# Appendix 1

# Assumptions register

## Quantitative Risk Assessment for the Euroa Hydrogen Domestic Project - Gladstone Hydrogen Production

## Appendix 1: Assumptions register

This FEED QRA is based on a number of key technical assumptions, which are summarised in the QRA report for the Euroa $H_2$ Domestic Project. These assumptions relate to the source release and gas dispersion, failure rates, ignition probabilities etc., as well as to modelling assumptions (e.g. release orientations, shielding, effects, etc.).

The key assumptions adopted for the quantitative consequence and risk assessment are provided below.

The assumptions are, as far as possible, supported by:

- Actual operating experience and experimental data in the literature, taking into account the reliability of the sources, and, in particular the size of the item population and the time period of the data collection, and comparing actual operating experience with historical data;
- Advice by QRA modelling software developers (TNO / Gexcon; DNV)
- Similar assumptions made by experts in the field and a general consensus among risk analysts; and
- As a last resort, if no other data is available, engineering judgement of the analyst.

The main objectives are to minimise uncertainty in the risk estimate as far as is possible, and to ensure that the assumptions result in a *conservative best estimate* of hazards risk.

The table below lists the assumption title included in this register by their general subject (or topic).

### List of assumptions by topic

| General topic | Assumption No. | Assumption title |
|---|---|---|
| Design Parameters | 0 | Major design parameters |
| Hazard identification | 1 | Hazard mechanism |
| Locational data | 2 | Ambient conditions (wind speed, stability conditions, wind directions) |
| | 3 | Surface roughness length |
| Consequence modelling | 4 | Release modelling |
| | 5 | Representative hole sizes |
| | 6 | Height of release |
| | 7 | Direction of release / obstruction |
| | 8 | Dispersion |

| General topic | Assumption No. | Assumption title |
|---|---|---|
| | 9 | Heat radiation modelling |
| | 10 | Explosion overpressure modelling |
| | 11 | Determining fraction of cloud involved in explosion |
| Likelihood Analysis | 12 | Failure rate data |
| | 13 | Sources of ignition and flammable outcome |
| | 14 | Probability of ignition |
| | 15 | Reduction factor |

## Design Parameters

### Assumption No. 0 Major Design Parameters

**Subject**: Major Design Parameters

**Assumption:**

- The major design parameter assumptions for the QRA are included in the table below.

Table A1.0: Major design parameter assumptions

| Isolatable section code | Isolatable section, title and colour coding | |
|---|---|---|
| ISOL1A_ELS | Electrolyser Skid (2" pipe) – High Pressure side | 1. Electrolyser skid contains two isolatable sections (Plug document P107828-BEDP-PC-PID-001):<br>• SDVS101 (from WTP) to SDVS-302,303 – consequence assessed separately for HP side (2”, 3”, ¾”) and UPW side (3”)<br>• SDVS-303 to SDVS306, 307, 308 – consequence assessed for LP side (2”)<br>2. Plug assumption of pipework length per electrolyser system:<br>• HP 2" header = 30m per electrolyser system (15m per header x 2)<br>• HP 2" out of HP cathode to SDV = 7m per electrolyser system<br>• HP 3" = 2.5m per electrolyser system<br>• HP ¾” = 21m per electrolyser system (2.1m per stack x 10 stacks)<br>• LP 2” = 25m per electrolyser system<br>• UPW 3" = 55m per electrolyser system<br>3. ISOL1E_ELS conservatively modelled as containing full volume of hydrogen (design of system will be predominantly liquid filled) |
| ISOL1B_ELS | Electrolyser Skid (3" pipe) – High Pressure side | |
| ISOL1C_ELS | Electrolyser Skid (2" pipe) – Low Pressure side | |
| ISOL1D_ELS | Electrolyser Skid (3/4" pipe) | |
| ISOL1E_ELS | Electrolyser Ultrapure Water side (3" pipe) | |
| ISOL1-2_PIP | Electrolyser to purification interunit pipework | 1. UGL assumption of interunit pipework length:<br>• Electrolysers to purification = 62m<br>2. Underground pipework<br>3. Assumed pipeline isolatable from electrolyser outlet to isolation at hydrogen purification inlet |
| ISOL2_GSP | Gas Purifier | 1. UGL assumption of pipework length of 150m within hydrogen purification unit |

| | | |
|---|---|---|
| | | 2. Assumed gas purifier isolatable from inlet and outlet of hydrogen purification unit |
| ISOL2-3_PIP | Purification to compression interunit pipework | 1. UGL assumption of interunit pipework length:<br>• Purification to main compression = 165m<br>2. Underground pipework<br>3. Assumed pipeline isolatable from isolation at purification outlet to isolation at main compression inlet |
| ISOL3_CPI | Compression inlet | 1. Compressor supplier assumption of pipework length of 18m per compressor (stage 1 & 2 suction/discharge, stage 3 suction)<br>2. Assumed main compressor isolatable from inlet and outlet of compressor package<br>3. Only two compressors operating at one time |
| ISOL4_CPO | Compression outlet | 1. Compressor supplier assumption of pipework length of 5m per compressor (stage 3 discharge)<br>2. Assumed main compressor isolatable from inlet and outlet of compressor package<br>3. Only two compressors operating at one time |
| ISOL4-5_PIP | Compression to storage management interunit pipework | 1. UGL assumption of interunit pipework length:<br>• Main compression to storage management package = 90m<br>2. Above ground pipework<br>3. Assumed pipeline isolatable from isolation at main compression outlet to isolation at storage management package inlet |
| ISOL5_SMP | Storage management Package | 1. UGL assumption of pipework length of 20m at storage management package<br>2. Assumed pipeline isolatable from inlet and outlet of storage management package |
| ISOL5-6_PIP | Storage management to dispensing compression interunit pipework | 1. UGL assumption of interunit pipework length:<br>• Storage management package to dispensing compression = 78m<br>2. Above ground pipework<br>3. Assumed pipeline isolatable from isolation at storage management package to isolation at dispensing compression inlet |
| ISOL6_DCI | Dispensing compression inlet | 1.Compressor supplier assumption of pipework length of 7m per dispensing compression<br>2. Assumed dispensing compressor isolatable from inlet and outlet of dispensing compressor package |

| | | |
|---|---|---|
| | | 3. Conservatively assumed four dispensing compressors operating at one time (design of system will have 3 out of 4 operating). |
| ISOL7_DCO | Dispensing compression outlet | 1.Compressor supplier assumption of pipework length of 8m per dispensing compression<br>2. Assumed dispensing compressor isolatable from inlet and outlet of dispensing compressor package<br>3. Conservatively assumed four dispensing compressors operating at one time (design of system will have 3 out of 4 operating). |
| ISOL7-8_PIP | Dispensing compression to dispensing bay interunit pipework | 1. UGL assumption of interunit pipework length:<br>• Dispensing compression to dispensing bay = 105m<br>2. Above ground pipework<br>3. Assumed pipeline isolatable from isolation at dispensing compression outlet to isolation at dispensing inlet |
| ISOL8_DIS | Dispensers | 1. UGL assumption of pipework length of 7.2m per dispenser<br>2. Assumed dispenser isolatable from shutdown valves located on the dispenser pipework |
| ISOL5-9_PIP | Storage management to storage pipework | 1. UGL assumption of interunit pipework length:<br>• Storage management to storage pipework = 91m<br>2. Above ground pipework<br>3. Assumed pipeline isolatable from isolation at storage management package outlet to isolation at each hydrogen storage package |
| ISOL9_STO | Storage | 1. UGL assumption of pipework length of 20m for all interconnecting pipework for hydrogen storage package (x7)<br>2. Assumed each hydrogen storage package is isolatable |
| ISOL10_TUB | Tube trailer inc. loading hose | 1. Pipework from dispensers to the tube trailer loading hoses and loading hoses assumed to be 10m (from available vendor drawings). |

## Hazard identification

| Assumption No. 1 Hazard mechanism |
|---|
| **Subject**: Hazard identification and mechanism |

**Assumption:**

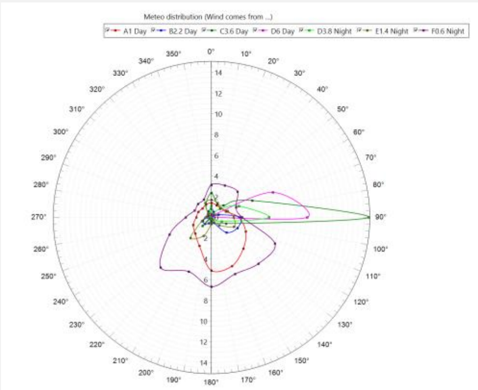
- Hydrogen gas behavior upon release to the atmosphere is taken from Effects® modelling showing dense vapour cloud at the point of release
- As a high reactivity material, the risk of hydrogen exploding or burning is high compared with the standard petroleum gases and liquids (e.g. propane, butane) [TNO, Purple Book]
- Ignition of hydrogen gas at the point of release is possible, in which case the gas would burn as a jet (or torch) flame.
- There is evidence that hydrogen clouds can generate significant overpressures and may even detonate (DNV, 2022) and, while this is contrary to some opinions expressed in the literature, this possibility is included in the present QRA.
- In line with current recommendations for hydrogen risk assessment modelling (several, including DNV 2022), each hydrogen release is taken as resulting in some overpressure, with the Multi-Energy Model (MEM), developed by TNO curve number 5 used as representative of the environment for a hydrogen cloud in a low or medium congestion area. Where there is potential for congested gas accumulation and confined vapour cloud explosion at the area of release (based on LFL contour), an overpressure detonation scenario is modelled using MEM blast strength 10 (see assumption no. 10).
- Hazards associated with of non-ignited compressed gas:
    - Asphyxiation hazard is low compared with flammability hazard for a release of hydrogen. Oxygen deficiency is not believed to constitute a major issue because the flammability limits and fire concerns (for hydrogen) will most likely be the dominant effects. With standard confined space entry procedures and appropriate security arrangements, the risk associated with asphyxiation from hydrogen is not included as a credible safety risk.
    - Locally, the pressure of compressed hydrogen gas may be hazardous in case of an uncontrolled release. This is a hazard for example to maintenance personnel. However, it is not included as a precursor to a credible safety risk associated with the Project within the scope of this study. Pressure hazards, while important to people working at the site, do not have implications beyond the immediate location of the release.
    - Therefore, the risk associated with non-ignited compressed hydrogen gas does not form part of the scope of the present risk assessment.

