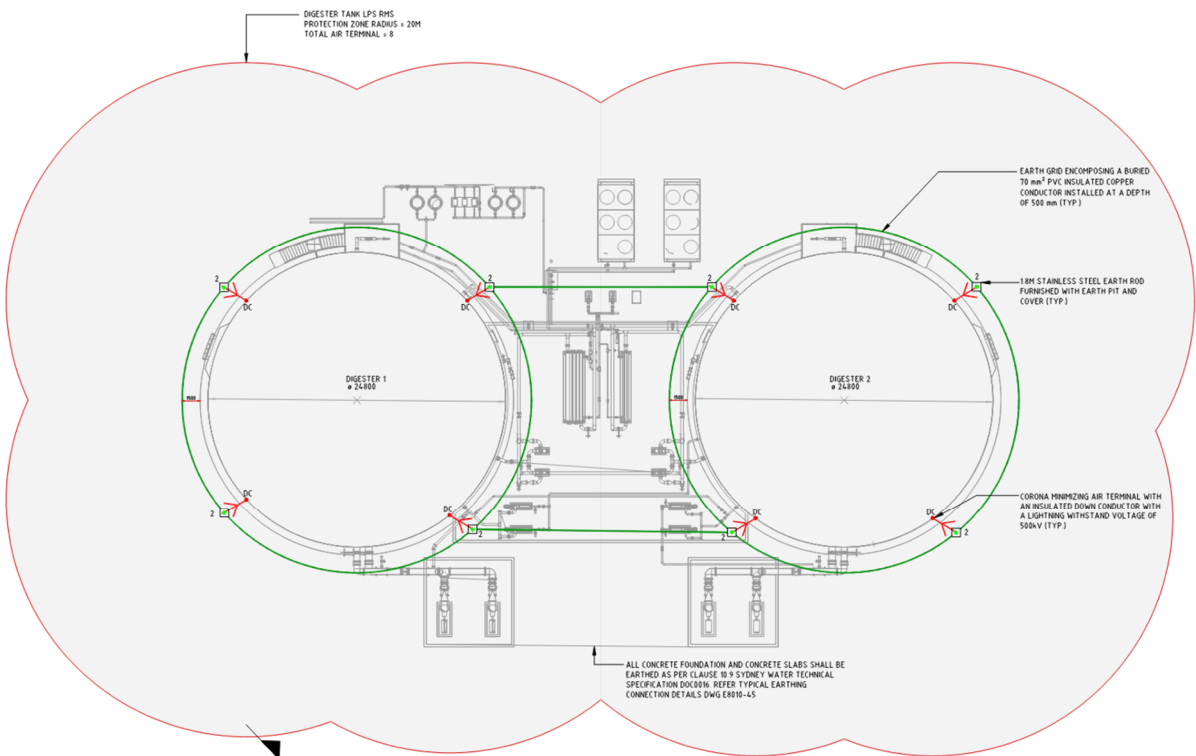
Furthermore, **flame arrestors will be installed in various locations (detailed in Figure 23) to prevent the ignition of flammable vapour.** A flame arrester essentially limits the damage caused by an ignition. Flame arrestors are installed at various locations and are listed below:

- Gas pipework separating the booster blowers from the main digester pipe (not shown in Figure 23, shown in separate P&ID)
- Air support pipework at the air outlet to atmosphere (in the unlikely event that there is some methane gas in the discharge due to inner membrane damage)



**Figure 23** Flame arrestor locations (indicative of final design)

Lightning and earthing protection will also be available in this area, to minimise ignition sources. Figure 24 contains further information regarding the lightning and earthing protection.



**Figure 24** Lighting Protection

### 5.1.5 Additional Measures

A level transmitter exists on the digester, however the purpose of this is not to help with overpressure or vapour cloud formation but is instead provided to measure the amount of gas in the inner membrane holder. **The waste gas burner shall operate when the level or pressure in the gas holder reaches the set point from the transmitter.** As a result, the combustion of excess methane can be classified as reducing the overall accumulation of combustible waste, thus complying with AS 1375-2023's guidelines regarding the "prevention of accidental fires".

Regarding environmental impacts such as bushfires, **it is recommended that a bushfire management plan be developed and implemented to reduce the total flammable gas stored or produced in the digester.**

Furthermore, as mentioned in Section 4.1, the NFPA 820 standards, require hydrants and fire extinguishers for biogas holders. However, the area of concern is the methane holder approximately 13.6 m above the ground (indicated in Figure 25). At this height, ground hydrants and fire extinguishers are not expected to aid in the prevention of a flash fire and VCE as these are instantaneous events caused by the formation of flammable cloud and ignition source.

Instead, to accurately cater to the design of the biogas holders and intent of the NFPA standard, **hydrant coverage will be provided to the digester, and fire extinguishers will be provided to areas surrounding the digester pipework at ground level.** As such, these measures can instead provide cooling to a potential ground fire close to the digester or mitigate small ground fires surrounding pipework with an extinguisher.

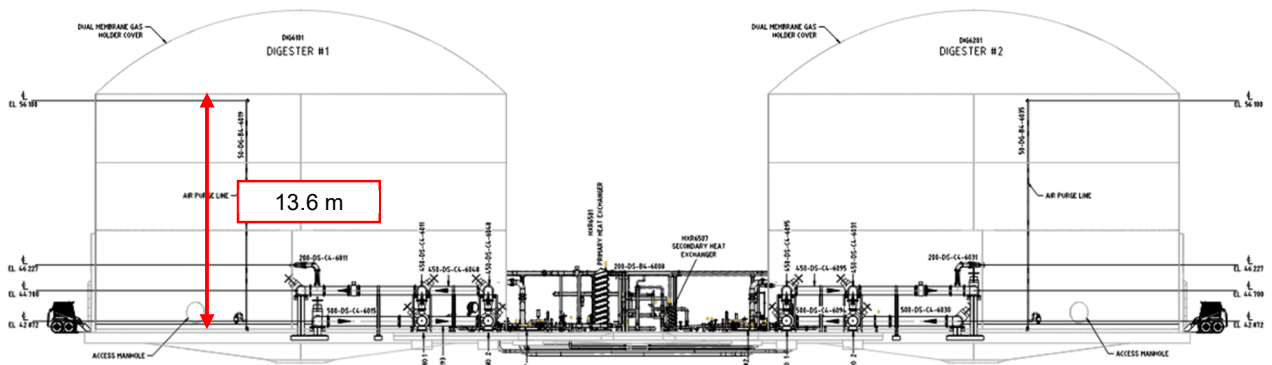


Figure 25 Digester height

### 5.1.6 Secondary Fires from flashfire or VCE

A secondary fire to infrastructure on site as a result of a flashfire event is unlikely to occur given the gas holder is located 13.6 m above grade, the properties of methane gas and flashfires being short-lived events of up to a maximum of 3 seconds (Margolin, 2014).

It has however possible for a flashfire at one digester to have a cascading effect to the second digester gas holder, albeit unlikely. The concentration of methane released from one digester will need to be significant, and able to disperse in a manner where it reaches the second digester, and lower explosive limits (LEL) are maintained. Under these conditions, the flames from a flashfire event may cause a cascading effect to the second digester, due to the gas holder membrane being flammable and methane being housed beneath.

As discussed throughout this report, there are limited firefighting means for a VCE or flashfire event due to its instantaneous occurrence, and the emphasis is placed around preventative controls as discussed in prior sections.

However, the pressure waves generated from a VCE may potentially cause a secondary fire to occur to other parts of the facility. An area identified as being at potential risk is the biosolids switch room. Refer to Section 3.4.3.1 for details.

The biosolids switch room occupies a floor area of approximately 235 m<sup>2</sup>. Buildings with a floor area of less than 500 m<sup>2</sup> are not required to be protected with a hydrant system as permitted under the NCC. The reasoning being that buildings with smaller footprints do not justify the installation of a hydrant system due to the reduced hazards. However, fire hydrants are provided throughout the facility, including coverage to the switch room.

Therefore, in the event of a secondary fire occurring at the switch room, the nearby hydrant may be used to fight such. The secondary fire at the switch room may occur simultaneously as a fire at the base of the digesters where the VCE originated.

The site is currently designed for two (2) hydrant outlets to operate simultaneously, therefore the number of outlets available at the digester during a fire at the switch room, would be limited to one (1). Fire hydrants are used to extinguish any ground fires that may arise as a result of the VCE or flashfire, and not applied directly on the gas holder. Equipment located at the base of the digester is limited to piping and infrastructure associated with the digester itself, and in the event of a fault resulting in a VCE, operating of such equipment would have been ceased, cutting off any flammable gas that may be present in the system. As such, a fire in this area is not expected to be substantial.

In the event of a VCE and the destruction of a gas membrane cover on one of the digesters, the usage of gas from the digesters for heating should immediately cease. The gas hot water heater and the gas blowers feeding gas should be shut down. Any excess gas still being produced from the other operating digester should be directed to the waste gas burners.

Therefore, there are no increased fire water requirements as a result of this event.

## 5.2 Gas Flare

The primary risk presented at the gas flare is a jet fire, caused by the on-demand failure of the flare and subsequent ignition of released biogas.

The distinctive components leading to a jet fire is:

- 1) On-demand failure of the flare
- 2) Premature release of methane / biogas into the air and the subsequent formation of a vapour cloud
- 3) Presence of an ignition source

As such, prevention strategies and measures are based on preventing the on-demand failure of the flare, premature release of biogas, and minimising the presence of ignition sources. Overall, AS 3814 -2018 as discussed in Section 4.2 accurately capture the jet fire protection measures installed in the designed gas flare.

### 5.2.1 Preventing Ignition failure

Excess biogas shall be flared off via a low-pressure enclosed flare waste gas burner. The flare is designed to include a biogas pilot light, with a standby Liquefied Petroleum Gas (LPG) system.

To ensure ignition of the main burner is not compromised upon minimised pilot burner activation, **a pilot turndown test is required** to ensure the main burner can safely and reliably ignite with the flame safeguard system activated, reducing the risk of ignition failure.

### 5.2.2 Vapour Cloud Prevention

A driving factor behind vapour cloud formation is the release of biogas during the on-demand failure of the flare. As such the flare is fitted with a flame safeguard system or burner management system to ensure the supply of biogas to the burners is appropriately terminated in the event of an ignition failure. Components included in such a system have been included in the biogas flare design and are listed below as well as highlighted in Figure 26:

- **A flame detector(s) shall be installed to detect if the flame has ignited or extinguished. Both the main burner and pilot burner require a detector.**
- **Safety shut off valve system shall exhibit minimum requirements as stipulated by AS 3814-2018.** This being that two valves in series are required with the valves to be class 1 automatic valves.

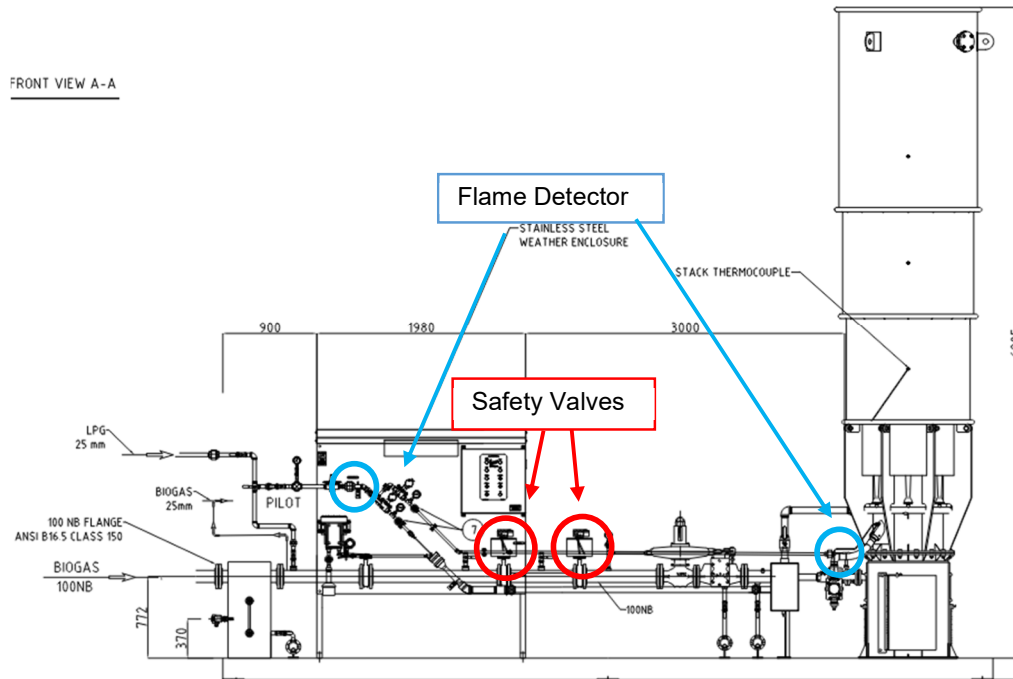


Figure 26 Gas Flare design

To further ensure adequate isolation of biogas in the event of an ignition failure, **appropriate standards for gas piping and fittings shall be used dependant on design pressure.** The waste gas burners only require a gas feed pressure (at the inlet of the skid) of approx. 1.6 kPa to operate reliably. After allowing for equipment and control valve losses in the skid, the resultant pressure at the base of the flare will still be at least 1.0 kPa which the flare requires to operate reliably.