## Locational data

| Assumption No. 2: Ambient conditions (wind speed, stability conditions, wind directions) |
|---|
| **Subject:** Locational Data |

**Assumptions:**

- Behavior of the gas a distance away from a release, once momentum ceases to dominate release behavior, is dependent on ambient conditions such as wind speed and weather stability
- Dispersion of gas clouds and impacts of thermal radiation is governed by prevalent weather conditions including, wind speed and direction (horizontal mixing) as well as stability of the atmosphere (vertical mixing). The latter is the extent that wind turbulence, responsible for the dispersion, is either suppressed or assisted. On cold windless nights, cold air is trapped close to the surface of the earth and any gas release would not be easily dispersed. In comparison, on a hot summer's day there is increased turbulence of the air due to heating of the earth's surface, this aids the dispersion of gases.
- The meteorological data available in the public domain for Aldoga (Gladstone Region) 2021 hourly meteorological data (located approximately 2km north-west of the site) has been used for the study.
- Atmospheric conditions are summarised in the following Pasquil-Gifford classes:
    - A – Turbulent
    - B – Moderately unstable
    - C – Slightly unstable
    - D – Neutral
    - E – Slightly stable
    - F – Moderately stable
- Pasquil stability categories (A to F) used to define the stability of the atmosphere are used as input into Riskcurves®. The wind rose for Aldoga (Gladstone Region) is provided below:




- A full set of wind spreads and weather conditions can be entered into Riskcurves® to calculate the risk profile. To provide the reader with an overview of the results from the assessment, seven representative wind weather conditions have been defined to represent typical day time and typical night time wind weather conditions:

- Pasquil stability category A at windspeed of 1 m/s (A1), B at windspeed of 2.2 m/s (B2.2), C at windspeed of 3.6 m/s (C3.6), D at windspeed of 6 m/s (D6) is set to represent typical day-time conditions and
- Pasquil stability category D with windspeed of 3.8 m/s (D3.8), E at windspeed of 1.4 m/s (E1.4), F at windspeed of 0.6m/s (F0.6) is set to represent typical night time conditions.

* Relative humidity is set at 60%
* The mean atmospheric pressure: Use default in Effects® of 1.013bar
* Average $CO_2$ in atmosphere: This QRA uses the default in Effects® of 0.03%
* Average ambient temperature (day/night) is set at 25°C.

Assumption No. 3: Surface roughness length

**Subject:** Locational data

**Assumptions:**

- The roughness factor used for all scenarios is described as follows:
  - *High crops, scattered large obstacles*

**Justification of assumptions:**

- Ground roughness effects the turbulent flow properties of wind, hence dispersion of a released material. Terrain effects are taken into account to some degree in dispersion modelling by use of a surface roughness length.
- Effects® requires the user to select a surface roughness length that is representative of the types of terrain and obstacles near the proposed site.
- It is possible to define different surface roughness lengths for different locations (land and water) for different scenarios. It is not possible to define different roughness lengths within a single Effect®-model.
- The roughness length for different surface types, as listed in the Effects® user manual, is shown below in the table below.

Table A1.1: Surface roughness length

| Description | Roughness Length (m) |
|---|---|
| Open water, at least 5 km | 0.0002 |
| Mud flats, snow, no vegetation, no obstacles | 0.005 |
| Open flat terrain, grass, few isolated objects | 0.03 |
| Low crops; occasional large obstacles, x/h > 20 | 0.1 |
| **High crops, scattered large obstacles, 15<x/h<20** | **0.25** |
| Parkland, bushes, numerous obstacles, x/h<15 | 0.5 |
| Regular large obstacle coverage (suburb, forest) | 1 |
| City centre with high- and low-rise buildings | 3 |

| Assumption No. 4: Release Modelling |
| --- |
| **Subject:** Consequence Analysis |

**Assumptions:**

- Effects® is used to model release behaviour for gases released from plant and equipment.
- Effects® is used to model release conditions and outflow rates, gas dispersion, and heat radiation and explosion overpressures from an ignited release
- Riskcurves® is used to combine the consequences and the likelihoods to develop the risk profile for the Project
- Input data includes the type of release, location of release with respect to initial conditions of the fluid (i.e. before release) and atmospheric conditions (i.e. once the release has occurred)
- The release rate is assumed to remain constant until isolation can be achieved and the "representative" release rate, as suggested by Effects® is used
- Escape by people e.g. due to hazard warning, is ignored as per the convention for risk assessments
- Riskcurves® and Effects® are internationally recognised as suitable models for release behaviour of a range of material in a range of conditions.
- Release rate is dependent on pressure, and releases directly from pipeline and vessels are modelled at the operating pressure.
- Assuming the release rate as remaining constant until isolation can be achieved is a simplified approach as Riskcurves® cannot include more than one release rate for the same scenario. It is a conservative approach as in reality there would be pressure reduction and hence reduction in leak rate, but justifiable as exposure to the initial heat or overpressure is likely to cause the representative injury or damage.

**Reference(s):**

- Yellow Book (TNO), Guidelines for Quantitative Risk Assessment, Committee for the Prevention of Disasters, CPR 18E, First Edition, The Hague, 3rd Ed, 2nd print, 2005

| Assumption No. 5: Representative hole sizes |
|---|
| **Subject:** Consequence Analysis |

**Assumption:**

- Representative hole sizes were assumed for each release case in line with the methodology in the HyRAM for hydrogen plant and equipment. The following hole sizes are included in the QRA:
    - Small – Leak area is 0.01 % of total flow area
    - Minor – Leak area is 0.1% of total flow area
    - Medium – Leak area is 1% of total flow area
    - Major – Leak area is 10% of total flow area
    - Rupture – Leak area is 100% of total flow area.
- HyRAM database is used for hydrogen release cases

**References:**

- HyRAM V2.0 User Guide, Sandia National Laboratories operated for the United States Department of Energy by National Technology and Engineering Solutions of Sandia, LLC
- HyRAM computer tool v4.1, 28 April 2022

## Assumption No. 6: Height of release

**Subject:** Consequence Analysis

**Assumptions:**

- All releases from underground interunit pipework are modelled at a release height of 0 m above ground level.
- All releases from aboveground interunit pipework are modelled at a release height of 1.5 m above ground level.
- All releases from aboveground equipment are modelled at a release height of 2.5 m above ground level, with the exception of the dispensers, tube trailer inc. loading hose and hydrogen storage modelled at a release height of 1.5 m above ground level

Assumption No. 7: Direction of release / obstruction

**Subject:** Consequence Analysis

**Assumptions:**

- The direction of release is dependent on the failure mode and representative hole size.
- For the worst-case consequence modelling, the direction of release has been selected to direct the release to the closest site boundary.
- All hole sizes are modelled as follows:
  - Jet fire non obstructed: Horizonal release
  - Jet fire obstructed: Horizontal release (normally should be assumed as vertical which gives lower heat radiation distances)
  - Jet fire obstructed: where fire walls are present at direction of release, fire walls are assumed to be designed such that it is 100% effective at deflecting and/or absorbing heat radiation, in which case the jet flame is assumed to be directed vertically.
  - Dispersion and/or vapour cloud explosion: downward release

## Assumption No. 8: Dispersion

**Subject**: Consequence Analysis

**Assumption:**

- Effects® software is used to model flammable hydrogen gas dispersion
- Hydrogen is modelled as a neutral dispersion with Effects® predicting when the flammable gas cloud becomes lighter than air.
- Release rates for gas dispersion models are taken from gas release rates calculated by Effects®.
- Benchmarking hydrogen gas dispersion using the Effects® model against other commercially available software models e.g. Phast® by DNV indicates Effects® dispersion provides conservative results
- The developers of Effects® (Gexcon / TNO) are updating the models for better representation of hydrogen effects – as such models are not commercially available to-date, the modelling conducted in this QRA uses a series of conservative assumptions throughout. Full 3D environment around the facility, requiring a 3D CFD based modelling approach, such as FLACS, may be useful during detailed design of this facility.
- The height of the target is set at 1.5 metres, which is standard for QRAs.

## Assumption No. 9: Heat radiation modelling

**Subject**: Consequence Analysis

**Assumption:**

- Heat radiation effects are dependent on the quantity of flammable or combustible product released, its heat of combustion, flame dimensions and the fraction of heat radiated.
- Heat radiation is determined as a sum of the net energy released as a result of the combustion reaction. It is assumed to occur outdoors, hence, with an infinite supply of oxygen.
- Jet fires are modelled using the standard "Chamberlain approach" in Effects® which has been benchmarked against other commercially available models and found to provide acceptable if somewhat conservative results
- The heat flux at a particular distance from a fire is calculated using the view factor method.
- Jet flame dimensions and burning rates vary depending on the wind weather conditions.
- The effect or impact of heat radiation on people is shown in the table below.

Table A1.2: Effects of heat radiation

| Radiant Heat Level ($kW/m^2$) | Physical Effect (effect depends on exposure duration) |
|---|---|
| 1.2 | Received from the sun at noon in summer |
| 2.1 | Minimum to cause pain after 1 minute |
| 4.7 | Will cause pain in 15-20 seconds and injury after 30 seconds' exposure |
| 12.6 | Significant chance of fatality for extended exposure. High chance of injury |
| 23 | Likely fatality for extended exposure and chance of fatality for instantaneous (short) exposure |
| 35 | Significant chance of fatality for people exposed instantaneously |

## Assumption No. 10: Explosion overpressure modelling

**Subject**: Consequence Analysis

**Assumption:**

- An explosion is primarily defined by the environment in which the gas disperses.
- Partial confinement is a major cause of blast in gas cloud deflagrations for VCEs from obstructed releases of from high pressure equipment.
- The peak side-on overpressure resulting from an explosion is estimated using the Multi Energy method option in the Effects® software assuming 100% of the cloud between LEL and UEL participating in the explosion [TNO, Purple Book and modelling software developers' recommendation]. MEM curve 5 is used for all hydrogen releases where worst-case release (towards closest site boundary) is not in a congested area.
- Where there is potential for congested gas accumulation and confined vapour cloud explosion at the area of release (based on LFL contour), an overpressure detonation scenario is modelled using MEM blast strength 10. If dimensions of equipment in the congested area are unknown, it is conservatively assumed that 100% of the cloud is involved in the explosion. Volume blockage ratios have been determined for the electrolyser building and hydrogen storage areas for this study (see assumption 11).
- Only overpressure effects are included as being the representative hazard from vapour cloud explosions. Projectiles and whole-body displacement are not included.
- The effect or impact of explosion overpressure is shown in Table A1-7 below.