The piping withing the skid is Schedule 10S stainless steel, which for a DN100 pipe at the skid inlet, has a design pressure of at least 5,500 kPa. The condensate trap at the inlet of the skid has a maximum design pressure of 172 kPa. These design pressures far exceed the digester gas operating pressure of approx. 2.0 kPa.

In addition to physical components on the flare, the flame safeguard system or burner management system shall also be calibrated to the appropriated flame failure response time as per AS 3814-2018. The waste gas burner is an enclosed type unit with a 'flame front' ignition system. The maximum gas feed capacity is 120 Nm<sup>3</sup>/hr, which represents approximately 720 kW of combustion power assuming 60% methane in the feed and a heating value of 36 MJ/Nm<sup>3</sup> for the methane content. As such, **the flame safeguard system or burner management system shall also be calibrated to a flame failure response time of 3 seconds.**

### 5.2.3 Prevention of Premature Ignition Sources

A flow transmitter is expected to be used to measure the total biogas feed to the waste gas burner. As such, **flare operation dependent on flow shall be fitted with lockout features** to activate when:

- The device is not confirmed to be in a “no flow” state before ignition
- Loss of flow occurs during operation

The reasoning behind this, is that if the fuel supply was not confirmed to be in a “no flow” state, excess biogas is possibly being released from the digester into the flare, mixing with air and forming a flammable cloud. If the pilot burner is to then commence, the prematurely released biogas will ignite and cause a jet fire. Therefore, it is necessary to prove “no flow” prior to flow and pilot burner commencing.

Furthermore, if flame failure should occur, **reignition attempts shall conform to Section 3.5.5 Automatic reignition attempt on flame failure of AS 3814 -2018.** This is to ensure the line is adequately purged to ensure premature released flammable vapour is not ignited.

### 5.2.4 Additional Measures

In the event that all safeguard measures fail, and a jet fire does occur, the primary method for jet fire mitigation is to shut off fuel supply. **As such, an interlock system to shut off the fuel supply separate to the Burner Management System is recommended.** The reasoning behind this is to ensure fuel supply can be shut off even in the event of system failure.

### 5.2.5 Secondary Fires from Jet Fire

A secondary fire to infrastructure on site as the result of a jet fire event is unlikely to occur given the results of the consequence analysis. From heat radiation contours, the area within 7 m radius from the epicentre receives 12.5 kW/m<sup>2</sup> of radiation.

According to radiant heat exposure impacts detailed in HIPAP 4, and captured in Table 19, a heat flux of 12.6 kW/m<sup>2</sup> is capable of:

- Causing the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure, and
- Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.

However, within the 7 m radiation contour additional infrastructures are not present, inherently preventing a secondary fire from occurring.

## 5.3 Consolidated Prevention and Mitigation Measures

All fire and explosion prevention and mitigation measures discussed as far are consolidated individually for the Biogas Holders and Gas Flare in Table 26 and Table 27.

**Table 26** *Biogas holders' prevention and mitigation measures*

Parameter	Prevention and Mitigation Measures
Gas fittings, piping, and valves	All gas piping's and fittings shall be designed and installed in accordance with <i>AS/NZS 5601</i> The relief devices shall be designed and installed in accordance with <i>AS 1271—2003</i>
Electrical equipment	All electrical equipment used for operations and monitoring for the digester within the hazardous area zone, is required to comply with <i>AS/NZS 60079.14</i> . Electrical bonding and earthing of isolated equipment will be required in accordance with <i>AS/NZS 1020</i> in hazardous areas.
Methane detection	A methane detector (indicated in Figure 20) is provided downstream of the biogas holders. The detector will be exposed to clean air. In the event of membrane failure, the instrument shall be checked and re-calibrated. <ul style="list-style-type: none"> <li>– The detector will be configured to a threshold of 20% LFL (Lower Flammability Limit).</li> <li>– An uninterrupted power supply (UPS) is provided for all critical safety elements including the methane detector and programmable logic controller (PLC).</li> </ul>
Minimising ignition sources	<ul style="list-style-type: none"> <li>– Duty and standby fans that are used to inflate the outer membrane are recommended to be designed to prevent frictional sparking risks</li> <li>– Flame arrestors will be installed in various locations across the digester (detailed in Figure 23)</li> <li>– Lightning protection to be available in this area (detailed in Figure 24)</li> </ul>
Excess digester gas	Surplus methane produced in the digester shall be combusted and not accumulated The waste gas burner shall operate when the level or pressure in the gas holder reaches the set point from the transmitter Supervisory Control and Data Acquisition (SCADA) is recommended to monitor gas levels in the digester and control the amount of gas flared

Parameter	Prevention and Mitigation Measures
Operational procedures	<p>Procedures shall be developed to include the required steps to prevent and monitor a tear in the inner membrane during different stages of the digester - commissioning, maintenance and operation.</p> <p>Procedures shall reflect the requirement to maintain sufficient gas in the digester headspace to keep the membrane at least 20% above “empty level” during operation.</p>
Maintenance procedure	A maintenance procedure shall be developed and implemented as per the suppliers’ recommendations to ensure fittings and the associated pipework is appropriately maintained.
Bushfires	It is recommended that a bushfire management plan be developed and implemented to reduce the total flammable gas stored or produced in the digester.
First aid fire fighting	Hydrant coverage will be provided to the digester, and fire extinguishers will be provided to areas surrounding the digester pipework at ground level

**Table 27 Gas flare prevention and mitigation measures**

Parameter	Prevention and Mitigation Measures
Gas piping and fittings and valves	<ul style="list-style-type: none"> <li>– Appropriate standards for gas piping and fittings shall be used (AS 4041 and Section 2 of AS/NZS 5601).</li> </ul> <p>Safety shut off valve system shall exhibit minimum requirements as stipulated by AS 3814-2018. This being that two valves in series are required with the valves to be class 1 automatic valves.</p>
Burners	<ul style="list-style-type: none"> <li>– Flame detector shall be installed for both the main burner and pilot burner may require a detector.</li> </ul> <p>A pilot turndown test is required to be completed at a period defined by the supplier.</p>
Operating system	<p>Flame Safeguard System or Burner Management System shall be designed and installed in accordance with AS 3814 -2018.</p> <ul style="list-style-type: none"> <li>– The Flame Safeguard System or Burner Management System shall also be calibrated to a flame failure response time of 3 seconds.</li> </ul> <p>An interlock system to shut off the bio gas fuel supply separate to the flame safeguard system or burner management system is recommended</p>
Lock out systems	<p>Flare operation dependent on flow shall be fitted with lockout features to activate when:</p> <ul style="list-style-type: none"> <li>– The device is not confirmed to be in a “no flow” state before ignition.</li> <li>– Loss of flow occurs during operation.</li> </ul>
Operational procedures	Operational procedures for reignition attempts after flame failure shall conform to Section 3.5.5 <i>Automatic reignition attempt on flame failure of AS 3814 -2018</i>

## 6 Fire water services layout

The site is provided with a firewater ring main, and its indicative layout is shown in Figure 27. The proposed hydrant locations and coverage (red dots and circles) achieved along with each building's hydrant compliance triggers is shown in the same figure.

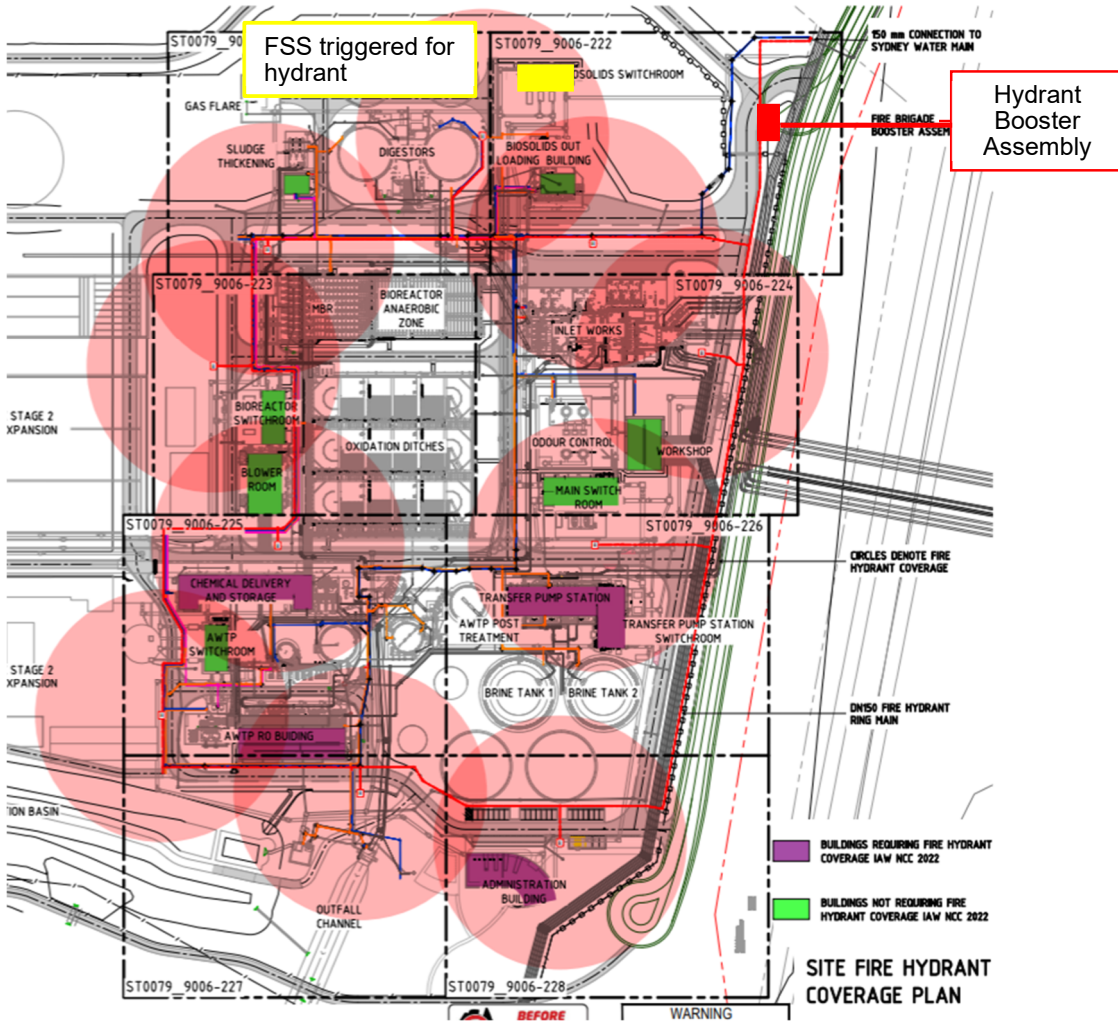


Figure 27 Fire Services Layout – Sitewide

The firewater ring main is currently designed to provide hydrant coverage across the entire process site, and not just to buildings that require coverage in accordance with the NCC. Coverage will be achieved through external attack fire hydrants in accordance with AS 2419.1-2005.

As the project site is greenfield, no existing infrastructure is present. However, Sydney Water have undertaken water flow modelling based on current assets, as well as those to reflect 2024 conditions to estimate the pressure and flow available to the site. Findings of the model indicate that adequate pressure and flow should be available. Refer Appendix C for modelling outputs.

## 6.1 Firefighting water supply

The fire water supply for the site can be broken down into different demand areas. Depending on the design, each area is expected to draw from the fire water supply provided for the site, and therefore needs to be considered to ensure sufficient fire water storage is provided for the site. The primary demand areas include:

- Fire water requirements driven by the NCC. These typically include demands required of sprinklers (if present) and fire hydrant systems.
- Fire water requirements driven by special hazards identified in this report. Where a special hazard requires additional fire water for firefighting, the impact of this demand would need to be considered in the fire water supply.
- Fire water requirements from bushfire firefighting. AWRC is located in a bushfire prone area, therefore requiring provision of fire water for fighting a bushfire.

The sum of the demand across each of these areas yield the total fire water volume required for the site.

### 6.1.1 NCC fire water demand

In accordance with the referenced BCA reports (Table 4), there are multiple buildings on site which require fire hydrants to be provided for protection. The most onerous demand being the operation of two (2) fire hydrant outlets simultaneously for a duration of four (4) hours.

No buildings have been identified as requiring automatic suppression i.e. sprinklers. Therefore, the water requirements for automatic suppression systems are not part of the resultant fire water demand.

The fire water demand for the hydrant system, designed in accordance with AS 2419.1:2005 is summarised in Table 28.

**Table 28** Fire hydrant design requirements – AS 2419.1:2005

Parameter	Value
Number of fire hydrant outlets required to run simultaneously	2
Flow rate per outlet	10 L/s
Minimum pressure	700 kPa
Duration	4 hours
<b>Total fire water demand</b>	<b>288,000 L</b> 2 hydrant outlets x 10 L/s x 60 sec x 60 min x 4 hours

### 6.1.2 Fire water demand based on special hazard scenarios

In addition to the fire water requirements of the NCC, additional demand may arise from the special hazard scenarios assessed as part of this report.

As hydrant coverage is provided sitewide, the additional demand on the system would only arise where water exceeding NCC required fire water capacity is identified.

Based on the findings of Section 5, no additional fire water demand is required for the special hazard scenarios assessed.

### 6.1.3 Bushfire firefighting water demand

Bushfire fire water is not included in the overall water requirement of the site as they are a separate consideration. Please see bushfire assessment report for further details (*Reference No: AWRC-DJV-RPT-GEN-0501-0019, Revision 01, dated 28 July 2023*)

### 6.1.4 Total fire water demand

Based on the fire water demands from each of the key areas discussed above, the total fire water demand for the site is summarised in Table 29.

**Table 29**      *Summary of fire water demand*

Demand Area	Demand volume
NCC (Fire hydrants)	288,000 L
Special hazards	Nil additional requirements, beyond NCC. Special hazards do not increase the fire water demand above those required under the NCC.
Bushfire	Nil Bushfire fire water demand is separate to those required for on site structural firefighting.
<b>Total fire water demand for structural firefighting</b>	<b>288,000 L</b>

### 6.1.5 Total fire water supply

As the total fire water demand (288,000 L) for the site is equivalent to the design parameters to satisfy the NCC fire water demand requirements as shown in Table 29, the currently proposed method for fire water supply is appropriate.

**The primary fire-fighting water supply to the site is currently proposed to be provided by the town’s main.**

Furthermore, the water flow modelling undertaken by Sydney Water results indicate that the flow and pressure demand for the site can be met (refer to Appendix C)

The fire brigade booster assembly is currently shown to be located off the southern site access road. See Figure 28.

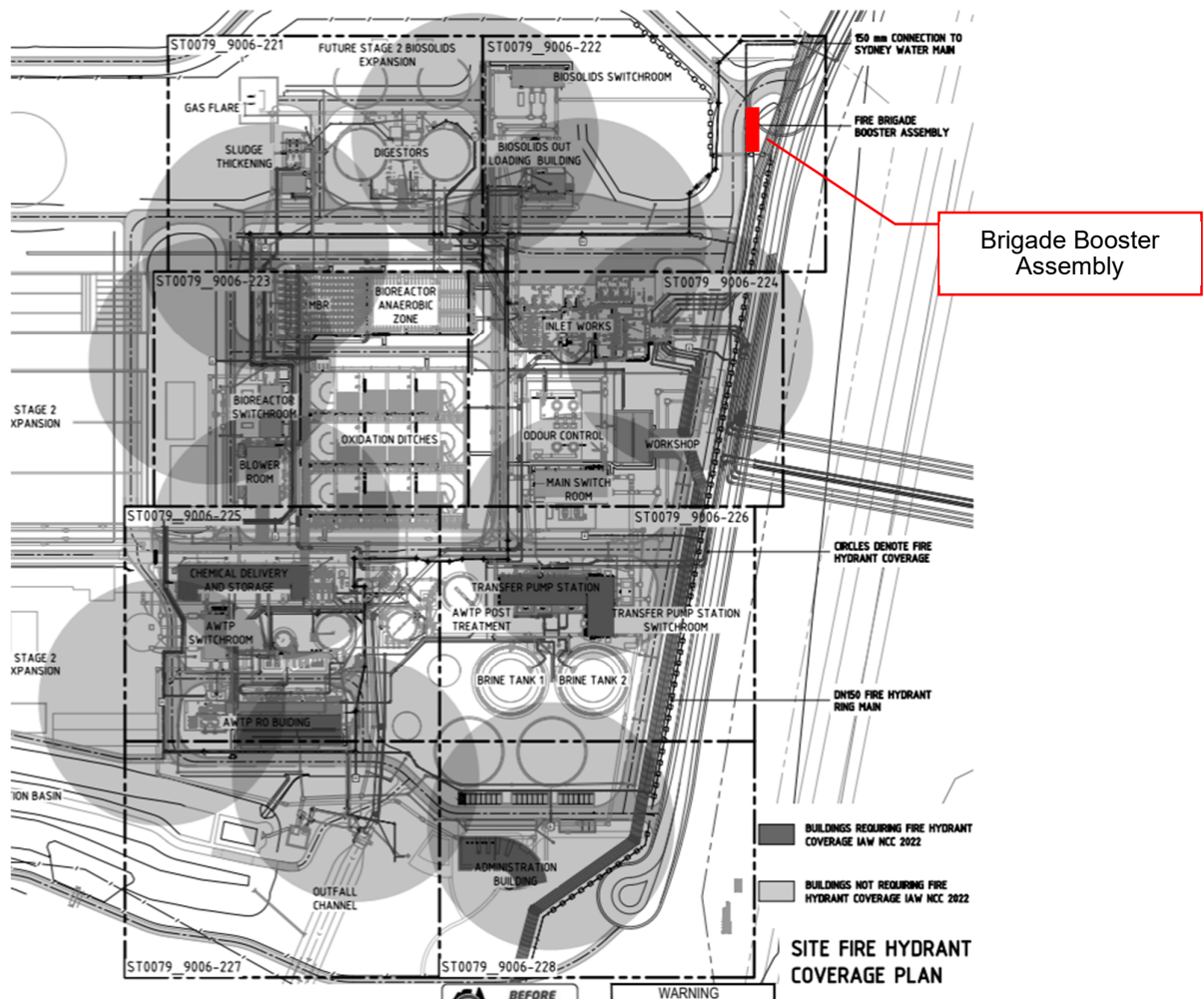


Figure 28 Fire Hydrant Booster Assembly

## 6.2 Firefighting water containment

Being a wastewater treatment facility, it is highly likely for firewater that comes into contact with the incoming waste stream or processing areas to be contaminated. Due to the potential for contaminated fire water to enter the environment, the stormwater system is required to allow for sufficient capacity to contain the firewater in the event of a fire and retain it until testing confirms it is safe for release.

In consideration of the guidance provided in the *Best Practice Guidelines for Contaminated Water Retention and Treatment Systems* (HMPCC, 1994), the stormwater system considers rainfall events in the area and has been designed to contain a 1 in 20-year rainfall event within the drainage systems, pipes, pits and swales.

The layers of the catchment system and the volume of water that can be contained is summarised in Table 30.

Table 30 Water Containment Area and Capacity

Catchment Area	Catchment Volume
First Flush Tank	130 kL
~175 m DN1200 Trunk	197 kL
~171m DN110 Trunk = 162 kL (Pit 1-8 to 1-13)	162 kL
<b>Total catchment volume</b>	<b>489 kL</b>

As shown in Table 30, the stormwater catchment system capable of containing up to 489 kL of water, providing sufficient capacity to capture all contaminated fire-water run-off produced by the fire hydrants (288,000 L), including during anticipated rain events.

### 6.3 First aid protection arrangements and equipment

#### 6.3.1 Non-special hazard buildings

First aid protection to non-special hazard buildings is captured in Section 2.2 and primarily includes fire extinguishers and fire hose reels. Where fire hose reels and/or fire extinguishers are required to be installed in these areas per the NCC, they shall comply with the relevant standards summarised in Table 31.

Table 31 First aid protection requirements

Item	Location(s)	Installation Requirements	Maintenance Requirements
Fire extinguishers	At locations as stipulated in AS 2444:2001	As per AS 2444:2001	As stipulated in AS 1851-2012
Fire Hose Reels	At locations as stipulated in AS 2441-2005	As per AS 2441:2005	As stipulated in AS 1851-2012

Suitable fire extinguishers shall be provided to suit the area of protection. Various types of fire extinguishers and its efficacy in given scenarios are shown in Figure 29.

Type of extinguisher		Type of Fire, Class and Suitability						Comments (Refer Appendix B)	
Colour scheme AS/NZS1841 -1997	AS1841 -1992	A Wood, paper, plastics,etc	B Flammable liquids	C Flammable gases	E Energized electrical equipment	F Cooking oils and fats	D** Metal fires		
		Water							Dangerous if used on flammable liquid, energized electrical equipment and cooking oil/fat fires
		Wet Chemical							Dangerous if used on energized electrical equipment
		Foam***							Dangerous if used on energized electrical equipment.
		ABE							Special powders are available specifically for various types of metal fires (see **).
		BE							
		Carbon Dioxide							Generally not suitable for outdoor use. Suitable only for small fires.
		Vaporizing Liquid							Check the characteristics of the specific extinguishant.
		Fire Blanket							

\* Limited indicates that the extinguishant is not the agent of choice for the class of fire, but that it will have a limited extinguishing capability.  
 \*\* Class D fires (involving combustible metals). Use only special purpose extinguishers and seek expert advice.  
 \*\*\* Solvents which may mix with water, e.g. alcohol and acetone, are known as polar solvents and require special foam. These solvents break down conventional AFFF.

Figure 29 Fire Extinguisher Types - Figure A1 of AS 2444

#### 6.3.2 Special hazard Areas

For special hazard areas, the following first aid protection measures provided are summarised in Table 34. It is to be noted that the equipment listed is not expected to aid in protection from special hazard consequences (VCE, Flash Fire and Jet Fires) but rather provide compliance with NFPA 820 standards and provide some additional protection to the surrounding area.

**Table 32** *First aid fire protection*

Location	First aid fire prevention
Anaerobic digestors and Biogas holders	Fire extinguisher required to mitigate small ground fires surrounding digester pipework.
Gas Flare	No first aid fire protection required – biogas supply to be shut off in the fire event

Fire extinguishers for the anaerobic digester shall be installed as per Table 33.

**Table 33** *First aid protection requirements*

Item	Location(s)	Type	Installation Requirements	Maintenance Requirements
Fire extinguishers	At the base of the anaerobic digester, near where equipment / pipework. Distance between each fire extinguisher covering the area shall be no greater than 15 m intervals.	ABE or other suitable type determined by fire services engineer.	As per AS 2444:2001	As stipulated in AS 1851-2012

Suitable fire extinguishers shall be provided to suit the area of protection. Various types of fire extinguishers

## 6.4 Consolidated Fire Services Requirements

All fire services requirements discussed as far are consolidated in Table 34.

**Table 34** *Fire Services requirements*

Parameter	Fire Services Requirements
Fire Water Supply and Demand	Total fire water demand for the site is 288,000 L. There are no additional fire water demand from the special fire hazard scenarios assessed.
Fire Water Supply	The primary fire-fighting water supply to the site is currently proposed to be provided by the town's ring main.
Bushfire Firefighting Water	Bushfire fire water is not included in the overall water requirement of the site as they are a separate consideration. Please see bushfire assessment report for further details (Reference No: AWRC-DJV-RPT-GEN-0501-0019, Revision 01, dated 28 July 2023)
Stormwater System	The proposed stormwater drainage system for the site has been designed to capture a 1 in 20 year rainfall event. This equates to a capacity of approximately 489 kL. Therefore, the design is capable of capturing the full 288,000 L of potentially contaminated fire water run off as a result of the fire hydrants operating on site, inclusive of standard rain events.
First Aid Protection	First aid protection primarily comprises of fire hose reels and fire extinguishers as summarised in Section 6.3. No additional requirements for special hazard scenarios.

## **7 Conclusions**

The overall main findings of this Fire Safety Study are summarised in the Executive Summary in Table 1, 2, and 3.

## 8 References

- AFAC. (2020). *Fire Brigade Intervention Model Manual*. Australasian Fire and Emergency Service Authorities.
- Chempedia.info. (2019). Methane Flame Speed - Big Chemical Encyclopedia.
- Department of Planning. (2011). *Hazardous Industry Planning Advisory Paper No 2 - Fire Safety Study Guidelines*. NSW: Department of Planning.
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- GHD & Jacobs . (2023). *Design Report*.
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- GHD & Jacobs. (2023). *Hazardous Area Classification - Explosive Atmospheres*.
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- HMPCC, N. (1994). *Best Practice Guidelines for Contaminated Water Retention and Treatment Systems*. NSW.
- Margolin, S. M. (2014). Duration and Energy of Hydrocarbon Flash Fire and Performance of FR Clothing. *Paper presented at the ASSE Professional Development Conference and Exposition*. Orlando, Florida USA,.

## Appendix A. FRNSW Review

Consultation with FRNSW has occurred through report the submission process. A non-finalised revision (Rev01) of this Fire Safety Study was submitted to FRNSW for review and consultation. On 15 January 2024 FRNSW provided a response with comments (File Ref FRN21/3162 BFS23/7605 8000032895). Figure 30 is the cover page of the letter. FRNSW comments and requirements have been addressed in Revision 02 of the Fire Safety Study as captured in Table 35.