Table A1.3: Effects of explosion overpressure

| Explosive overpressure(kPa) | Physical Effect (effect depends on exposure duration) |
|---|---|
| 3.5 | 90% glass breakage. No fatality, very low probability of injury |
| 7 | Damage to internal partitions & joinery. 10% probability of injury, no fatality |
| 14 | Houses uninhabitable and badly cracked |
| 21 | Reinforced structures distort, storage tanks fail. 20% chance of fatality to person in building |
| 35 | Houses uninhabitable, rail wagons & plant items overturned. Threshold of eardrum damage, 50% chance of fatality for a person in a building, 15% in the open |
| 70 | Complete demolition of houses. Threshold of lung damage, 100% chance of fatality for a person in a building or in the open |

## Assumption No. 11: Determining fraction of cloud involved in explosion

**Subject**: Consequence Analysis

**Assumption:**

- The vapour cloud explosion consequence is determined by the volume of vapour space where the hydrogen can accumulate, at a concentration higher than the LFL. Gas accumulation and fraction of cloud involved in explosion at the electrolyser building and hydrogen storage areas have been determined in the tables below.

| Area | Overall congested area dimension Note 3 | | | | Electrolyser skid Note 4 | | | | Volume blockage ratio (VBR) | TNO MEM blast strength |
|---|---|---|---|---|---|---|---|---|---|---|
| | L (m) | W (m) | H (m) | V ($m^3$) | L (m) | W (m) | H (m) | V ($m^3$) | | |
| Electrolyser Building | 53.0 | 30.5 | 4.56 | 7,374 | 12.85 | 3.5 | 4.562 | 1026 Note1 | 13.91% | 10 |

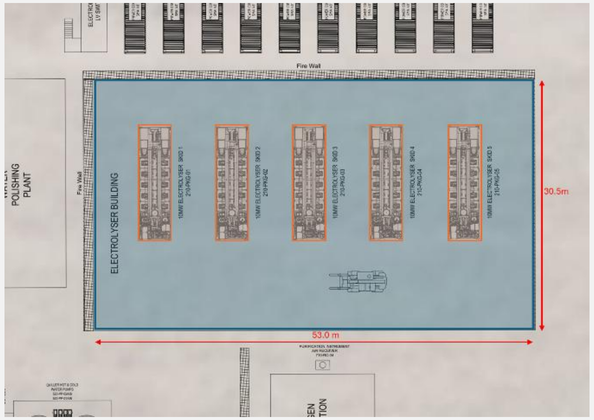
Note:

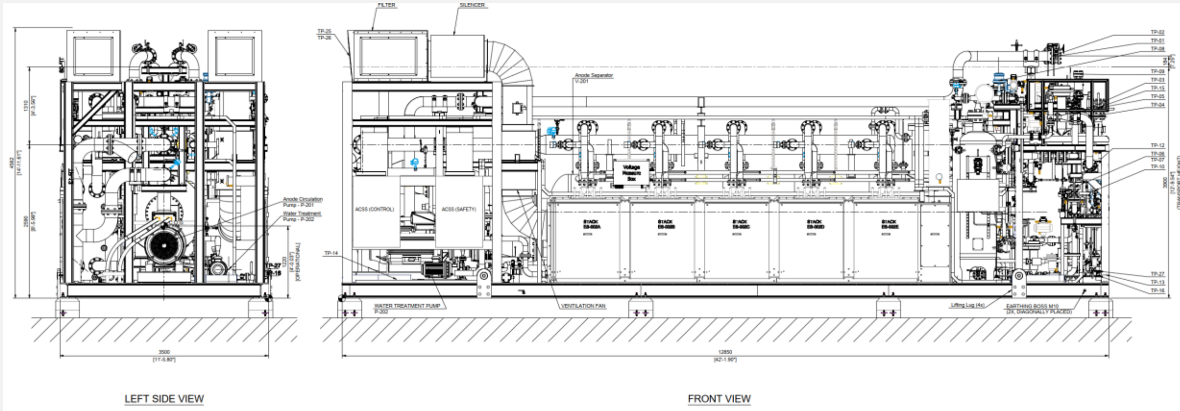
1. Total volume of 5 x 10MW electrolyser skids

2. ‘Electrolyser Skid (2") – HP’ used as representative volume (worst-case scenario output for VCE from electrolyser skid with largest hydrogen mass in the congested area)

3. Electrolyser building dimensions as per UGL drawing 17695-SITE-GA-1002-01 Hydrogen Plant General Arrangement

4. Electrolyser skid dimensions as per Plug document P107828-BEDP-PP-GAS-001



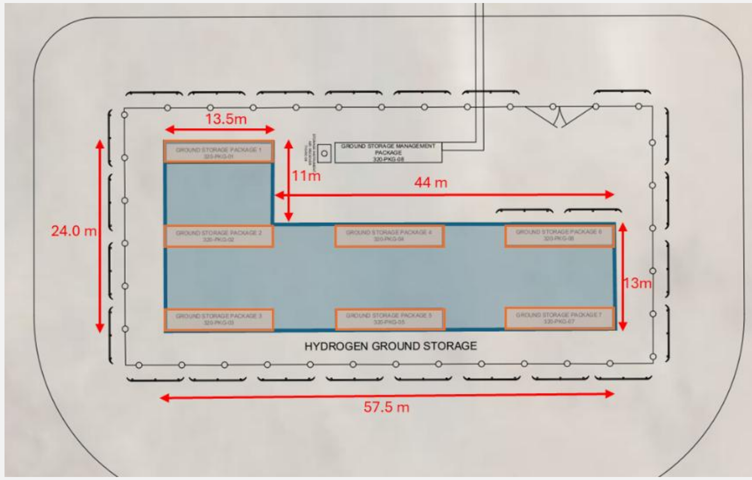

| Area | Overall congested area dimension | | | | Hydrogen storage package | | | | Volume blockage ratio (VBR) | TNO MEM blast strength |
|---|---|---|---|---|---|---|---|---|---|---|
| | L (m) | W (m) | H (m) | V (m³) | L (m) | W (m) | H (m) | V (m³) | | |
| Hydrogen Ground Storage | Note1 | Note1 | 2.75 | 2464 | 12.19 | 2.55 | 2.75 | 599 Note2 | 24.29% | 10 |

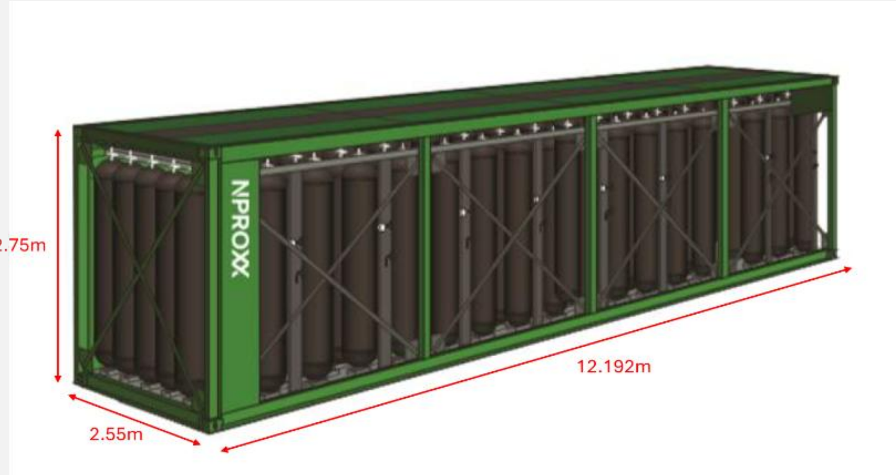
Notes:

1. Congested area dimensions as per UGL drawing 17695-SITE-GA-1002-01 Hydrogen Plant General Arrangement

2. Total volume of 7 x hydrogen storage packages

3. Hydrogen package dimensions as per NPPROXX Factsheet


13.5m
11m
44 m
24.0 m
13m
GROUND STORAGE MANAGEMENT PACKAGE
320-PKG-08
HYDROGEN GROUND STORAGE
57.5 m


2.75m
NPROXX
12.192m
2.55m

## Likelihood Analysis

### Assumption No. 12: Failure rate data

**Subject**: Likelihood Analysis

**Assumption:**

- The parts count of major equipment, piping/fittings used is derived using a count of the number of components for each identified failure case within an isolatable inventory. This is completed by taking the component count from piping and instrument diagrams available at the FEED-stage (versions available at the time of the assessment) and multiplying by the release frequencies as defined in the body of the report.
- All vessels, process equipment and piping are assumed to be fully welded
- Process piping lengths are estimated as provided by UGL or the vendor
- For tube trailer unloading, the frequency of hose coupling error and truck driveaway whilst still connected is shown in the table below. This frequency data assumes the following:
    - Multi safety system facility as excess flow valve at hose connection and breakaway coupling are included in current design (UK HSE, 2017):
        - Multi safety system: Two pullaway prevention systems, and also an effective pullaway mitigation system and inspection and pressure/leak tests to prevent transfer system leaks and burst
        - The safety systems applicable to the facility are pullaway prevention (e.g. wheel chocks, interlock brakes, interlock barriers), pullaway mitigation that stops the flow in the event of a pullaway (e.g. short airline, but only if it will separate and activate a shut off valve before the transfer system fails, movement detectors), and hose failure protection (pressure leak test, hose inspection)
    - No additional credit is given for duplicate non-redundant safety systems

Table A1.4: Hose failure frequency for multi safety system facility (UK HSE, 2017)

| Component | unit | Very Small | Minor | Medium | Major | Rupture |
|---|---|---|---|---|---|---|
| Hose coupling error and drive away whilst still connected | Per connection | 0.00E+00 | 6.00E-06 | 4.00E-07 | 0.00E+00 | 2.00E-07 |

## Assumption No. 14: Sources of ignition and flammable outcome

**Subject**: Likelihood Analysis

**Assumption:**

- Hydrogen is considered a *high reactivity* gas (e.g. TNO Purple Book).
- The term immediate ignition is used to represent ignition due to a nearby source that occurs before an appreciable vapour cloud is produced [UK HSE RR 1034].
- Immediate ignition is incident generated, e.g. in the case where a pipe is broken on impact, by the frictional sparks that may be generated and acting as an ignition source, thus resulting in immediate ignition. Immediate ignition may also be generated through friction of the outflowing material. It is assumed that immediate ignition occurs within 30 s of a release [UK HSE RR 1034].
- Immediate ignition of a jet of flammable gas from a hole in a pipe or vessel will result in a jet fire.
- If immediate ignition does not occur, the released flammable cloud may continue to travel downwind until it encounters a sufficient source of ignition. This type of ignition is referred to as *delayed remote ignition*. Delayed remote ignition can occur if there are insufficient ignition sources close to the release point.
- An immediate and a delayed ignition probability are defined for each minor and major release case
- The Probability of ignition is provided in Assumption No. 15.