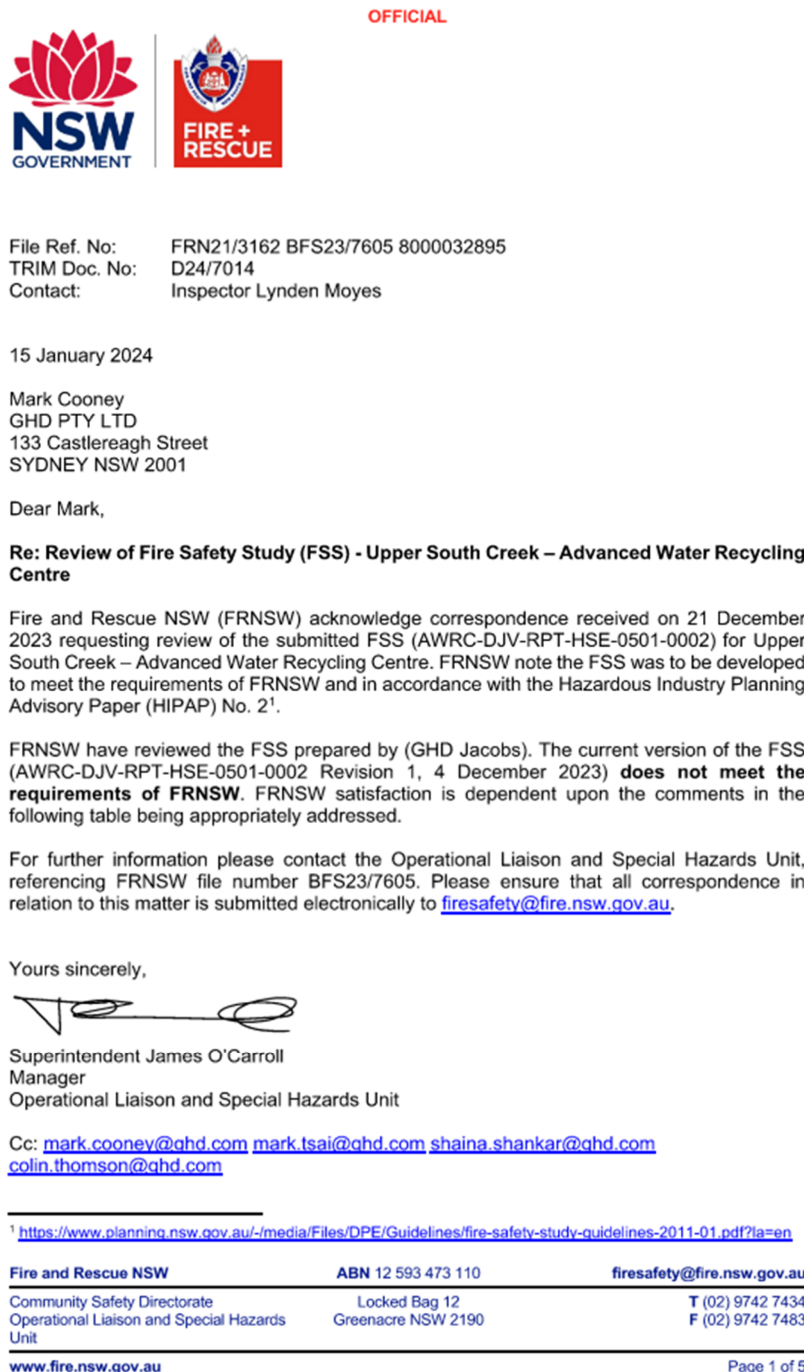


Figure 30 FRNSW cover letter (Rev01)

Table 35 FRNSW Comments

Item number	Section (Rev01)	Fire Safety Study Comment	FRNSW Comment	Updates to Revision 02
1	Summary of Main Findings and Recommendations	-	FRNSW reiterates the requirements of Section 3.3 of HIPAP2 that the Summary of Main Findings and Recommendations, which is titled as Executive Summary. The executive summary must include an implementation program agreed to by the proponent company or the owner or operator, as required by Section 3.3 of HIPAP2. If any recommendations are not to be proceeded with reasons should be given.	An implementation program has been included in Appendix E.
2	Section 2.2.1 – Dewatering and out loading building	Irrespective of these performance solutions, the dewatering and out loading building is free from any distinctive special fire hazards, and consequently, it is solely subject to compliance with fire safety regulations as stipulated by NCC.	NFPA820 notes that sludge gases are flammable gases that result from the fermentation or anaerobic decomposition of organic matter. Explosive conditions, especially concerning compression and storage, can result when these gases are mixed with air. FRNSW recommends consideration of the sludge gases that may be produced within the sludge centrifuges.	Flammable gasses resulting from the decomposition of sludge have been considered and detailed in multiple sections. This includes sections regarding the dewatering and out loading building and the odour control facility Sections specific to the dewatering and out loading building is Section 2.2.1 and Section 3.3.4
3	Section 2.2.3 – Sludge thickening structure	The structure is free from any distinctive fire hazards and consequently, it is solely subject to compliance with fire safety regulations as stipulated by NCC	FRNSW notes quantities of liquid polymer stored within the building. In addition, FRNSW recommends specific quantities and locations of the dangerous goods stored be provided for review. Liquid polymer and sludge, being organic material, may present a special hazard. It is unclear without the specific quantities and locations provided for each building.	The liquid polymer stored in the sludge thickening structure has been deemed nonhazardous. Refer to Section 2.2.4 for further details. The DG table in Section 3.1 has been updated to include location.
4	Section 2.2.7 – Chemical storage and dosing building	Chemical storage and dosing building (WL18)	FRNSW provides the following comments: <ul style="list-style-type: none"> <li>– An assessment of potential interactions between stored chemicals with consideration of exothermic reactions or gas generations.</li> <li>– Potential ignition sources</li> <li>– While powdered hydrated lime and ferric chloride might not be inherently flammable, fine dust particles can potentially create explosive mixtures in the presence of an ignition source.</li> </ul> FRNSW recommends further assessment be provided regarding the risk of dust explosions.	As detailed in Section 2.2.9, the chemical storage and dosing building was concluded to be free from fire hazards. The FHA (GHD & Jacobs, 2024) provides an interaction summary between the stored chemicals as well as AS 3780 -2008 compliant separation distances for the stored chemicals on site. Appendix D also details the interactions of the chemical storage and dosing building.
5	Section 2.2.8 – AWTP RO Building	The Advanced Water Treatment Reverse Osmosis building houses reverse osmosis membranes used for the removal of contaminants. Reverse osmosis	FRNSW recommends presence of dangerous goods within AWTP RO building be confirmed.	As detailed in Section 2.2.10, there are no hazardous chemicals stored within the AWTP RO building.

Item number	Section (Rev01)	Fire Safety Study Comment	FRNSW Comment	Updates to Revision 02
		processes are free from any special fire hazards.		
6	Section 3.1 Materials identified	Table 15	FRNSW recommends a site plan / floor plans indicating the location of the DGs listed in Table 15 be provided for review.	The DG table in Section 3.1 has been updated to include location.
7	Section 3.2	The hazard scenarios detailed in Table 16 have been identified in the FHA. Of the list, three (3) have been identified as potential events that may result in offsite impacts and further assessed in the FHA.	FRNSW recommends verifying the basis for concluding no offsite impact is present.	Section 3.2, details the HAZID identification process and the subsequent determination of fire hazards that are carried forward in this FSS
8	Section 3.4	Table 17	FRNSW recommends heat radiation criteria of 3kW/m <sup>2</sup> used for the firefighter's operation. The value is derived from Fire Brigade Intervention Model Manual Version 3.0 dated 14 April 2020. In addition, the heat radiation criteria of 2.1 kW/m <sup>2</sup> be used for areas where the occupants can traverse, as per Table 6 of HIPAP No4.	Table 19 has been updated.
9	Section 3.4	Table 18	It is noted that HIPAP4 lists 3.5 kPa as an explosion overpressure criterion stating its effect to be 90% glass breakage, but the Table 18 excludes them from the assessment criteria. FRNSW recommends clarification be provided for this exclusion.	Table 20 has been updated.
10	Section 3.4.2	The consequence for this scenario is a direct result of the pressure waves generated from the blast. Results shown in Figure 6 and Figure 7 have been extracted from the FHA.	Section 2.3 of HIPAP2 requires "all models and assumptions used to estimate consequences should be justified." It is noted that there are no details of the models/calculations used for the fire safety study. FRNSW recommends details of the models used to be provided in the FSS. As a minimum, it should include: <ul style="list-style-type: none"> <li>- Theories, formulas, and scientific basis of the model</li> <li>- Applicability of the model</li> </ul> Assumptions and inputs, with appropriate justification.	Appendix B details the consequence calculation summary.
11	Section 3.4.3	Infrastructure within this range is subject to 0.35 bars or 35 kPa, which according to HIPAP 4.	FRNSW recommends justification of the explosion overpressure criteria of 35 kPa chosen for the assessment.	Section 3.4.3 now justifies the overpressure criteria of 21 kPa.
12	Section 3.4.3	The fire safety study is specifically interested in the likelihood for a secondary fire to occur due to such pressure. In order to assess this potential, plant and equipment located within this region are required to be reviewed.	FRNSW notes that the assessment is incomplete. FRNSW also recommends its impact on the firefighting infrastructure be assessed. The firefighting infrastructure, as a minimum, includes fire hydrants, fire hydrant and sprinkler booster assembly, fire control centre and hardstands for firefighting appliances. This comment applies to all consequence analysis.	Section 3.4.3 has been updated to assess fire fighting infrastructure (Section 3.4.3.5)
13	Section 3.4.3.1	While a blast pressure of 37.5kPa has the potential to overturn plant equipment, the volume of polymer	FRNSW recommends the following:	Section 3.4.3 has been updated to consider the probability of a dust explosion (Section 3.4.3.1)

Item number	Section (Rev01)	Fire Safety Study Comment	FRNSW Comment	Updates to Revision 02
		stored in the building is understood to be relatively low and is stored in a conical hopper. On this basis, the likelihood of a dust explosion is low. At this stage, the likelihood for a secondary fire to occur at the dewatering and out-loading building is low.	<ul style="list-style-type: none"> <li>It is considered that there is insufficient analysis conducted to justify the low probability of the dust explosion.</li> </ul> <p>It is apparent that the Hazardous Area Classification report should be read in conjunction with the FSS. FRNSW recommends a copy of the report be provided.</p> <ul style="list-style-type: none"> <li>FRNSW considers that it is important to understand the specific explosiveness characteristics of the polymer powder and the ease of forming flammable dust clouds in the storage area. The MEC (minimum explosible concentration) and dust ignition energy are critical parameters that can provide better understanding of the risk.</li> </ul> <p>A 37.5 kPa blast pressure can have significant ramifications for personnel safety and structural integrity of the hopper, as indicated in Table 6 of HIPAP4. A comprehensive assessment of these consequences is essential to understand the full picture of the risk.</p>	
14	Section 3.4.5	The heat flux contours of a biogas flashfire event are shown in Figure 8.	Refer to comment provided for Section 3.4.2	Appendix B details the consequence calculation summary.
15	Section 3.4.5.1	Flashfire events are known to be brief thermal hazards which typically last for a maximum duration of 3 seconds	Whilst it is acknowledged that flashfires are typically a brief thermal event, FRNSW recommends justification provided for the maximum duration of 3 seconds. It is considered that the type and amount of fuel available will significantly impact burn time. In addition, ventilation and wind conditions can have impact on the burn time.	Section 3.4.4 has been updated to detail the duration of a catastrophic failure flash fire event.
16	Section 3.4.5.1	Given methane gas is lighter than air, a loss of containment event would result in the gas dispersing into the atmosphere, typically in the upward direction. As a result, flames of the flashfire event would remain at high level, and no direct impingement is expected to lower-level infrastructure around site.	While acknowledging upward dispersion, the statement doesn't account for potential wind conditions that could influence gas movement and increase localised fire risk.	Section 3.4.4 has been updated to include dispersion modelling of a catastrophic failure flash fire event.
17	Section 3.4.6	Should a flame out occur, the biogas will entrain over time triggering a 15-minute site shutdown. In this time, a gas cloud of 0.1 m diameter may form.	FRNSW seeks to understand the underlying basis for the estimated 0.1-meter gas cloud diameter in case of a flame out event. Further elaboration on the assumptions, calculations, or modelling used to determine these values would be recommended.	Appendix B details the consequence calculation summary.
18	Section 5.1.3	To prevent the loss of detection, an uninterrupted power supply (UPS) is recommended, for all critical safety elements including the methane	It is noted that the design would need to be finalised.	Noted. The design has been finalised. Please see 5.1.3.

Item number	Section (Rev01)	Fire Safety Study Comment	FRNSW Comment	Updates to Revision 02
		detector and programmable logic controller (PLC). Further details will be confirmed with the electrical designers.		
19	Section 6	Fire water services layout	It is noted that there is no local authority pressure and flow statement provided within the FSS. HIPAP2 notes that the adequacy of the water supply available from town mains should be assessed based on written advice from the local water authority.	Noted. Section 6.1.5 has been updated. Furthermore, the fire flow modelling undertaken by Sydney Water results indicate that the flow and pressure demand for the site can be met (refer to Appendix C)
20	Section 6.3	The design of the firefighting water containment system is required to accommodate the total firefighting water volume supplied to the site, that is 288,000 L, considering the potential rainfall events for the sites geographic location. The method by which this is achieved is under development.	It is noted that the design would need to be finalised. Please note that Section 3.13 of HIPAP2 requires consideration of the nature and quantity of materials involved and the effect of rain events, which has not been considered in the calculation. Also, the " <i>Best Practice Guidelines for Potentially Contaminated Water Retention and Treatment Systems</i> ", which the FSS and HIPAP2 references, provides a guideline on probabilistic analysis.	Noted. Section 6.2 has been updated.
21	Section 6.3	First aid protection arrangements and equipment	Relevant matters to be covered would include: <ul style="list-style-type: none"> <li>– provision of portable fire extinguishers - size, type, medium, number, location, testing and maintenance;</li> <li>– provision of hose reels - number, location, type, testing and maintenance. Installed hose reels can remove the need for water type extinguishers</li> <li>– provision of warning signs (including exit signs, placarding and first aid firefighting equipment use instruction signs), location, type, size;</li> </ul>	Noted. 6.3 has been updated accordingly.

## Appendix B. Consequence Calculation Summary

*Contents taken from Caltex Kurnell Report- Appendix V Consequence Models Rev A*

A part of the risk assessment process involves generating consequences for the release events identified. The steps involved in determining consequences are:

- Determine release conditions based upon materials involved, process conditions and available inventory etc;
- Based on release conditions, determine the types of events which will occur (eg jet fire, toxic cloud, evaporating pool or explosion etc);
- Calculate the extent of the consequences; and
- Establish the impact of the consequence (e.g. proportion of people killed when exposed to a toxic dose)

The consequences are calculated using empirically derived models, which can then be used to determine which release cases generate offsite effects and should be included in the risk model. The level at which fatal consequences are considered to occur will directly influence the risks.

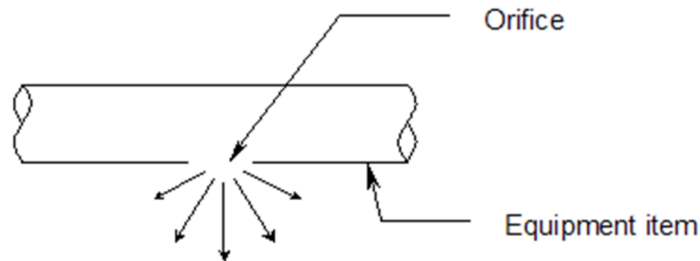
This Appendix discusses basic concepts and theory behind the various consequence models used in the analysis. The models discussed are:

- Discharge Modelling
- Dispersion
- Flammable Effects
  - Jet Fire;
  - Pool Fire;
  - Fireball;
  - Multi Energy Explosion;
- Verification and Validation models

## Discharge Modelling

If there is a hole in a pipeline, vessel, flange or other piece of process equipment, the fluid inside will be released through the opening, provided the process pressure or static head is higher than ambient pressure. The properties of the fluid upon exiting the hole play a large role in determining consequences, eg, vapour or liquid, velocity of release etc. Figure 31 illustrates an example scenario.

**Figure 31** Typical Discharge



The discharge can be considered to have two stages, the first is expansion from initial storage conditions to orifice conditions, the second from orifice conditions to ambient conditions.

The conditions at the orifice are calculated by assuming isentropic expansion, ie, entropy before release = entropy at orifice. This allows enthalpy and specific volume at the orifice to be calculated.

The equations for mass flow rate ( $\dot{m}$ ) and discharge velocity ( $u_0$ ) are then given by:

$$\dot{m} = C_d A_o \rho_o \sqrt{-2(H_o - H_i)}$$

And  $u_0 = C_d \sqrt{-2(H_o - H_i)}$

Where

- $C_d$  = Discharge coefficients
- $A_o$  = Area of the orifice
- $\rho_o$  = density of the material in the orifice
- $H_o$  = Enthalpy at the orifice
- $H_i$  = Enthalpy at initial storage conditions

The discharge parameters passed forward to the dispersion model are as follows:

- release height (m) and orientation;
- thermodynamic data: release temperature (single phase) (oC) or liquid mass fraction (two-phase), initial drop size (m);
- other data:
  - for instantaneous release: mass of released material (kg), expansion energy (J)
  - for continuous release: release angle (degrees), rate of release (kg/s), release velocity (m/s), release duration (s).

## Dispersion

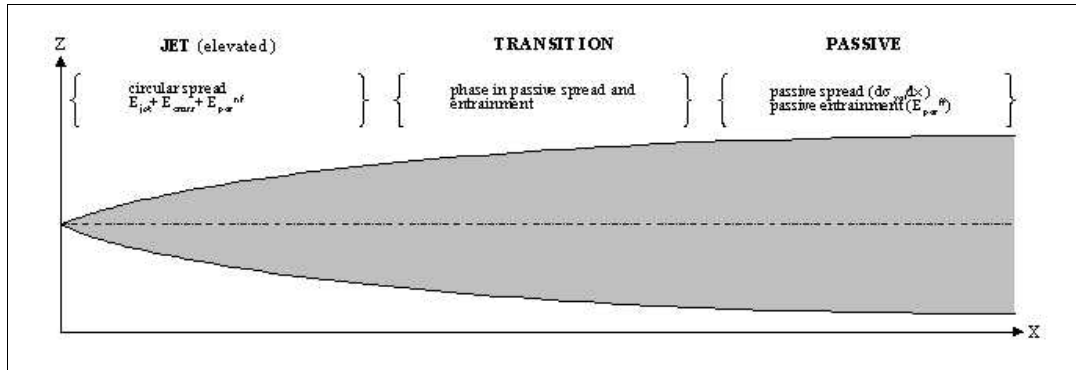
When a vapour leak occurs, some material will be released into the atmosphere. Upon being released it will start to disperse and dilute into the surrounding atmosphere. The limiting (lowest) concentration of interest is related to flammable and toxic limits for flammable and toxic substances respectively. The model used to determine extent of release is described below, along with some of the key input parameters.

The consequence modelling package PHAST utilises the Unified Dispersion Model (Witlox *et al*, 1999). This models the dispersion following a ground level or elevated two phase unpressurised or pressurised release. It allows for continuous, instantaneous, constant finite duration and general time varying releases. It includes a unified model for jet, heavy and passive two phase dispersion including possible droplet rain out, pool spreading and re-evaporation. SAFETI is built on the base models in PHAST.

## Jet Dispersion

For a continuous, pressurised release, a vapour is released as a jet, ie, high momentum release. The jet eventually loses momentum and disperses as a passive cloud. Figure 32 below shows a typical release and the various phases involved.

Figure 32 Jet Dispersion



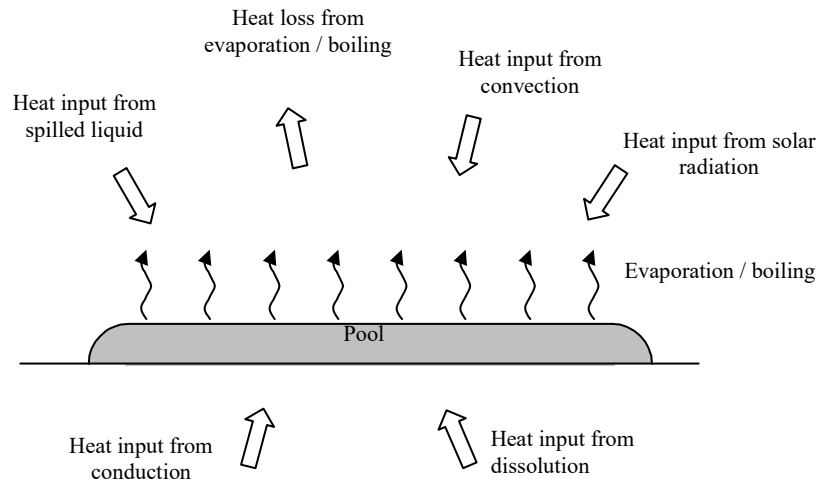
The cloud is diluted by air entrainment until it eventually reaches the lower limit of concern. During the jet phase, the mixing is turbulent and much air is entrained. In the passive phase, less air is potentially entrained, and it occurs via a different mechanism to the turbulent jet phase. The calculation of the plume therefore depends on many factors, the key parameters being:

- Vapour released, specifically molecular weight;
- Discharge conditions including phase(s) of release, velocity etc;
- Atmospheric conditions (a cloud will generally travel further in more stable conditions with lower wind speeds).

## Dispersion from Pool Evaporation

If a rupture occurs from a tank or vessel containing a liquefied gas, the liquefied gas pools on the ground whilst rapid vaporisation occurs forming a vapour cloud, which ultimately disperses, as a low momentum cloud. Due to the low momentum, the cloud is not turbulent, which is a significant factor in air entrainment and dilution of the cloud. Figure 33 below shows a typical release and some of the inputs into the calculation.

**Figure 33 Pool Evaporation Heat Balance**



The rate of the evaporation depends on numerous factors, the most important ones being:

- Surface it is released onto (e.g. its thermal properties and temperature);
- Atmospheric conditions (a cloud will generally travel further in more stable conditions with lower wind speeds).
- Boiling point of the liquid;
- Pool size.

The concentration of interest is normally related to the flammable, or toxic limits or specified Emergency Response Planning Guideline (ERPGs) limits set for the contained hazardous material. .

## Flammable Effects

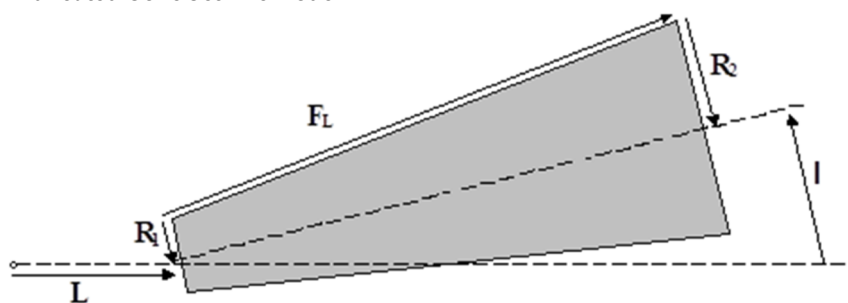
If the release is of a flammable material, it is possible for the release to be ignited. The type of fire which results (eg jet, pool fire, flash fire etc) depends on the physical properties of the release and whether the ignition is immediate or delayed. This chapter discusses the various flammable effects, which can occur.

### Jet Fire

Jet fires are a result of high momentum releases. If a flammable release is ignited instantaneously, a jet fire will result. The flame will have a degree of 'lift off' as the flammable mixture has to dilute to be within the flammable limits. This section briefly discusses the model used for jet fires as well as key parameters in the calculation.

The jet fire calculation utilises the Chamberlain model (Chamberlain 1987). In this model, jet fires are modelled as a conical flame, with the ignited portion lift off, inclination and shape being determined by the material being released, the pressure at which it is being released and the hole size that it is being released through. These release parameters are the main inputs to the jet fire radiation calculations. Figure 34 below shows a graphical representation of the jet fire model.

Figure 34 Truncated Cone Jet Fire Model



Where;

- L = Lift off
- I = Flame Inclination
- R<sub>1</sub> = Flame Base Radius
- R<sub>2</sub> = Flame End Radius
- F<sub>L</sub> = Flame Length

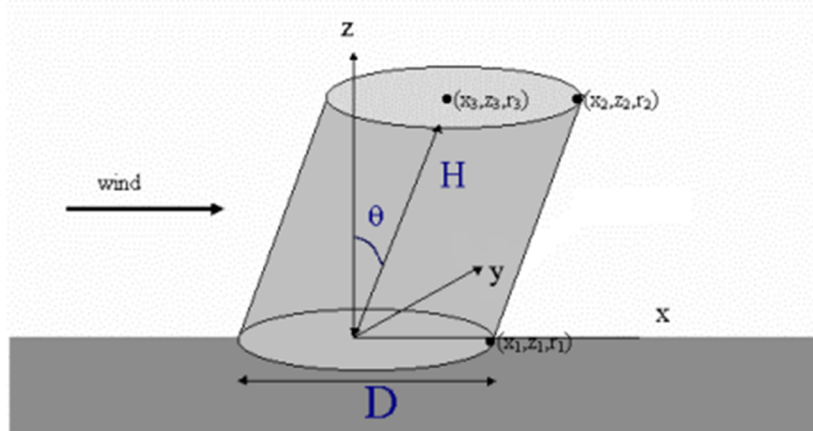
The jet fire calculations model radiation from the entire surface of the ignited portion of the jet. This includes radiation from the cone forming the body of the flame, as well as from the ends of the cone. The amount of radiation that a nearby receiver is exposed to is determined by its distance from the flame surface, as well as by the orientation of the flame relative to the receiver. The key parameters in the calculation of the radiation exposure of a receiver are therefore the flame lift off, the flame inclination, and the dimensions of the ignited portion of the jet (i.e. flame length and end radii).

### Pool Fire

If a flammable/combustible liquid spill ignites it will form a pool fire. Pools can also form if a pressurised liquid is released and then 'rains out' to form a pool. Pool fires have low momentum flames and therefore their direction is dependent on wind conditions. This section describes the pool fire model and the equations used in calculating size and radiation emitted from a pool fire.

Pool fire flames are modelled as cylinders sheared in the direction of the wind, with diameter  $D$ , height  $H$  and tilt angle  $q$  (measured from the vertical). The flame is described by three circles ( $c_1, c_2, c_3$ ) arranged along the centreline of the flame, each defined by the downwind co-ordinate  $x$  and elevation  $z$  of the centre of the circle, and by the radius  $r$ . These flame-circle co-ordinates are the main input to the radiation calculations. Figure 35 below shows a graphical representation of the pool fire model.

Figure 35 'Sheared Cylinder' Pool Fire Model



With these three circles, the radiation calculations will model radiation from two surfaces: from the side of the flame between c1 and c2, and from the top of the flame between c2 and c3. This approach ensures that the bottom of the pool fire is not treated as a radiating surface.