## Assumption No. 15: Probability of ignition

**Subject:** Likelihood analysis

**Assumption:**

- Ignition probabilities used in the QRA for hydrogen release cases is obtained from Table 5-6 of a report by Sandia National Laboratories, and has been summarised in the table below. The ignition probabilities are a function of the hydrogen release rate. The Sandia report refers to 'Tchouvelev values' and a 'HYSAFE' program model as follows:
    - 'HYSAFE' program model[7]: Immediate ignition probabilities range from 0.0001 to 0.9, and delayed ignition probabilities range from 0.004 to 0.5. The HYSAFE probabilities are for self-ignition only, and hence are not recommended by the Sandia report.
    - Tchouvelev ignition model[8] : were adapted for hydrogen from values suggested in Cox, Lee, & Ang. The Sandia report states it has been determined that Tchouvelev value were reasonable and should be used in the base line risk analysis
- It should be noted the maximum immediate and delayed ignition probability, based on Tchouvelev Model is capped at 0.23 and 0.12 for immediate and delayed ignition for release rate > 6.25 kg/s. In order to reflect higher ignition probability for larger release, ignition model in TNO Purple Book (Uijt de Haag and Ale, 2005, Table 4.5 and Table 4.A.1), is combined with Tchouvelev model, to cover a wide range of release rate, i.e. > 6.25 kg/s

Table A1.5: Hydrogen Ignition Probability

| Combined model of Tchouvelev and TNO Purple Book | | | HYSAFE Model (reference only) | |
|---|---|---|---|---|
| Hydrogen Release Rate (kg/s) | Immediate Ignition Probability | Delayed Ignition Probability | Hydrogen Release Rate (kg/s) | Immediate Ignition Probability |
| <0.125 | 0.008 | 0.004 | 0.01 – 0.1 | 0.001 |
| 0.125 – 6.25 | 0.053 | 0.027 | 0.01 – 1 | 0.001 + 0,001 when P>100 bar |
| 6.25 -10 | 0.23 | 0.12 | 1 – 10 | 0.01 + 0.01 when P>100 bar |
| 10-100 | 0.5 | 0.35[1] | >10 | 0.1 + 0.01 or 0.02 |
| >100 | 0.7 | 0.21[1] | N/A | N/A |

Note 1: Based on TNO Purple book, delayed ignition probability of flammable cloud within heavy industry site is 0.7, if not immediately ignited before the full growth of cloud

*[7] L.K. Rodsaetre and K. Ottestad Holmefjord, "An Ignition Probability Model for Hydrogen Risk Analysis," HYSAFE Deliverable No.71, January 6, 2007.*

*[8] Canadian Hydrogen Safety Program, "Quantitative Risk Comparison of Hydrogen and CNG Refueling Options," Presentation, IEA Task 19 Meeting, 2006.*

Assumption No. 17: Reduction factors

**Subject**: Likelihood analysis

**Assumption:**

- The protection factor included in the QRA are presented in the table below.

Table A1.6: Reduction factors

| Mitigation measure | Reduction factor | Used in the QRA |
|---|---|---|
| Automated plant trip and shutdown via automatic closure of isolation valves on process upset detection within system (e.g. due to a rupture or major leak causing a major loss of pressure) | 0.05 | Safety system assumed as minimum SIL1 with PFD of 0.05. Assumed to activate for rupture and major leak scenarios only (not activated for very small, minor and medium size release scenarios). |
| Automated plant trip and shutdown via automatic closure of isolation valves on gas or fire detection | 0.05 | Safety system assumed as minimum SIL1 with PFD of 0.05. Includes blowdown (where relevant) upon activation. |
| Automatic opening of blowdown valves upon emergency shutdown to relieve the gas inventory between the isolatable section to the flare header | - | A total time from trigger to full blowdown valve opening is taken as 220 milliseconds and set as the maximum release duration when assessing isolated cases for the QRA. |

- For isolated scenarios, blowdown valve opening times have been obtained from available literature on hydrogen blowdown release experiments[9]. The experiment states "*A reaction time of approx. 40 ms elapses before the ball in the pneumatic valve starts to rotate, and to open the full cross section of the valve further approx. 180 ms are needed".* A total time from trigger to full blowdown valve opening is taken as 220 milliseconds and set as the maximum release duration when assessing isolated scenarios for the QRA.

[9] *A. Veser, A. Friedrich, M. Kuznetsov, T. Jordan, N. Kotchourko, "Hydrogen Blowdown Release Experiments at Different Temperatures in the DISCHA-Facility", 9th International Conference on Hydrogen Safety (ICHS), Edinburgh, UK, 21–23 September 2021.*

# Appendix 2

# Consequence analysis results

**Quantitative Risk Assessment for the Euroa Hydrogen**

**Domestic Project - Gladstone Hydrogen Production**

## Appendix 2: Consequence analysis results for isolation fail scenarios (worst case)

Consequence analysis results for isolation fail scenarios (worst case):

| | | | | | | | | | | Distance to heat radiation level (m) | | Distance to overpressure level (m) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Isolatable section | Section Code | Release Category Code | Connection size (mm) | Release size (mm) | Material | Mass inventory of isolatable section (kg) | Operating Temp. (°C) | Operating Pressure (barg) | Release rate (kg/s) | 4.7kW/m$^2$ | 12.6 kW/m$^2$ | 7 kPa | 14 kPa | Flammable dispersion - distance to LFL (m) |
| Electrolyser Skid (2" pipe) – Low Pressure side | ISOL1A_ELS | XL | 50.8 | 50.8 | $H_2$ | 51.922 | 75 | 40 | 1.982 | 47 | 41 | 96 | 65 | 48 |
| Electrolyser to purification interunit pipework | ISOL1-2_PIP | XL | 76.2 | 76.2 | $H_2$ | 51.922 | 75 | 40 | 4.534 | 56 | 46 | 85 | 57 | 68 |
| Gas Purifier | ISOL2_GSP | XL | 76.2 | 76.2 | $H_2$ | 62.610 | 15 | 40 | 3.597 | 63 | 55 | 137 | 92 | 64 |
| Purification to compression interunit pipework | ISOL2-3_PIP | XL | 76.2 | 76.2 | $H_2$ | 62.610 | 15 | 40 | 3.459 | 52 | 43 | 90 | 60 | 61 |
| Compression inlet | ISOL3_CPI | XL | 76.2 | 76.2 | $H_2$ | 62.610 | 15 | 40 | 6.773 | 82 | 72 | 167 | 111 | 85 |
| Compression outlet | ISOL4_CPO | XL | 25.4 | 25.4 | $H_2$ | 17.830 | 15 | 450 | 7.400 | 82 | 72 | 109 | 70 | 84 |
| Compression to storage management interunit pipework | ISOL4-5_PIP | XL | 25.4 | 25.4 | $H_2$ | 17.830 | 15 | 450 | 2.731 | 54 | 47 | 64 | 45 | 63 |
| Storage management Package | ISOL5_SMP | XL | 25.4 | 25.4 | $H_2$ | 17.830 | 15 | 450 | 5.109 | 70 | 61 | 104 | 68 | 77 |
| Storage management to dispensing compression interunit pipework | ISOL5-6_PIP | XL | 25.4 | 25.4 | $H_2$ | 17.830 | 15 | 450 | 2.917 | 56 | 49 | 64 | 44 | 65 |
| Dispensing compression inlet | ISOL6_DCI | XL | 25.4 | 25.4 | $H_2$ | 17.830 | 15 | 450 | 6.920 | 80 | 70 | 111 | 71 | 82 |
| Dispensing compression outlet | ISOL7_DCO | XL | 25.4 | 25.4 | $H_2$ | 8.751 | 15 | 650 | 9.320 | 91 | 80 | 100 | 63 | 81 |
| Dispensing compression to dispensing bay interunit pipework | ISOL7-8_PIP | XL | 25.4 | 25.4 | $H_2$ | 8.751 | 15 | 650 | 3.516 | 60 | 53 | 47 | 31 | 65 |
| Dispensers | ISOL8_DIS | XL | 25.4 | 25.4 | $H_2$ | 10.242 | -30 | 650 | 10.370 | 99 | 87 | 52 | 33 | 89 |
| Storage management to storage pipework | ISOL5-9_PIP | XL | 25.4 | 25.4 | $H_2$ | 17.830 | 15 | 450 | 2.718 | 54 | 47 | 105 | 71 | 63 |
| Storage | ISOL9_STO | XL | 25.4 | 25.4 | $H_2$ | 7022.200 | 25 | 400 | 4.427 | 65 | 57 | 87 | 62 | 77 |
| Tube trailer inc. loading hose | ISOL10_TUB | XL | 25.4 | 25.4 | $H_2$ | 4520.900 | -30 | 517 | 7.852 | 88 | 77 | 124 | 89 | 111 |

# Appendix 3

# Likelihood assessment

**Quantitative Risk Assessment for the Euroa Hydrogen**

**Domestic Project - Gladstone Hydrogen Production**

# Appendix 3: Likelihood assessment

## Likelihood assessment for isolated scenarios:

| Section code | Release Category | Connection size (mm) | Release size (mm) | Material | Release rate (kg/s) | Release Frequency (/year) | ISOL base frequency with risk reduction (does not include ignition probabilities) | ISOL VCE at tube trailer loading bay frequency (/year) | ISOL VCE at H2 storage frequency (/year) | ISOL VCE at main compressors frequency (/year) | ISOL VCE at dispensing compressors frequency (/year) | ISOL VCE at purification unit frequency (/year) | ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL1A_ELS | XS | 50.8 | 0.51 | $H_2$ | 0.000 | 2.08E+00 | 2.08E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1A_ELS | S | 50.8 | 1.6 | $H_2$ | 0.004 | 1.48E-01 | 1.48E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1A_ELS | M | 50.8 | 5.1 | $H_2$ | 0.034 | 6.97E-02 | 6.97E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1A_ELS | L | 50.8 | 16.1 | $H_2$ | 0.373 | 2.66E-03 | 2.53E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.98E-04 |
| ISOL1A_ELS | XL | 50.8 | 50.8 | $H_2$ | 2.190 | 7.90E-04 | 7.50E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.15E-05 | 1.18E-04 |
| ISOL1B_ELS | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 3.66E-01 | 3.66E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1B_ELS | S | 76.2 | 2.4 | $H_2$ | 0.008 | 2.54E-02 | 2.54E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1B_ELS | M | 76.2 | 7.6 | $H_2$ | 0.076 | 1.22E-02 | 1.22E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.93E-03 |
| ISOL1B_ELS | L | 76.2 | 24.1 | $H_2$ | 0.839 | 3.45E-04 | 3.28E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.56E-05 | 5.16E-05 |
| ISOL1B_ELS | XL | 76.2 | 76.2 | $H_2$ | 5.671 | 7.44E-05 | 7.07E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.68E-06 | 1.11E-05 |
| ISOL1C_ELS | XS | 50.8 | 0.51 | $H_2$ | 0.000 | 1.57E+00 | 1.57E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1C_ELS | S | 50.8 | 1.6 | $H_2$ | 0.001 | 1.13E-01 | 1.13E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1C_ELS | M | 50.8 | 5.1 | $H_2$ | 0.005 | 5.28E-02 | 5.28E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1C_ELS | L | 50.8 | 16.1 | $H_2$ | 0.055 | 2.25E-03 | 2.14E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.38E-04 |
| ISOL1C_ELS | XL | 50.8 | 50.8 | $H_2$ | 0.370 | 6.92E-04 | 6.57E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.04E-04 |
| ISOL1D_ELS | XS | 19.1 | 0.19 | $H_2$ | 0.000 | 2.52E-06 | 2.52E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1D_ELS | S | 19.1 | 0.6 | $H_2$ | 0.001 | 1.18E-06 | 1.18E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1D_ELS | M | 19.1 | 1.9 | $H_2$ | 0.005 | 5.29E-07 | 5.29E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1D_ELS | L | 19.1 | 6 | $H_2$ | 0.052 | 2.37E-05 | 2.25E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1D_ELS | XL | 19.1 | 19.1 | $H_2$ | 0.251 | 2.04E-05 | 1.94E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.15E-05 |
| ISOL1E_ELS | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 2.94E-02 | 2.94E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1E_ELS | S | 76.2 | 2.4 | $H_2$ | 0.008 | 2.05E-03 | 2.05E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