The flame length H, flame diameter D and tilt angle  $\theta$  are used to calculate three co-ordinates of the flame, as follows:

$x_1 = 0.0$	$x_2 = H \sin \theta$	$x_3 = H \sin \theta$
$z_1 = d_{elev}$	$z_2 = H \cos \theta + d_{elev}$	$z_3 = H \cos \theta + d_{elev}$
$r_1 = D/2$	$r_2 = D/2$	$r_3 = 0.0$

Where:

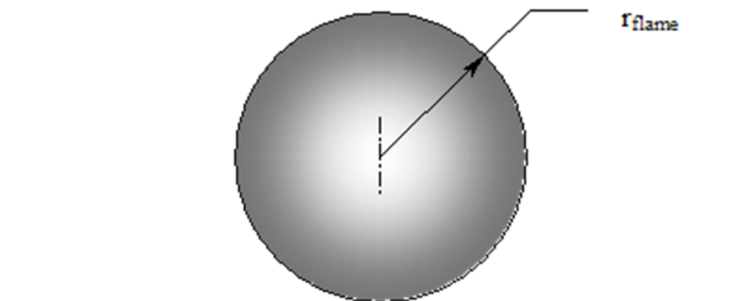
$d_{elev}$  = elevation of flame surface above ground.

### BLEVE Model

A BLEVE is a 'Boiling Liquid Expanding Vapour Explosion' and refers to the release of energy when a vessel of liquefied gas erupts due to flame impingement. If there is direct flame impingement beneath the liquid line on the vessel, the evaporating liquid will provide cooling to the vessel walls. If designed correctly, the vessel pressure relief ensures that the pressure inside the vessel does not rise above design limits. If the flame impingement is on the vapour space, the pressure will also increase but there is inadequate cooling of the vessel wall. The metal temperature will rise to an extent where the mechanical strength is reduced. A point will be reached where the mechanical integrity of the vessel is insufficient for the pressure inside the vessel and the vessel erupts in a BLEVE. The BLEVE itself is the explosion resulting from rapid evaporation of the liquefied gas as it is released to atmospheric pressure. This section describes the equations used to determine BLEVE properties and key input parameters.

BLEVEs are modelled as spheres as shown in Figure 36, with the shape described by ten circles. The method of using circles is also used for pool and jet fires. These circles are equally spaced along the flame diameter. Each circle is defined by the elevation z of the centre of the circle and the radius r. The centre of the fireball is located immediately above the point of release, at a height equal to the radius of the fireball.

Figure 36 BLEVE Model



The radius of the BLEVE is calculated from:

$$r_{flame} = 2.9M_{BLEVE}^{\frac{1}{3}}$$

Where  $M_{BLEVE}$  is the flammable mass involved in the BLEVE. This is a function of the total mass released and the vapour fraction.

The duration of the BLEVE is important as it gives the time for which personnel are exposed to the effects of the fireball. It is a function of the BLEVE mass, and is given by the equations below:

$$t_{flame} = \begin{cases} 0.45M_{BLEVE}^{\frac{1}{3}}, & M_{BLEVE} < 37000kg \\ 2.59M_{BLEVE}^{\frac{1}{6}}, & M_{BLEVE} \geq 37000kg \end{cases}$$

The amount of radiation that a person receives is dependent not only on the duration of exposure but also on their distance from the fireball and the heat emitted by the fireball. The emissive power of the flame surface is a function of  $M_{BLEVE}$ , heat of combustion of the material and fire ball size and duration.

### Multi Energy Explosion Model

The Multi Energy Model gives overpressure of an explosion as a function of distance from the explosion. The explosion is modelled as a sphere and overpressure is calculated based on scaled distance from the centre. This section explains the key parameters involved in the multi energy model.

The energy released by the explosion, E, is calculated as the product of the mass of fuel in the cloud and the heat of combustion. This assumes a stoichiometric mixture of fuel and air.

The distance scaling factor, S, is related to the energy released by the explosion and the atmospheric pressure by

$$S = \left[ \frac{E}{P_a} \right]^{\frac{1}{3}}$$

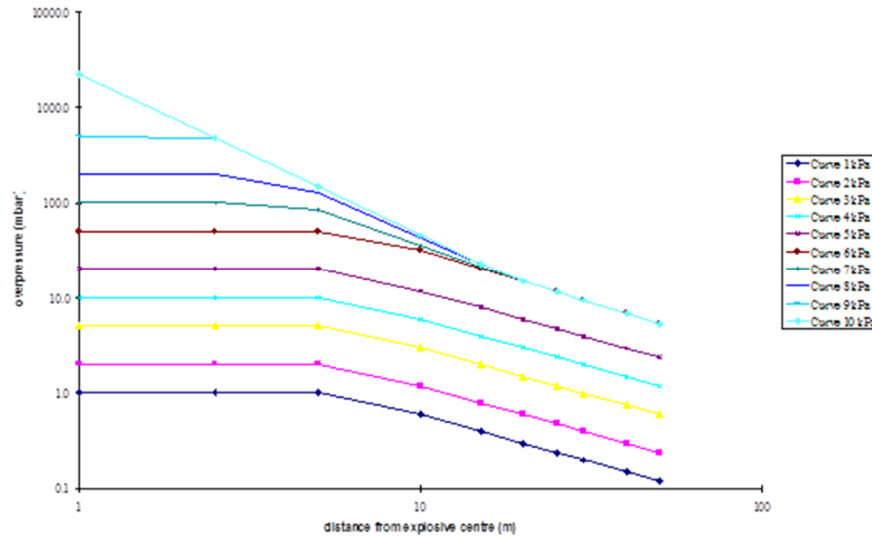
The scaled distance r is then given by

$$r = \frac{d}{S}$$

where d is the actual distance of the receiver from the cloud centre.

To calculate overpressure a set of 10 curves is used. The actual curve used depends on the degree of confinement, with a confinement of 1 being least confined and 10 most confined. Process plants generally have a confinement factor of 7, though it needs to be assessed for each individual process. The graph showing the 10 curves is included in Figure 37 below.

Figure 37 Multi Energy Curves



**Validation and Verification**

Verification and validation of consequence models for accidental releases of toxic or flammable chemicals to the atmosphere

The UDM is an enhanced model used to predict gas dispersion patterns. It now considers time-varying effects due to pressure drops in vessels or pipes and rainout from pools. Specifically designed for heavy-gas low-momentum releases at low wind speeds. Figure C.1 showcases an improved model for predicting gas dispersion rested against the HEGADAS-FT model for elevated releases from pipelines and rainout cases. Figure C.2 showcases validation against the Kit Fox experiments (20-second releases of CO2 from a ground-level area source during both neutral and stable conditions).

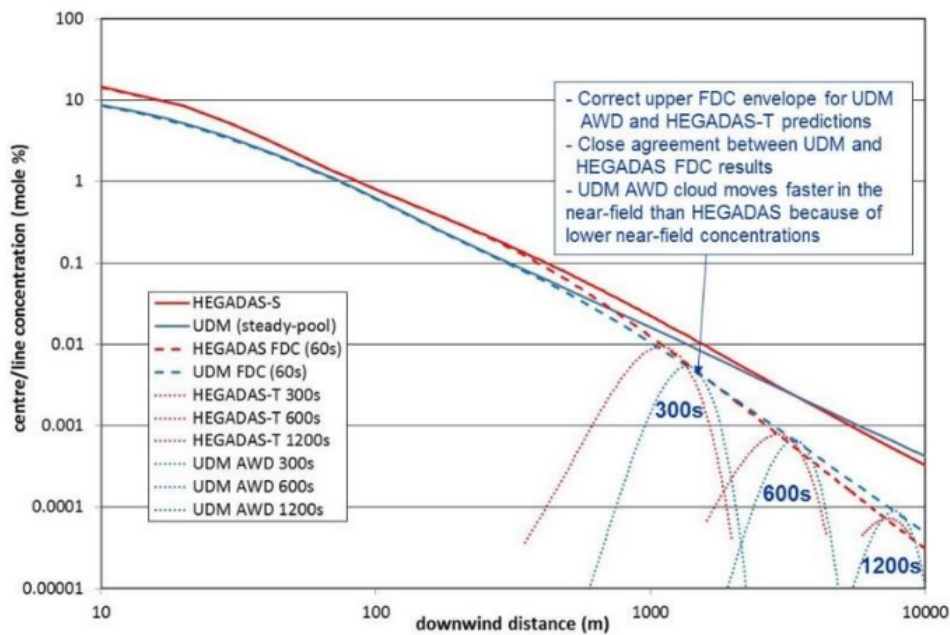


Figure 38 UDM Verification against HEGAS for 60s spill of butane (pool on water with bund radius 10m: dispersion over land) – (Witlox et al., 2015)

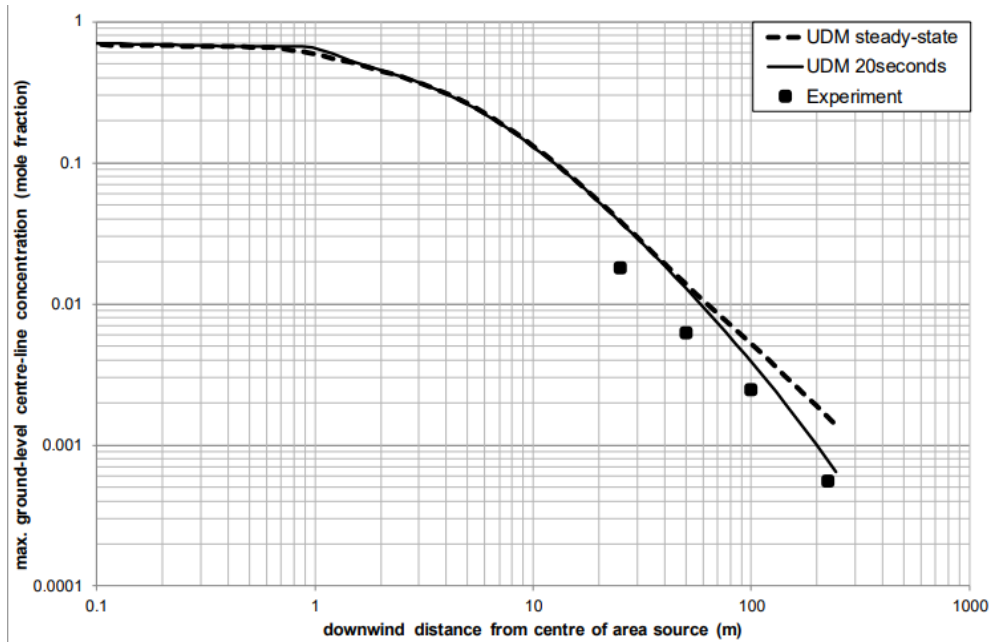


Figure 39 UDM Validation for Kit Fox experiment KF0706 (20 second release) (Witlox and Harper, 2014)

### Validation of obstructed region explosion model

BFETS2 was conducted by the Steel Construction institute for 1d vapour cloud explosions and BFETS3a was a follow-on project carried out by British Gas to investigate gas explosions. Figure C.3 compares the predicted side-on overpressures of ME and BST against the measurements. The BST model with a given correction factor of 2 has significantly under predicted when compare with the ME predictions.

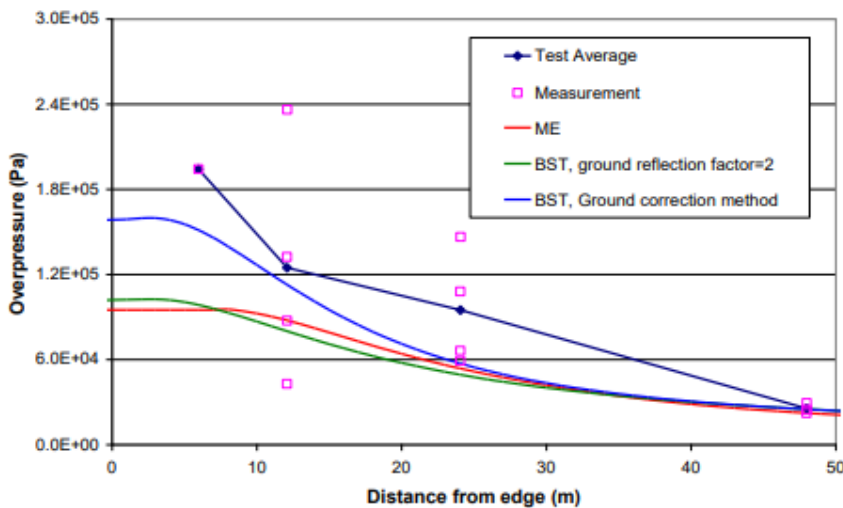


Figure 40 Plot of BGET3a\_A, 2D, high congestion, methane tests: measured, ME and BST predicted overpressures as a function of distance (Fitzgerald, 2021)

## Appendix C. Fire Flow Modelling – Pressure and Flow

### Model 1 - Fire service

Fire flow model developed that Tap in team can use and produce the formal results if that is required. The fire flow model is generally based on existing current assets. However, as this is for AWRC assessment, some assets to reflect 2024 condition have been included. Below are some indicative results, showing that the flow and pressure demand can be met.

AWRC is located within Cecil Park Reduced 1 pressure zone (WK0017). Pressure setting at this PRV will have impact to the pressure at AWRC. The results are based on the best available information and subject to change.