| Section code | Release Category | Connection size (mm) | Release size (mm) | Material | Release rate (kg/s) | Release Frequency (/year) | ISOL base frequency with risk reduction (does not include ignition probabilities) | ISOL VCE at tube trailer loading bay frequency (/year) | ISOL VCE at H2 storage frequency (/year) | ISOL VCE at main compressors frequency (/year) | ISOL VCE at dispensing compressors frequency (/year) | ISOL VCE at purification unit frequency (/year) | ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL1E_ELS | M | 76.2 | 7.6 | $H_2$ | 0.076 | 9.85E-04 | 9.85E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.86E-04 |
| ISOL1E_ELS | L | 76.2 | 24.1 | $H_2$ | 0.837 | 3.13E-05 | 2.98E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.23E-06 | 1.77E-05 |
| ISOL1E_ELS | XL | 76.2 | 76.2 | $H_2$ | 5.160 | 6.59E-06 | 6.26E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.80E-07 | 3.72E-06 |
| ISOL1-2_PIP | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 1.54E-01 | 1.47E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1-2_PIP | S | 76.2 | 2.4 | $H_2$ | 0.008 | 1.20E-02 | 1.14E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1-2_PIP | M | 76.2 | 7.6 | $H_2$ | 0.084 | 5.20E-03 | 4.94E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1-2_PIP | L | 76.2 | 24.1 | $H_2$ | 0.821 | 2.26E-04 | 2.04E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1-2_PIP | XL | 76.2 | 76.2 | $H_2$ | 4.651 | 1.18E-04 | 1.06E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2_GSP | XS | 50.8 | 0.51 | $H_2$ | 0.001 | 1.93E+01 | 1.84E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2_GSP | S | 50.8 | 1.6 | $H_2$ | 0.009 | 1.39E+00 | 1.32E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2_GSP | M | 50.8 | 5.1 | $H_2$ | 0.092 | 6.53E-01 | 6.21E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2_GSP | L | 50.8 | 16.1 | $H_2$ | 0.909 | 2.63E-02 | 2.37E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.10E-02 |
| ISOL2_GSP | XL | 50.8 | 50.8 | $H_2$ | 3.976 | 1.35E-02 | 1.22E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.69E-03 |
| ISOL2-3_PIP | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 1.56E-01 | 1.48E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2-3_PIP | S | 76.2 | 2.4 | $H_2$ | 0.009 | 1.25E-02 | 1.19E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2-3_PIP | M | 76.2 | 7.6 | $H_2$ | 0.092 | 5.46E-03 | 5.18E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2-3_PIP | L | 76.2 | 24.1 | $H_2$ | 0.902 | 3.42E-04 | 3.09E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2-3_PIP | XL | 76.2 | 76.2 | $H_2$ | 3.737 | 2.18E-04 | 1.97E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 5.95E+00 | 5.65E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | S | 76.2 | 2.4 | $H_2$ | 0.009 | 4.83E-01 | 4.59E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | M | 76.2 | 7.6 | $H_2$ | 0.092 | 2.29E-01 | 2.18E-01 | 0.00E+00 | 0.00E+00 | 8.72E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | L | 76.2 | 24.1 | $H_2$ | 0.911 | 1.84E-02 | 1.66E-02 | 0.00E+00 | 0.00E+00 | 6.65E-03 | 4.83E-03 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | XL | 76.2 | 76.2 | $H_2$ | 6.917 | 8.76E-03 | 7.90E-03 | 0.00E+00 | 0.00E+00 | 3.17E-03 | 2.30E-03 | 0.00E+00 | 0.00E+00 |
| ISOL4_CPO | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.63E+00 | 1.54E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4_CPO | S | 25.4 | 0.8 | $H_2$ | 0.010 | 1.60E-01 | 1.52E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4_CPO | M | 25.4 | 2.5 | $H_2$ | 0.099 | 6.62E-02 | 6.29E-02 | 0.00E+00 | 0.00E+00 | 2.52E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Planager
Risk Management Consulting

| Section code | Release Category | Connection size (mm) | Release size (mm) | Material | Release rate (kg/s) | Release Frequency (/year) | ISOL base frequency with risk reduction (does not include ignition probabilities) | ISOL VCE at tube trailer loading bay frequency (/year) | ISOL VCE at H2 storage frequency (/year) | ISOL VCE at main compressors frequency (/year) | ISOL VCE at dispensing compressors frequency (/year) | ISOL VCE at purification unit frequency (/year) | ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL4_CPO | L | 25.4 | 8 | $H_2$ | 1.007 | 2.67E-03 | 2.41E-03 | 0.00E+00 | 0.00E+00 | 9.66E-04 | 7.01E-04 | 0.00E+00 | 0.00E+00 |
| ISOL4_CPO | XL | 25.4 | 25.4 | $H_2$ | 8.110 | 4.25E-04 | 3.83E-04 | 0.00E+00 | 4.51E-05 | 1.54E-04 | 1.12E-04 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 3.38E-01 | 3.21E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | S | 25.4 | 0.8 | $H_2$ | 0.010 | 3.00E-02 | 2.85E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | M | 25.4 | 2.5 | $H_2$ | 0.099 | 1.14E-02 | 1.09E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | L | 25.4 | 8 | $H_2$ | 0.955 | 8.65E-04 | 7.81E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | XL | 25.4 | 25.4 | $H_2$ | 2.934 | 4.62E-04 | 4.17E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 2.17E+00 | 2.07E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | S | 25.4 | 0.8 | $H_2$ | 0.010 | 1.58E-01 | 1.50E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | M | 25.4 | 2.5 | $H_2$ | 0.098 | 7.22E-02 | 6.86E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | L | 25.4 | 8 | $H_2$ | 0.952 | 2.27E-03 | 2.05E-03 | 0.00E+00 | 1.19E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | XL | 25.4 | 25.4 | $H_2$ | 5.117 | 6.39E-04 | 5.76E-04 | 0.00E+00 | 3.35E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.16E+00 | 1.10E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | S | 25.4 | 0.8 | $H_2$ | 0.010 | 8.88E-02 | 8.44E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | M | 25.4 | 2.5 | $H_2$ | 0.099 | 3.87E-02 | 3.68E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | L | 25.4 | 8 | $H_2$ | 0.959 | 1.70E-03 | 1.53E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | XL | 25.4 | 25.4 | $H_2$ | 3.112 | 6.47E-04 | 5.84E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.15E+00 | 1.10E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | S | 25.4 | 0.8 | $H_2$ | 0.010 | 9.58E-02 | 9.10E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | M | 25.4 | 2.5 | $H_2$ | 0.099 | 4.24E-02 | 4.03E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.39E-03 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | L | 25.4 | 8 | $H_2$ | 1.003 | 1.44E-03 | 1.30E-03 | 0.00E+00 | 0.00E+00 | 6.69E-04 | 2.38E-04 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | XL | 25.4 | 25.4 | $H_2$ | 7.484 | 2.73E-04 | 2.47E-04 | 0.00E+00 | 0.00E+00 | 1.27E-04 | 4.53E-05 | 0.00E+00 | 0.00E+00 |
| ISOL7_DCO | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.38E+00 | 1.31E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7_DCO | S | 25.4 | 0.8 | $H_2$ | 0.014 | 1.12E-01 | 1.07E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7_DCO | M | 25.4 | 2.5 | $H_2$ | 0.136 | 5.11E-02 | 4.85E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.91E-03 | 0.00E+00 | 0.00E+00 |
| ISOL7_DCO | L | 25.4 | 8 | $H_2$ | 1.383 | 2.48E-03 | 2.24E-03 | 0.00E+00 | 0.00E+00 | 1.15E-03 | 4.10E-04 | 0.00E+00 | 0.00E+00 |

| Section code | Release Category | Connection size (mm) | Release size (mm) | Material | Release rate (kg/s) | Release Frequency (/year) | ISOL base frequency with risk reduction (does not include ignition probabilities) | ISOL VCE at tube trailer loading bay frequency (/year) | ISOL VCE at H2 storage frequency (/year) | ISOL VCE at main compressors frequency (/year) | ISOL VCE at dispensing compressors frequency (/year) | ISOL VCE at purification unit frequency (/year) | ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL7_DCO | XL | 25.4 | 25.4 | $H_2$ | 10.077 | 3.10E-04 | 2.79E-04 | 0.00E+00 | 0.00E+00 | 1.44E-04 | 5.13E-05 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 4.95E-01 | 4.70E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | S | 25.4 | 0.8 | $H_2$ | 0.014 | 4.25E-02 | 4.04E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | M | 25.4 | 2.5 | $H_2$ | 0.136 | 1.67E-02 | 1.58E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | L | 25.4 | 8 | $H_2$ | 1.313 | 1.11E-03 | 9.99E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | XL | 25.4 | 25.4 | $H_2$ | 3.800 | 5.77E-04 | 5.21E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 4.51E-01 | 4.29E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | S | 25.4 | 0.8 | $H_2$ | 0.015 | 3.32E-02 | 3.15E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | M | 25.4 | 2.5 | $H_2$ | 0.145 | 1.54E-02 | 1.47E-02 | 4.57E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | L | 25.4 | 8 | $H_2$ | 1.380 | 7.64E-04 | 6.90E-04 | 2.15E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | XL | 25.4 | 25.4 | $H_2$ | 10.370 | 1.37E-04 | 1.23E-04 | 3.85E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 2.33E+00 | 2.22E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | S | 25.4 | 0.8 | $H_2$ | 0.010 | 1.70E-01 | 1.62E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | M | 25.4 | 2.5 | $H_2$ | 0.099 | 7.73E-02 | 7.34E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | L | 25.4 | 8 | $H_2$ | 0.955 | 2.44E-03 | 2.21E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | XL | 25.4 | 25.4 | $H_2$ | 2.921 | 9.24E-04 | 8.34E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.20E+00 | 1.14E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | S | 25.4 | 0.8 | $H_2$ | 0.009 | 8.81E-02 | 8.37E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | M | 25.4 | 2.5 | $H_2$ | 0.087 | 4.13E-02 | 3.92E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | L | 25.4 | 8 | $H_2$ | 0.887 | 2.18E-03 | 1.97E-03 | 0.00E+00 | 1.97E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | XL | 25.4 | 25.4 | $H_2$ | 5.039 | 3.73E-04 | 3.37E-04 | 0.00E+00 | 3.37E-04 | 8.74E-05 | 8.74E-05 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 3.45E-01 | 3.28E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | S | 25.4 | 0.8 | $H_2$ | 0.012 | 2.49E-02 | 2.36E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | M | 25.4 | 2.5 | $H_2$ | 0.121 | 1.18E-02 | 1.12E-02 | 3.48E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | L | 25.4 | 8 | $H_2$ | 1.233 | 5.69E-04 | 5.14E-04 | 1.60E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | XL | 25.4 | 25.4 | $H_2$ | 8.700 | 1.74E-04 | 1.57E-04 | 4.91E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Likelihood assessment for non-isolated (isolation fail) scenarios:

| Section code | Release Category | Connection size (mm) | Release size (mm) | Material | Release rate (kg/s) | Release Frequency (/year) | NON-ISOL base frequency with risk reduction failed (/year) (does not include ignition probabilities) | NON-ISOL VCE at tube trailer loading bay frequency (/year) | NON-ISOL VCE at H2 storage frequency (/year) | NON-ISOL VCE at main compressors frequency (/year) | NON-ISOL VCE at dispensing compressors frequency (/year) | NON-ISOL VCE at purification unit frequency (/year) | NON-ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL1A_ELS | XS | 50.8 | 0.51 | $H_2$ | 0.000 | 2.08E+00 | 2.08E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1A_ELS | S | 50.8 | 1.6 | $H_2$ | 0.004 | 1.48E-01 | 1.48E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1A_ELS | M | 50.8 | 5.1 | $H_2$ | 0.035 | 6.97E-02 | 6.97E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1A_ELS | L | 50.8 | 16.1 | $H_2$ | 0.336 | 2.66E-03 | 1.33E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.10E-05 |
| ISOL1A_ELS | XL | 50.8 | 50.8 | $H_2$ | 1.982 | 7.90E-04 | 3.95E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.29E-06 | 6.23E-06 |
| ISOL1B_ELS | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 3.66E-01 | 3.66E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1B_ELS | S | 76.2 | 2.4 | $H_2$ | 0.008 | 2.54E-02 | 2.54E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1B_ELS | M | 76.2 | 7.6 | $H_2$ | 0.076 | 1.22E-02 | 1.22E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.93E-03 |
| ISOL1B_ELS | L | 76.2 | 24.1 | $H_2$ | 0.756 | 3.45E-04 | 1.72E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.87E-06 | 2.72E-06 |
| ISOL1B_ELS | XL | 76.2 | 76.2 | $H_2$ | 5.184 | 7.44E-05 | 3.72E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.04E-07 | 5.87E-07 |
| ISOL1C_ELS | XS | 50.8 | 0.51 | $H_2$ | 0.000 | 1.57E+00 | 1.57E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1C_ELS | S | 50.8 | 1.6 | $H_2$ | 0.001 | 1.13E-01 | 1.13E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1C_ELS | M | 50.8 | 5.1 | $H_2$ | 0.005 | 5.28E-02 | 5.28E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1C_ELS | L | 50.8 | 16.1 | $H_2$ | 0.051 | 2.25E-03 | 1.13E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.78E-05 |
| ISOL1C_ELS | XL | 50.8 | 50.8 | $H_2$ | 0.341 | 6.92E-04 | 3.46E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.45E-06 |
| ISOL1D_ELS | XS | 19.1 | 0.19 | $H_2$ | 0.000 | 2.52E-06 | 2.52E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1D_ELS | S | 19.1 | 0.6 | $H_2$ | 0.001 | 1.18E-06 | 1.18E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1D_ELS | M | 19.1 | 1.9 | $H_2$ | 0.005 | 5.29E-07 | 5.29E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1D_ELS | L | 19.1 | 6 | $H_2$ | 0.047 | 2.37E-05 | 1.18E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1D_ELS | XL | 19.1 | 19.1 | $H_2$ | 0.226 | 2.04E-05 | 1.02E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.07E-07 |
| ISOL1E_ELS | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 2.94E-02 | 2.94E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1E_ELS | S | 76.2 | 2.4 | $H_2$ | 0.008 | 2.05E-03 | 2.05E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1E_ELS | M | 76.2 | 7.6 | $H_2$ | 0.076 | 9.85E-04 | 9.85E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.86E-04 |
| ISOL1E_ELS | L | 76.2 | 24.1 | $H_2$ | 0.755 | 3.13E-05 | 1.57E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.70E-07 | 9.31E-07 |

| Section code | Release Category | Connection size (mm) | Release size (mm) | Material | Release rate (kg/s) | Release Frequency (/year) | NON-ISOL base frequency with risk reduction failed (/year) (does not include ignition probabilities) | NON-ISOL VCE at tube trailer loading bay frequency (/year) | NON-ISOL VCE at H2 storage frequency (/year) | NON-ISOL VCE at main compressors frequency (/year) | NON-ISOL VCE at dispensing compressors frequency (/year) | NON-ISOL VCE at purification unit frequency (/year) | NON-ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL1E_ELS | XL | 76.2 | 76.2 | $H_2$ | 4.709 | 6.59E-06 | 3.29E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.58E-08 | 1.96E-07 |
| ISOL1-2_PIP | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 1.54E-01 | 7.72E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1-2_PIP | S | 76.2 | 2.4 | $H_2$ | 0.008 | 1.20E-02 | 5.98E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1-2_PIP | M | 76.2 | 7.6 | $H_2$ | 0.076 | 5.20E-03 | 2.60E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1-2_PIP | L | 76.2 | 24.1 | $H_2$ | 0.754 | 2.26E-04 | 2.20E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL1-2_PIP | XL | 76.2 | 76.2 | $H_2$ | 4.534 | 1.18E-04 | 1.15E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2_GSP | XS | 50.8 | 0.51 | $H_2$ | 0.001 | 1.93E+01 | 9.66E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2_GSP | S | 50.8 | 1.6 | $H_2$ | 0.009 | 1.39E+00 | 6.94E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2_GSP | M | 50.8 | 5.1 | $H_2$ | 0.084 | 6.53E-01 | 3.27E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2_GSP | L | 50.8 | 16.1 | $H_2$ | 0.819 | 2.63E-02 | 2.56E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.19E-03 |
| ISOL2_GSP | XL | 50.8 | 50.8 | $H_2$ | 3.597 | 1.35E-02 | 1.32E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.15E-04 |
| ISOL2-3_PIP | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 1.56E-01 | 7.78E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2-3_PIP | S | 76.2 | 2.4 | $H_2$ | 0.009 | 1.25E-02 | 6.27E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2-3_PIP | M | 76.2 | 7.6 | $H_2$ | 0.084 | 5.46E-03 | 2.73E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2-3_PIP | L | 76.2 | 24.1 | $H_2$ | 0.817 | 3.42E-04 | 3.34E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL2-3_PIP | XL | 76.2 | 76.2 | $H_2$ | 3.459 | 2.18E-04 | 2.13E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | XS | 76.2 | 0.76 | $H_2$ | 0.001 | 5.95E+00 | 2.98E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | S | 76.2 | 2.4 | $H_2$ | 0.009 | 4.83E-01 | 2.42E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | M | 76.2 | 7.6 | $H_2$ | 0.084 | 2.29E-01 | 1.15E-02 | 0.00E+00 | 0.00E+00 | 4.59E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | L | 76.2 | 24.1 | $H_2$ | 0.834 | 1.84E-02 | 1.79E-03 | 0.00E+00 | 0.00E+00 | 7.18E-04 | 5.22E-04 | 0.00E+00 | 0.00E+00 |
| ISOL3_CPI | XL | 76.2 | 76.2 | $H_2$ | 6.773 | 8.76E-03 | 8.54E-04 | 0.00E+00 | 1.01E-04 | 3.42E-04 | 2.48E-04 | 0.00E+00 | 0.00E+00 |
| ISOL4_CPO | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.63E+00 | 8.13E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4_CPO | S | 25.4 | 0.8 | $H_2$ | 0.010 | 1.60E-01 | 7.98E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4_CPO | M | 25.4 | 2.5 | $H_2$ | 0.089 | 6.62E-02 | 3.31E-03 | 0.00E+00 | 0.00E+00 | 1.33E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4_CPO | L | 25.4 | 8 | $H_2$ | 0.907 | 2.67E-03 | 2.60E-04 | 0.00E+00 | 0.00E+00 | 1.04E-04 | 7.58E-05 | 0.00E+00 | 0.00E+00 |

Planager
Risk Management Consulting

| Section code | Release Category | Connection size (mm) | elease size (mm) | aterial | Release rate (kg/s) | Release Frequency (/year) | NON-ISOL base frequency with risk reduction failed (/year) (does not include ignition probabilities) | NON-ISOL VCE at tube trailer loading bay frequency (/year) | NON-ISOL VCE at H2 storage frequency (/year) | NON-ISOL VCE at main compressors frequency (/year) | NON-ISOL VCE at dispensing compressors frequency (/year) | NON-ISOL VCE at purification unit frequency (/year) | NON-ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL4_CPO | XL | 25.4 | 25.4 | $H_2$ | 7.400 | 4.25E-04 | 4.14E-05 | 0.00E+00 | 4.88E-06 | 1.66E-05 | 1.21E-05 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 3.38E-01 | 1.69E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | S | 25.4 | 0.8 | $H_2$ | 0.010 | 3.00E-02 | 1.50E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | M | 25.4 | 2.5 | $H_2$ | 0.089 | 1.14E-02 | 5.72E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | L | 25.4 | 8 | $H_2$ | 0.869 | 8.65E-04 | 8.44E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL4-5_PIP | XL | 25.4 | 25.4 | $H_2$ | 2.731 | 4.62E-04 | 4.50E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 2.17E+00 | 1.09E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | S | 25.4 | 0.8 | $H_2$ | 0.010 | 1.58E-01 | 7.89E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | M | 25.4 | 2.5 | $H_2$ | 0.089 | 7.22E-02 | 3.61E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | L | 25.4 | 8 | $H_2$ | 0.900 | 2.27E-03 | 2.22E-04 | 0.00E+00 | 1.29E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5_SMP | XL | 25.4 | 25.4 | $H_2$ | 5.109 | 6.39E-04 | 6.23E-05 | 0.00E+00 | 3.62E-05 | 7.44E-06 | 8.71E-06 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.16E+00 | 5.79E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | S | 25.4 | 0.8 | $H_2$ | 0.010 | 8.88E-02 | 4.44E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | M | 25.4 | 2.5 | $H_2$ | 0.089 | 3.87E-02 | 1.93E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | L | 25.4 | 8 | $H_2$ | 0.874 | 1.70E-03 | 1.66E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-6_PIP | XL | 25.4 | 25.4 | $H_2$ | 2.917 | 6.47E-04 | 6.31E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.15E+00 | 5.77E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | S | 25.4 | 0.8 | $H_2$ | 0.010 | 9.58E-02 | 4.79E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | M | 25.4 | 2.5 | $H_2$ | 0.089 | 4.24E-02 | 2.12E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.89E-04 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | L | 25.4 | 8 | $H_2$ | 0.906 | 1.44E-03 | 1.40E-04 | 0.00E+00 | 0.00E+00 | 7.23E-05 | 2.57E-05 | 0.00E+00 | 0.00E+00 |
| ISOL6_DCI | XL | 25.4 | 25.4 | $H_2$ | 6.920 | 2.73E-04 | 2.66E-05 | 0.00E+00 | 4.20E-06 | 1.38E-05 | 4.89E-06 | 0.00E+00 | 0.00E+00 |
| ISOL7_DCO | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.38E+00 | 6.88E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7_DCO | S | 25.4 | 0.8 | $H_2$ | 0.013 | 1.12E-01 | 5.61E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7_DCO | M | 25.4 | 2.5 | $H_2$ | 0.122 | 5.11E-02 | 2.55E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.69E-04 | 0.00E+00 | 0.00E+00 |
| ISOL7_DCO | L | 25.4 | 8 | $H_2$ | 1.251 | 2.48E-03 | 2.42E-04 | 0.00E+00 | 0.00E+00 | 1.25E-04 | 4.43E-05 | 0.00E+00 | 0.00E+00 |