Fire Flow residual pressure at AWRC site (elevation = 41.8 m)

95% Percentile Flow			Peak Flow			Minimum Flow		
	Hydrant Fire Flow (l/s)	Hydrant Residual Pressure (m)		Hydrant Fire Flow (l/s)	Hydrant Residual Pressure (m)		Hydrant Fire Flow (l/s)	Hydrant Residual Pressure (m)
	0.00	89.90		0.00	89.53		0.00	84.43
	0.11	89.78		0.12	89.54		0.11	84.62
	1.00	89.34		0.66	89.35		1.00	84.88
	5.00	88.90		5.00	88.25		5.00	85.08
	10.00	88.66		10.00	88.14		10.00	85.16
	15.00	88.25		15.00	87.73		15.00	84.59
	20.00	87.85		20.00	87.26		20.00	84.57
	30.00	86.76		30.00	86.18		30.00	83.60
	40.00	85.57		40.00	84.84		40.00	82.98
	50.00	83.63		50.00	83.19		50.00	81.60
	56.00	82.69		56.00	81.67		56.00	80.79
	60.00	81.79		60.00	81.01		60.00	79.85
	80.00	77.75		80.00	77.05		80.00	75.80

### Model 2 - Operations (domestic/industrial service)

The model was run for different planning horizons to check pressure for 55.75 L/sec. The results at AWRC site (elevation = 41.8 m) are as follows:

- 2023/2024 = 81.6 m pressure
- 2026 = 70.4 m pressure
- 2036 = 75.7 m pressure

Please note that these pressure assessments are based on based available information and based on the assumption that the future assets will be available.

## Appendix D. Material Interactions – Chemical storage and dosing building

	CARBON DIOXIDE							
SODIUM HYDROXIDE SOLUTION	<b>Incompatible</b> ■ Corrosive Generates heat	SODIUM HYDROXIDE SOLUTION						
SULFURIC ACID	<b>Incompatible</b> ■ Explosive Generates gas Generates heat Toxic	<b>Incompatible</b> ■ Corrosive Generates gas Generates heat Intense or explosive reaction Toxic	SULFURIC ACID					
FERRIC CHLORIDE, SOLUTION	<b>Caution</b> ■ Corrosive Generates heat	<b>Incompatible</b> ■ Corrosive Generates gas Generates heat Intense or explosive reaction Toxic	<b>Incompatible</b> ■ Corrosive Explosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	FERRIC CHLORIDE, SOLUTION				
SODIUM HYPOCHLORITE	<b>Incompatible</b> ■ Corrosive Generates gas Generates heat Intense or explosive reaction Toxic	<b>Incompatible</b> ■ Corrosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	<b>Incompatible</b> ■ Corrosive Explosive Generates gas Generates heat Intense or explosive reaction Toxic	<b>Incompatible</b> ■ Corrosive Explosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	SODIUM HYPOCHLORITE			
SODIUM BISULFITE SOLUTION	<b>Incompatible</b> ■ Corrosive Generates gas Generates heat Toxic	<b>Caution</b> ■ Corrosive Generates gas Generates heat Toxic	<b>Incompatible</b> ■ Corrosive Generates gas Generates heat Toxic	<b>Incompatible</b> ■ Corrosive Generates gas Generates heat Toxic	<b>Incompatible</b> ■ Corrosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	SODIUM BISULFITE SOLUTION		
AMMONIUM HYDROXIDE	<b>Caution</b> ■ Corrosive Generates heat	<b>Caution</b> ■ Corrosive Generates gas Generates heat Toxic	<b>Incompatible</b> ■ Corrosive Generates gas Generates heat Intense or explosive reaction Toxic	<b>Incompatible</b> ■ Corrosive Generates gas Generates heat Intense or explosive reaction	<b>Incompatible</b> ■ Corrosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	<b>Caution</b> ■ Generates heat	AMMONIUM HYDROXIDE	
CITRIC ACID	<b>Compatible</b> ■	<b>Incompatible</b> ■ Corrosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	<b>Incompatible</b> ■ Explosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	<b>Incompatible</b> ■ Flammable Generates gas Generates heat Toxic	<b>Incompatible</b> ■ Corrosive Explosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	<b>Caution</b> ■ Generates gas Generates heat Toxic	<b>Caution</b> ■ Generates gas Generates heat	CITRIC ACID
SUCROSE	<b>Compatible</b> ■	<b>Incompatible</b> ■ Flammable Generates gas Generates heat	<b>Incompatible</b> ■ Explosive Flammable Generates gas Intense or explosive reaction Toxic	<b>Caution</b> ■ Generates heat	<b>Incompatible</b> ■ Corrosive Explosive Flammable Generates gas Generates heat Intense or explosive reaction Toxic	<b>Compatible</b> ■	<b>Compatible</b> ■	<b>Caution</b> ■ Flammable Generates gas Generates heat Intense or explosive reaction

## **Appendix E. Implementation Program**

In accordance with HIPAP2 Section 3.3 an implementation program describing how the recommendations as detailed in the executive summary will be achieved is detailed in the tables below. It is to be noted, that the design requirements are expected to be implemented prior to construction while the relevant parties responsible for operations and maintenance will comply with operational obligations once the site is active.

**Table 36** *Biogas holders' prevention and mitigation measures*

Parameter	Prevention and Mitigation Measures	Implementations
Gas fittings, piping, and valves	All gas piping's and fittings shall be designed and installed in accordance with <i>AS/NZS 5601</i> The relief devices shall be designed and installed in accordance with <i>AS 1271—2003</i>	The relevant sections of <i>AS/NZS 5601</i> and <i>AS 4041</i> will be complied with for pipes, fittings and valves.
Electrical equipment	All electrical equipment used for operations and monitoring for the digester within the hazardous area zone, is required to comply with <i>AS/NZS 60079.14</i> . Electrical bonding and earthing of isolated equipment will be required in accordance with <i>AS/NZS 1020</i> in hazardous areas.	The adjacent standards are part of the design and are identified in the Hazardous Area Classification report (GHD & Jacobs, 2023)
Methane detection	A methane detector (indicated in Figure 20) is provided downstream of the biogas holders. The detector will be exposed to clean air. In the event of membrane failure, the instrument shall be checked and re-calibrated. <ul style="list-style-type: none"> <li>– The detector will be configured to a threshold of 20% LFL (Lower Flammability Limit).</li> <li>– An uninterrupted power supply (UPS) is provided for all critical safety elements including the methane detector and programmable logic controller (PLC).</li> </ul>	<ul style="list-style-type: none"> <li>– The methane gas detector will be fitted as described. The %LEL will be adjustable in the plant SCADA system and might be set at an even lower threshold if the gas membrane vendor recommends it.</li> <li>– A UPS to all critical safety elements within the digester has been confirmed with the electrical designers.</li> </ul>
Minimising ignition sources	<ul style="list-style-type: none"> <li>– Duty and standby fans that are used to inflate the outer membrane are recommended to be designed to prevent frictional sparking risks</li> <li>– Flame arrestors will be installed in various locations across the digester (detailed in Figure 23)</li> <li>– Lightning protection to be available in this area (detailed in Figure 24)</li> </ul>	<p>Duty and standby fans will be provided for each digester. The fan on each digester will be connected to a separate power supply bus to minimise the chance of power failure to both fans simultaneously. The fans will be ATEX rated for usage in above ground applications (equip. grp. II), category 2 (zone 1) gaseous environments.</p> <p>Each fan is fitted with a discharge non-return valve to prevent backflow into the fan housing whilst it is not operating or has faulted.</p> <p>A flame arrester will be provided on the gas membrane air outlet line for each digester in the unlikely event that there is some methane gas in the discharge due to inner membrane damage.</p> <ul style="list-style-type: none"> <li>– Lightning protection has been designed for the digester (detailed in Figure 24)</li> </ul>
Excess digester gas	<ul style="list-style-type: none"> <li>– Surplus methane produced in the digester shall be combusted and not accumulated.</li> </ul> <p>The waste gas burner shall operate when the level or pressure in the gas holder reaches the set point from the transmitter.</p> <p>Supervisory Control and Data Acquisition (SCADA) is recommended to monitor gas levels in the digester and control the amount of gas flared</p>	<ul style="list-style-type: none"> <li>– Surplus methane to any hot water heating needs will be flared in one of the waste gas burners. Normally there will be insufficient gas production to meet hot water heating needs anyway.</li> </ul>

Parameter	Prevention and Mitigation Measures	Implementations
		The SCADA system will continuously monitor the gas levels and pressures in both digesters and will instigate flaring of gas, if necessary, to stay within the safe operating parameters for the digester gas membrane system.
Operational procedures	Procedures shall be developed to include the required steps to prevent and monitor a tear in the inner membrane during different stages of the digester - commissioning, maintenance and operation. Procedures shall reflect the requirement to maintain sufficient gas in the digester headspace to keep the membrane at least 20% above “empty level” during operation.	<ul style="list-style-type: none"> <li>The inner membrane catcher system is designed to hold the full membrane operating pressure of 2 kPa without damaging the membrane itself. Under normal operation the inner gas membrane will be kept within a nominal operating range of 20% to 80% of its storage capacity and not come to rest on the catcher.</li> </ul> <p>Should a tear in the inner membrane ever occur, it will be detected by the on-line methane analyser on the air space outlet line. Operational procedures will be developed to determine the appropriate course of action in the event of a low level leak versus a much larger leak, measured as percentage of LEL.</p>
Maintenance procedure	A maintenance procedure shall be developed and implemented as per the suppliers’ recommendations to ensure fittings and the associated pipework is appropriately maintained.	Maintenance procedures regarding the fittings and pipeworks will be developed by the parties involved in operations, and will be implemented once the site is operational.
Bushfires	It is recommended that a bushfire management plan be developed and implemented to reduce the total flammable gas stored or produced in the digester.	A Bushfire Management Plan is in the process of being developed.
First aid fire fighting	Hydrant coverage will be provided to the digester, and fire extinguishers will be provided to areas surrounding the digester pipework at ground level	Hydrant coverage has been provided to the digester as showcased in the final hydrant layout design (see Figure 27) The installation and maintenance of fire extinguishers at the base of the digester shall be incorporated into the operational responsibilities of the site.

**Table 37 Gas flare prevention and mitigation measures**

Parameter	Prevention and Mitigation Measures	Implementations
Gas piping and fittings and valves	<ul style="list-style-type: none"> <li>Appropriate standards for gas piping and fittings shall be used (AS 4041 and Section 2 of AS/NZS 5601).</li> </ul> <p>Safety shut off valve system shall exhibit minimum requirements as stipulated by AS 3814-2018. This being that two valves in series are required with the valves to be class 1 automatic valves.</p>	<p>The relevant sections of AS/NZS 5601 and AS 4041 will be complied with for pipes, fittings and valves.</p> <ul style="list-style-type: none"> <li>The gas flare skid will have two automatic shut-off valves in series to control and isolate the gas flow to the skid. The valves will be pneumatically actuated, fail-closed valves with pressurised air supplied from a dedicated local air receiver.</li> </ul>

Parameter	Prevention and Mitigation Measures	Implementations
Burners	<ul style="list-style-type: none"> <li>Flame detector shall be installed for both the main burner and pilot burner may require a detector.</li> </ul> <p>A pilot turndown test is required to be completed at a period defined by the supplier.</p>	<p>The gas pilot will run continuously and will be fitted with a thermocouple to monitor its operation. The main burner flame will also be fitted with a thermocouple device. These are represented by TTB6614 and TTA6614 respectively on the P&amp;ID for waste gas burner 1.</p> <ul style="list-style-type: none"> <li>If a pilot turndown test is proposed as part of the flare commissioning it is expected to be captured in operational procedures.</li> </ul>
Operating system	<p>Flame Safeguard System or Burner Management System shall be designed and installed in accordance with AS 3814 -2018.</p> <ul style="list-style-type: none"> <li>The Flame Safeguard System or Burner Management System shall also be calibrated to a flame failure response time of 3 seconds.</li> </ul> <p>An interlock system to shut off the bio gas fuel supply separate to the flame safeguard system or burner management system is recommended</p>	<p>The gas flare will incorporate a Burner Management System in accordance with Sydney Water's technical requirements and AS 3418.</p>
Lock out systems	<p>Flare operation dependent on flow shall be fitted with lockout features to activate when:</p> <ul style="list-style-type: none"> <li>The device is not confirmed to be in a "no flow" state before ignition.</li> <li>Loss of flow occurs during operation.</li> </ul>	<ul style="list-style-type: none"> <li>The gas flare is intended to be locked out if it faults, thus requiring operator intervention to reset it. The specifics of this will need to be confirmed with the gas flare vendor.</li> </ul> <p>Operational procedures regarding lock outs on systems are expected to be compiled by the relevant parties responsible for the operation of the facility.</p>
Operational procedures	<p>Operational procedures for reignition attempts after flame failure shall conform to Section 3.5.5 <i>Automatic reignition attempt on flame failure of AS 3814 -2018</i></p>	<p>The vendor manual states that pilot system will attempt a number of re-ignition sequences (nominally 10 re-starts with 15 minute time limit) before the pilot system is faulted and the flare is shut down.</p> <p>Operational procedures regarding procedures for reignition after flame failure is expected to be compiled by the relevant parties responsible for the operation of the facility.</p>

**Table 38** *Fire Services requirements*

Parameter	Fire Services Requirements	Implementation
Fire Water Supply and Demand	<p>Total fire water demand for the site is 288,000 L. There are no additional fire water demand from the special fire hazard scenarios assessed.</p>	<p>The fire water supply and demand calculations are detailed in Section 6.1</p>

Parameter	Fire Services Requirements	Implementation
Fire Water Supply	The primary fire-fighting water supply to the site is currently proposed to be provided by the town's ring main.	The primary firefighting water supply is via a hydrant ring main that has been included in the final design (see Figure 27).
Bushfire Firefighting Water	Bushfire fire water is not included in the overall water requirement of the site as they are a separate consideration. Please see bushfire assessment report for further details (Reference No: AWRC-DJV-RPT-GEN-0501-0019, Revision 01, dated 28 July 2023)	Not applicable to this FSS
Stormwater System	The proposed stormwater drainage system for the site has been designed to capture a 1 in 20 year rainfall event. This equates to a capacity of approximately 489 kL. Therefore, the design is capable of capturing the full 288,000 L of potentially contaminated fire water run off as a result of the fire hydrants operating on site, inclusive of standard rain events.	As mentioned, the drainage system has been designed to capture 489 kL of water. The drainage system includes a first flush tank and drainage network. As such, the design is capable of capturing all 288,000 L of potentially contaminated fire water.
First Aid Protection	First aid protection primarily comprises of fire hose reels and fire extinguishers as summarised in Section 6.3. No additional requirements for special hazard scenarios.	Fire hose reels and fire extinguishers have been designed in each building in accordance to AS 2444:2001 and AS 2441-2005, with fire hose reels documented in every building over 500 m <sup>2</sup> and portable fire extinguishers in every building.