| Section code | Release Category | Connection size (mm) | Release size (mm) | Material | Release rate (kg/s) | Release Frequency (/year) | NON-ISOL base frequency with risk reduction failed (/year) (does not include ignition probabilities) | NON-ISOL VCE at tube trailer loading bay frequency (/year) | NON-ISOL VCE at H2 storage frequency (/year) | NON-ISOL VCE at main compressors frequency (/year) | NON-ISOL VCE at dispensing compressors frequency (/year) | NON-ISOL VCE at purification unit frequency (/year) | NON-ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL7_DCO | XL | 25.4 | 25.4 | $H_2$ | 9.320 | 3.10E-04 | 3.02E-05 | 0.00E+00 | 4.76E-06 | 1.56E-05 | 5.54E-06 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 4.95E-01 | 2.48E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | S | 25.4 | 0.8 | $H_2$ | 0.013 | 4.25E-02 | 2.13E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | M | 25.4 | 2.5 | $H_2$ | 0.122 | 1.67E-02 | 8.33E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | L | 25.4 | 8 | $H_2$ | 1.194 | 1.11E-03 | 1.08E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL7-8_PIP | XL | 25.4 | 25.4 | $H_2$ | 3.516 | 5.77E-04 | 5.63E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 4.51E-01 | 2.26E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | S | 25.4 | 0.8 | $H_2$ | 0.014 | 3.32E-02 | 1.66E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | M | 25.4 | 2.5 | $H_2$ | 0.133 | 1.54E-02 | 7.71E-04 | 2.41E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | L | 25.4 | 8 | $H_2$ | 1.356 | 7.64E-04 | 7.45E-05 | 2.32E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL8_DIS | XL | 25.4 | 25.4 | $H_2$ | 10.370 | 1.37E-04 | 1.33E-05 | 4.15E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 2.33E+00 | 1.17E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | S | 25.4 | 0.8 | $H_2$ | 0.010 | 1.70E-01 | 8.52E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | M | 25.4 | 2.5 | $H_2$ | 0.089 | 7.73E-02 | 3.86E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | L | 25.4 | 8 | $H_2$ | 0.869 | 2.44E-03 | 2.38E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL5-9_PIP | XL | 25.4 | 25.4 | $H_2$ | 2.718 | 9.24E-04 | 9.01E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 1.20E+00 | 6.00E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | S | 25.4 | 0.8 | $H_2$ | 0.009 | 8.81E-02 | 4.40E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | M | 25.4 | 2.5 | $H_2$ | 0.087 | 4.13E-02 | 2.07E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | L | 25.4 | 8 | $H_2$ | 0.873 | 2.18E-03 | 2.12E-04 | 0.00E+00 | 2.12E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL9_STO | XL | 25.4 | 25.4 | $H_2$ | 4.710 | 3.73E-04 | 3.64E-05 | 0.00E+00 | 3.64E-05 | 9.44E-06 | 9.44E-06 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | XS | 25.4 | 0.25 | $H_2$ | 0.001 | 3.45E-01 | 1.73E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | S | 25.4 | 0.8 | $H_2$ | 0.012 | 2.49E-02 | 1.24E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | M | 25.4 | 2.5 | $H_2$ | 0.121 | 1.18E-02 | 5.88E-04 | 1.83E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| ISOL10_TUB | L | 25.4 | 8 | $H_2$ | 1.193 | 5.69E-04 | 5.55E-05 | 1.73E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

| Section code | Release Category | Connection size (mm) | Release size (mm) | Material | Release rate (kg/s) | Release Frequency (/year) | NON-ISOL base frequency with risk reduction failed (/year) (does not include ignition probabilities) | NON-ISOL VCE at tube trailer loading bay frequency (/year) | NON-ISOL VCE at H2 storage frequency (/year) | NON-ISOL VCE at main compressors frequency (/year) | NON-ISOL VCE at dispensing compressors frequency (/year) | NON-ISOL VCE at purification unit frequency (/year) | NON-ISOL VCE at electrolysers frequency (/year) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL10_TUB | XL | 25.4 | 25.4 | $H_2$ | 7.852 | 1.74E-04 | 1.70E-05 | 5.31E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

# SCOPE OF WORKS & GENERAL SPECIFICATION

## GENERAL CONDITIONS

UNLESS OTHERWISE NOTED, ALL WORKMANSHIP AND MATERIALS SHALL BE IN ACCORDANCE WITH THE BUILDING REGULATIONS AND THE NCC.
THE FIRE CONTRACTOR IS TO UNDERTAKE THE FULL DESIGN OF THE FIRE HYDRANT, FIRE HOSE REEL, PORTABLE FIRE EXTINGUISHERS, FIRE DETECTION AND ALARM SYSTEMS.
CO-ORDINATE THE LOCATION OF ALL ITEMS WITH OTHER TRADES, INCLUDING BUT NOT LIMITED TO STRUCTURAL ELEMENTS, ELECTRICAL, MECHANICAL, CIVIL AND HYDRAULIC SERVICES LAYOUTS.

## CODES, RULES, PERMITS, AND FEES

ALL MATERIALS SUPPLIED, AND ALL WORKS UNDERTAKEN, SHALL COMPLY WITH CODES, RULES, AND REGULATIONS OF ALL STATUTORY AUTHORITIES INCLUDING, BUT NOT NECESSARILY LIMITED TO:

- NATIONAL CONSTRUCTION CODE (NCC), 2022
- AS 1670.1 - FIRE DETECTION, WARNING, CONTROL AND INTERCOM SYSTEMS – SYSTEM DESIGN, INSTALLATION AND COMMISSIONING – FIRE
- AS 1670.4 - FIRE DETECTION, WARNING, CONTROL AND INTERCOM SYSTEMS – EMERGENCY WARNING AND INTERCOM SYSTEMS
- AS 1603 - AUTOMATIC FIRE DETECTION AND ALARM SYSTEMS
- AS 2444 - PORTABLE FIRE EXTINGUISHERS AND FIRE BLANKETS
- AS 2419.1 - FIRE HYDRANT INSTALLATIONS – SYSTEM DESIGN, INSTALLATION AND COMMISSIONING
- AS 2441 - INSTALLATION OF FIRE HOSE REELS
- AS 2304 - WATER STORAGE TANKS FOR FIRE PROTECTION SYSTEMS
- AS 2941 - FIXED FIRE PROTECTION INSTALLATIONS – PUMPSET SYSTEMS
- AS 1074 - STEEL TUBES AND TUBULARS FOR ORDINARY SERVICE
- AS 1345 - IDENTIFICATION OF THE CONTENTS OF PIPES, CONDUITS AND DUCTS
- AS 3000 - WIRING RULES
- AS 3500 - PLUMBING AND DRAINAGE
- AS 1940 - STORAGE OF FLAMMABLE AND COMBUSTIBLE LIQUIDS
- AS 1851 - ROUTINE SERVICE OF FIRE PROTECTION SYSTEMS AND EQUIPMENT

THE CONTRACTOR SHALL MAKE ALL APPLICATIONS AND PAY ALL FEES REQUIRED TO COMPLY WITH THE RELEVANT AUTHORITY REQUIREMENTS. ALL NEW FIRE PROTECTION SERVICES EQUIPMENT PROVIDED SHALL BE LISTED IN THE ACTIVE FIRE REGISTER OF FIRE PROTECTION EQUIPMENT.

## INSPECTION

1. THESE DRAWINGS ARE TO BE TAKEN AS INDICATIVE OF THE INTENDED SYSTEM DESIGN, AND DO NOT PURPORT TO SHOW ALL PIPEWORK, CHANGES OF DIRECTION, DETECTORS, SPEAKERS, OR DEVICES TO PROVIDE A COMPLETE SYSTEM AND/OR COVERAGE. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO CONDUCT THEIR OWN DESIGN REVIEW BEFORE SUBMISSION OF THEIR TENDER. MAKE ALL ALLOWANCES FOR A CONFORMING AND FUNCTIONALLY ACCEPTED INSTALLATION AND DESIGN. DESIGN AND INSTALLATION SHALL TAKE INTO ACCOUNT THE FUNCTIONAL NEEDS OF THE INSTALLED ADJACENT EQUIPMENT AND ITS INTENDED USE BY THE CLIENT.

## SCOPE OF WORK

1. THESE DRAWINGS INDICATE THE DESIGN INTENT. THE DRAWINGS DO NOT PURPORT TO SHOW MINOR OFFSETS AND TRANSITIONS REQUIRED FOR COORDINATION WITH STRUCTURE AND OTHER SERVICES. MAKE ALLOWANCE FOR THESE OFFSETS AND TRANSITIONS.
2. THE SCOPE OF WORKS OF THE FIRE PROTECTION CONTRACTOR INCLUDES THE DETAILED DESIGN, SUPPLY, DELIVERY & / OR SHIPPING TO SITE, INSTALLATION, COMMISSIONING, AND SETTING TO WORK OF THE FOLLOWING SYSTEMS, EQUIPMENT, AND MATERIALS.

## WORKS TO BE INCLUDED

THE FOLLOWING WORK IS TO BE CARRIED OUT BY THE CONTRACTOR:

- THE FIRE PROTECTION SERVICES CONTRACTOR SHALL BE RESPONSIBLE FOR CO-ORDINATION WITH ALL OTHER SERVICES AND SHALL FURNISH ALL NECESSARY INFORMATION AS REQUIRED TO THE CONSTRUCTION MANAGER AND OTHER CONTRACTORS SO THAT THE WORKS CAN BE CARRIED OUT WITHOUT UNDUE DELAY TO THE CONSTRUCTION PROGRAM.
- ANY EXISTING OR OTHER SERVICES AND CONDITIONS DAMAGED DURING CONSTRUCTION OF THE SITE WORKS SHALL BE MADE GOOD AT THE CONTRACTOR'S EXPENSE. THE SITE, ON COMPLETION IS TO BE LEFT IN A NEAT AND TIDY CONDITION.
- PROTECTION OF FLOOR COVERINGS DURING THE WORK.
- FORMING AND MAKING GOOD ALL OPENINGS IN WALLS AND CEILINGS.
- TRENCHING AND BACKFILLING.
- SEAL ALL PENETRATIONS THROUGH FIRE RATED CONSTRUCTION, ACOUSTIC AND SMOKE BAFFLES WITH AN APPROVED FIRE, ACOUSTIC AND SMOKE SEALANT RESPECTIVELY.
- PAINTING AND IDENTIFICATION
- ALL OTHER WORKS REQUIRED FOR THE EXECUTION OF THE WORKS.