## Appendix F. HIPAP 2 Supporting documentation

Section 3.15 of HIPAP 2 details the supporting documentation that is recommended to be provided and included as an appendix to support the content of the FSS. The listed documents have been tabulated below, with the relevant documents being included in this Appendix.

**Table 39**      **HIPAP 2 documentation**

Documentation	Inclusion
Local water authority/Water Board water pressure form	A fire flow model conducted by Sydney Water has been included in Appendix C
Water authority approvals for pumps	There are no dedicated pumps on site to pressurise the water. Therefore this is not applicable to this site.
Water authority services site plan	The area is a greenfield site. A hydrant layout drawing and water supply drawings will be provided in this Appendix.
Subdivision plan;	A subdivision plan has been included in this Appendix
Development plan	General Arrangement site layout plans will be included in this Appendix
Building plans; (indicate fire rated walls, doors and escape routes)	Not included in this FSS as the buildings have been deemed as non-special fire hazards and are not pertinent to this FSS.
Drainage systems drawings	First flush arrangement and effluent discharge arrangement is provided in this Appendix .
Existing and/or proposed fire fighting equipment list and drawings	Fire fighting infrastructure and equipment are limited to hydrants, hydrant booster and FDCIE.  <b>Hydrant booster: Shown in</b> Figure 28 FDCIE: Shown in Figure 10 Hydrant layout: Shown in Figure 27 and included in this Appendix Road design drawings for firefighting access: included in this Appendix
Sprinkler/drencher system layouts	Not applicable to this site
CO2, flood systems layouts	Not applicable to this site
Proposed fire protection layouts	A hydrant layout drawing will be provided in this Appendix.
Hydraulic calculations	Hydraulic calculations have been completed throughout Section 6.
Fire protection/fighting equipment. type, design and specifications	Fire protection equipment, type and design specifications have been provided in Section 6.3.
Drawings referred to in text	All completed P&ID's regarding the digester and gas flare will be provided in this Appendix
Reference list	Refer to Section 8

## Appendix G. Revision 03 updates

A revision (Rev02) of this Fire Safety Study was submitted to FRNSW after comments from FRNSW had been addressed. On 4 April 2024 FRNSW stated that the FSS had been prepared to be satisfaction of FRNSW. (File Ref FRN21/3162 BFS24/1746 8000034500). Figure 41 is the cover page of the letter.

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File Ref. No: FRN21/3162 BFS24/1746 8000034500  
TRIM Doc. No: D24/39093  
Contact: Station Officer Luke Loseby

4 April 2024

MARK COONEY  
GHD Pty Ltd  
133 Castlereagh Street  
SYDNEY NSW 2000

Dear Mark,

**Re: Review of Fire Safety Study (FSS) - UPPER SOUTH CREEK – ADVANCED WATER RECYCLING CENTRE**

Fire and Rescue NSW (FRNSW) acknowledge correspondence received on 26 March 2024 requesting review of the submitted FSS (Document no. AWRC-DJV-RPT-HSE-0501-0002 dated: 26 March 2024) for UPPER SOUTH CREEK – ADVANCED WATER RECYCLING CENTRE. FRNSW note the FSS was to be developed to meet the requirements of FRNSW and in accordance with the Hazardous Industry Planning Advisory Paper (HIPAP) No. 2<sup>1</sup>.

FRNSW have reviewed the FSS prepared by GHD Pty Ltd along with other supporting and referenced documents. The current version of the FSS **has been prepared to the satisfaction of FRNSW.**

For further information please contact the Operational Liaison and Special Hazards Unit, referencing FRNSW file number BFS24/1746. Please ensure that all correspondence in relation to this matter is submitted electronically to [firesafety@fire.nsw.gov.au](mailto:firesafety@fire.nsw.gov.au).

Yours sincerely,

*8579 Lynden Moyes*

A / Superintendent Lynden Moyes  
Manager  
Operational Liaison and Special Hazards Unit

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[colin.thomson@ghd.com](mailto:colin.thomson@ghd.com)

<sup>1</sup> <https://www.planning.nsw.gov.au/-/media/Files/DPE/Guidelines/fire-safety-study-guidelines-2011-01.pdf?la=en>

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Figure 41 FRNSW cover letter (Rev 02)

Following the approval from FRNSW, comments regarding minor updates to the FSS was provided by Sydney Water and the Process Team. The comments and relevant updates of Revision 03 are captured in Table 40. The updates to Rev03 of the report do not entail any design changes to the site and do not impact the overall fire safety strategies defined in Revision 02 of this report.

**Table 40** Updates from Rev02 to Rev03

Item number	Section (Rev02)	Comments from Sydney Water and Process Team	Updates to this Revision
1	Table 17	The table states that Biogas will be used for cogeneration	The description of methane in Table 17 has been updated to now state "used for digester heating".
2	Table 17	The table states that Sulphuric acid, Biocide, Sodium Hypo, Bisulphite exceeds "Threshold" which they don't.	<p>It was found that Table 17 has incorrect thresholds or values for:</p> <ul style="list-style-type: none"> <li>– Ferric Chloride: updated to 130 t from 65 t</li> <li>– Sodium Hypochlorite: updated to 71 t from 36 t</li> <li>– Phosphoric Acid: no longer used in the process and was removed.</li> <li>– Ammonium Hydroxide: Added to Table 17</li> </ul> <p>In addition, Appendix D was updated to include the missing Dangerous Goods.</p> <p>Figure 5 was also updated to reflect these changes.</p>
3	Table 17	Not all Chemicals have been captured in this report; example: Citric Acid is missing	Citric acid was not included in Table 17 as it is not a Dangerous Good
4	Table 17	The Table is missing use of Sodium Hypo for MBR CIP	The description of Sodium Hypochlorite has been updated in Table 17 .
5	Table 17	Carbon Dioxide storage location and description has changed	<p>Location has been changed to "adjacent to Chemical Delivery and Storage area" instead of "near the biogas holder and pipework". "Alkalinity addition" has also been added to the description of Carbon Dioxide.</p> <p>Figure 5 was also updated to reflect these changes.</p>
6	Table 17	BIOMATE MBC location has updated	BIOMATE location has changed from the Chemical Delivery and Storage area to RO CIP area. Table 17 and Figure 5 was also updated to reflect these changes.
6	Table 18	"Spill Kit" has been identified as a means of managing Biogas leak	Table 18 has been updated to remove "spill kits" within the line item of methane release.
7	Table 18 Section 3.3.5	"Spill Kit", "Pressure Relief Valves" and "Burning excess Gas" have been identified as a means of safeguarding explosive gas mixture formation in "inlet works" area under odour covers	<p>"Spill Kit", "Pressure Relief Valves" and "Burning excess Gas" has been removed from Table 18 under line items referring to odour covers at inlet works and inlet works foul air ducts, fans, filters and exhaust stacks</p> <p>In addition "Spill kit" has been removed from Section 3.3.5</p>
8	Table 18	Burning excess gas" has been identified as a means of safeguarding RDTs against formed explosive gas	"Burning excess gas" has been removed from Table 18 under line item
9	Table 18	Report is missing to provide all incompatibility chemicals; example of a miss: Hypo and Citric Acid	<p>Table 18 has been updated under production of hazardous materials from the interaction of materials to mention the following safeguards against chlorine gas formation from the interaction of citric acid and hypochlorite:</p> <ul style="list-style-type: none"> <li>– Interlocks to prevent dosing incompatible chemicals simultaneously</li> <li>– Alarming of leak detection in common pipework dosing locations</li> </ul> <p>In addition, Appendix D already included the incompatibility of Citric Acid with Sodium Hypochlorite in the previous revisions.</p>

## Appendix H. Revision 04 updates

Following the minor comments addressed in Table 40, additional comments have been provided by Sydney Water. The updates to Rev04 of the report do not entail any design changes to the site and do not impact the overall fire safety strategies defined in Revision 02 and 03 of this report. The changes from Rev03 to Rev04 have been consolidated in Table 41.

**Table 41** Updates from Rev03 to Rev04

Item number	Section (Rev03)	Comments from Sydney Water and Process Team	Updates to this Revision
1	Table 17	Please fix as per markup. Only Sodium Hydroxide exceeds the threshold (75t>25t). Sulfuric (19t < 25 t) and Biomate (2t <25t) do not exceed the thrashed. This comment also applies to Fire Report	A sentence was added in Revision 04 to clarify this "It should be noted that the SEPP 33 Threshold Quantity considers the combined quantity of chemicals in each DG class and packing group (PG), not the individual chemicals." A new column for the 'Combined Storage Quantity per DG class and PG' was added to Table 17 so it is clear that the thresholds are exceeded due to the combined quantity.
2	Table 18	There is not any "Leak detection" on AWRC design. Please delete the "Leak Detection". This comment also applies to Fire Report	The identified safeguard of leak detection in line 3 has been removed
3	Table 18 Section 3.3.4 and Section 3.3.6	"Spill Kit" is irrelevant to gas release. Please remove the reference to "Spill Kit" This comment also applies to Fire Report	Any HAZID Line item that results in an explosion or gas release has spill kit removed from the identified safeguards In addition, "Spill kit" has been removed from Section 3.3.4 and Section 3.3.6
4	Section 3.3.1	It is sated "Ferric chloride" is used to minimise the hydrogen sulfide concentration in Biogas. I know you have added this as a general statement, but it is misleading and one would think we are talking about AWRC. AWRC does not use any ferric dosing for hydrogen sulfide control. To avoid confusion, please delete. This comment also applies to Fire Report	In Section 3.3.1, the ferric chloride statement 'with ferric chloride being used to minimise the concentration of hydrogen sulphide in the biogas.' was removed
5	Section 2.2 Section 6.1	BCA assessments were based on NCC 2019 Amendment 1, and all the design certificates reference this version of the BCA including the Standards referenced within the document, e.g. AS 2419.1:2005.	References to NCC 2022 were updated to NCC 2019 Amendment 1 and references to AS 2419.1:2021 were updated to AS 2419.1:2005.

## Appendix I. Revision 05 updates

Following minor comments addressed in Table 41, after submission to the Department of Planning (as required under the condition), additional comments have been provided. The updates to Rev05 of the report do not entail any design changes to the site and do not impact the overall fire safety strategies defined in Revision 02, 03 and 04 of this report. The changes from Rev04 to Rev05 have been consolidated in the table below.

**Table 42** Updates from Rev04 to Rev05

Item number	Section (Rev04)	Comments from Department of Planning	Updates to this Revision
1	Table 17	<p>The Department refers to the Fire Safety Study (FSS) which was submitted in accordance with Condition E135(b) of Schedule 3, Part E of the development consent for Upper South Creek Advanced Water Recycling Centre (SSI-8609189) as modified.</p> <p>The Department has reviewed the FSS and identified that standby liquefied petroleum gas (LPG) system intended to fuel the biogas flare pilot light (Section 5.2.1). However, there are no details provided regarding the storage of LPG on-site.</p> <p>As such, the Department requests the Applicant provide further information on the following.</p> <ol style="list-style-type: none"> <li>If LPG is stored on-site, the quantity and location should be clearly specified. Additionally, the hazards and risks associated with LPG and any additional firefighting requirements should be assessed as part of the FSS.</li> </ol>	<p>The LPG stored on site is 2 x 45 kg bottles of LPG.</p> <p>The LPG storage location is in the Digester Area, with the location compliant to AS 4332.</p> <p>The purpose of LPG storage is to back up the gas supply to gas the hot water heater, mainly during the plant commissioning period, when biogas production from the digesters will be insufficient to continuously run the gas heater off the biogas</p> <p>Table 17 has been updated to reflect this.</p> <p>See the Final Hazard Analysis for further details.</p> <p>Overall, these bottles do not pose a special fire hazard to the site, and no further updates are required to the FSS.</p>