THE ABOVE MAY NOT BE ALL INCLUSIVE. THE CONTRACTOR IS TO MAKE ALLOWANCE FOR ALL WORKS AND EQUIPMENT REQUIRED TO COMPLETE THE WORKS TO THE APPLICABLE STANDARDS, SCOPING, AND CERTIFICATION NECESSARY FOR HANDOVER.

## SITE WIDE

WORKS TO BE INCLUDED

- FIRE WATER STORAGE TANKS TO ACCOMMODATE SITE FIRE HYDRANT AND HOSE REEL SYSTEM C/W BASE
- CONTAINERISED DUTY STANDBY ELECTRIC/DIESEL FIRE HYDRANT PUMPSET COMPLETELY ASSEMBLED AND FACTORY TESTED PRIOR TO DELIVERY TO SITE.
- SITE WIDE RETICULATION OF THE FIRE HYDRANT SYSTEM C/W INGROUND AND ABOVE GROUND PIPEWORK AS NECESSARY, INCLUDING A SITE WIDE RING MAIN PROVIDING OPEN YARD PROTECTION TO ALL POTENTIAL EXTERNAL STORAGE AND PROCESSING AREAS.
- DUAL HEADED FIRE HYDRANTS C/W 65mm QRT CONNECTIONS
- INGROUND SLUICE ISOLATION VALVES COMPLETE WITH BOX AND COVER PLATE FOR ACCESS VIA SPINDLE, VALVES TO BE NUMBERED.
- BOLLARD PROTECTION AND ANTI VANDAL COVERS TO FIRE HYDRANT LOCATIONS.
- FIRE BRIGADE SUCTION AND BOOSTER ARRANGEMENT C/W BASE AND CABINET
- DATA GATHERING PANELS (OR SUB-FIPS) TO BUILDINGS WITH NETWORKED INGROUND CABLING TO THE MAIN FIRE DETECTION CONTROL & INDICATING EQUIPMENT (FDCIE) PANEL (ALSO REFERRED TO AS FIRE INDICATOR PANEL). THE FIP IS LOCATED IN THE HYDROGEN PRODUCTION FACILITY CONTROL ROOM. HYDROGEN PRODUCTION FACILITY IS LOCATED IN THE ELECTROLYSER HALL.
- OCCUPANT WARNING PANELS AS REQUIRED TO FACILITATE EVACUATION ALARMS TO BUILDINGS AS INDICATED

## ELECTROLYSER HALL

WORKS TO BE INCLUDED

- FIRE HYDRANT COVERAGE FROM EXTERNAL FIRE HYDRANTS
- FIRE HOSE REEL COVERAGE FROM INTERNAL FIRE HOSE REELS
- FIRE ALARM SYSTEM CONSISTING OF FLAME DETECTION, POINT TYPE THERMAL DETECTION, MANUAL CALL POINTS, VISUAL WARNING DEVICES, AND HORN SPEAKERS
- PORTABLE FIRE EXTINGUISHERS

## WORKSHOP & WAREHOUSE BUILDINGS

WORKS TO BE INCLUDED

- FIRE HYDRANT COVERAGE FROM EXTERNAL FIRE HYDRANTS
- FIRE HOSE REEL COVERAGE FROM INTERNAL FIRE HOSE REELS
- FIRE ALARM SYSTEM CONSISTING OF FLAME DETECTION, POINT TYPE SMOKE DETECTION, MANUAL CALL POINTS, VISUAL WARNING DEVICES, AND CEILING MOUNTED & HORN SPEAKERS
- PORTABLE FIRE EXTINGUISHERS

## CONTROL ROOM & AMMENITIES, H2 PRODUCTION FACILITY SWITCHROOM ELECTRICAL ROOMS (HV, LV, MV, RECTIFIER)

WORKS TO BE INCLUDED

- FIRE ALARM SYSTEM CONSISTING OF FLAME DETECTION, POINT TYPE SMOKE DETECTION, MANUAL CALL POINTS, VISUAL WARNING DEVICES, AND CEILING MOUNTED & HORN SPEAKERS
- PORTABLE FIRE EXTINGUISHERS

## OUTDOOR SYSTEMS (TRANSFORMERS, H2 GAS CLEANING, WATER TREATMENT, COOLING, COMPRESSION, H2 STORAGE, TUBE TRAILERS LOADING BAYS)

WORKS TO BE INCLUDED

- FIRE HYDRANT COVERAGE FROM EXTERNAL FIRE HYDRANTS
- PORTABLE FIRE EXTINGUISHERS
- FIRE ALARM SYSTEM CONSISTING OF FLAME DETECTION AND POINT TYPE THERMAL DETECTION (AS REQUIRED FOR HYDROGEN DETECTION)

## DETECTION SYSTEM

THE SCOPE OF WORK SHALL COMPRISE THE SUPPLY OF ALL LABOUR AND MATERIALS NECESSARY FOR THE COMPLETE SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF THE FOLLOWING SERVICES IN ACCORDANCE WITH THE SPECIFICATION, AND THE ACCOMPANYING DRAWINGS.

1. THE INSTALLATION OF THE FIRE DETECTION AND BUILDING OCCUPANT WARNING SYSTEM IS TO COMPLY WITH AS1670, NCC AND LOCAL AUTHORITY REQUIREMENTS.
2. PROVIDE AND INSTALL ONE OFF FDCIE C/W LABEL AT THE GROUND FLOOR WITH LABEL "FIRE DETECTING AND CONTROL EQUIPMENT (FDCIE)" IN THE EVENT OF FIRE CALL 000 AT THE FRONT OF THE CUPBOARD.
3. BUILDING OCCUPANCY WARNING SYSTEM INTEGRATED INTO THE FIP.
4. PROVIDE HEAT/SMOKE DETECTORS AS REQUIRED.
5. PROVIDE SPEAKERS AND CONNECT TO THE FIP. ALLOW FOR ADDITIONAL SPEAKERS AS DETERMINED BY ON-SITE MEASUREMENTS TO ACHIEVE THE REQUIRED SOUND LEVEL AS PER BY CODE.
6. PROVIDE SPEAKER AND CONNECT TO THE FDCIE. IN THE EVENT OF A FIRE, WARNING SIGNALS SHALL SOUND THROUGH THE BUILDING TO ALERT OCCUPANTS. ADJUST SPEAKER EXACT LOCATION ON SITE AS REQUIRED.
7. REFER TO FIRE ENGINEERING REPORT FOR DETAIL, PROGRAMING AND INSTALLATION.
8. PROVIDE COMPLIANCE CERTIFICATION ON COMPLETION OF THE INSTALLATION. PROVIDE 3 HARD COPIES AND ONE ELECTRONIC COPY OF AS-INSTALLED DRAWINGS AND O&M MANUALS.
9. ALARM SIGNALING EQUIPMENT (ASE) IS REQUIRED TO BE INSTALLED.
10. ENGAGEMENT OF AN INDEPENDENT SYSTEM CERTIFIER FOR EACH OF THE SYSTEMS INSTALLED OR MODIFIED AS PART OF THE WORKS. THE INDEPENDENT FIRE SERVICES CERTIFIERS SHALL BE ACCREDITED BY THE FIRE PROTECTION ASSOCIATION AUSTRALIA AND SHALL BE NOMINATED BY THE PRINCIPAL/CLIENT.
11. PROVIDE GFA (GENERAL FIRE ALARM) CONTACTS FOR THE MECHANICAL SWITCHBOARD WHERE REQUIRED
12. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE FINAL CO-ORDINATED SPEAKER AND VISUAL WARNING DEVICE (VWD) SET-OUT WITHIN AREAS TO COMPLY WITH THE RELEVANT CODES AND SOUND PRESSURE LEVELS AND VISUAL EFFECTIVENESS.
13. ALLOW FOR ALL WORKS/PANELS REQUIRED AT THE MAIN FDCIE AND SUB-FIP PANELS.
14. ANY PENETRATION SHALL BE SEALED FOR WATERPROOF AND FIRE RATED RESISTANCE
15. FIBRE OPTIC CABLES SHALL CONFORM TO IEC 60331-25 WITH A MINIMUM OF 12 MIN FLAME APPLICATION TIME.
16. MAIN AND SUB FIPS SHALL ACCEPT ALARM SIGNAL INPUTS FROM THE FOLLOWING HYDROGEN GAS, LEAK, AND FLAME DETECTION INSTRUMENTS AS SHOWN ON THE RELATED DRAWINGS.
    - HYDROGEN GAS LEAKAGE DETECTION, DRAWING 17695-FIRE-GA-1002-03
    - HYDROGEN FLAME DETECTION, DRAWING 17695-FIRE-GA-1002-02
    - HYDROGEN GAS DETECTION, DRAWING 17695-FIRE-GA-1002-01

## FIRE HYDRANT

- PROVIDE FOR 2 OFF WATER STORAGE TANKS FOR THE SITE FIRE HYDRANT SYSTEM TO ALLOW FOR 50% REDUNDANCY DURING DRAIN DOWN FOR CLEANING &/OR MAINTENANCE.
- TANK CAPACITY SHALL ALLOW FOR NOT LESS THAN 3 OFF FIRE HYDRANTS TO OPERATE AT A DUTY OF 10 L/s EACH FOR A PERIOD OF 4 HOURS.
  TANK CAPACITY CAN NOT BE REDUCED AS IT IS UNCERTAIN A RELIABLE AUTOMATIC INFILL CAN BE PROVIDED FROM THE RAW WATER MAIN.
- TANK SHALL BE OF GALVANISED STEEL CONSTRUCTION AND BE COMPLETE WITH GALVANISED SHEET METAL ROOFING AND ANTI-VERMIN PROTECTION, MANHOLE ACCESS IN THE ROOF AND AT THE SIDE AT LOW LEVEL, EXTERNAL GALVANISED LADDER TO AS1567, TANK LEVEL INDICATOR, TANK SIGNAGE TO AS2419.1, INLET, OUTLET WITH ANTI-VORTEX PLATE, OVERFLOW CONNECTION, SCOUR OUTLET, AND TEST RETURN CONNECTION.
- PROVIDE A CONTAINERISED DUTY / STANDBY ELECTRIC / DIESEL FIRE HYDRANT PUMP WITHIN AN ENCLOSURE COMPLYING WITH AS2941 AND BE COMPLETE WITH JACKING PUMP AND ALL CONTROLS.
- THE FIRE PUMP IS TO BE SIZED TO MEET THE FIRE HYDRANT AND HOSE REEL SYSTEM DUTY FLOWS WHILE THE 3 MOST REMOTE HYDRANTS ARE OPERATING AT NOT LESS THAN 700kPa.
- INGROUND PIPING RETICULATION TO BE IN HDPE (PE100 RCD PIPE RECOMMENDED FOR SYSTEM LONGEVITY) NOMINALLY 180mm AND 125mm AND SHALL BE COORDINATED WITH OTHER TRADES AND STRUCTURES. HDPE PIPING SHALL BE BLACK WITH RED STRIP. HDPE PIPE FITTINGS MAY BE ALL BLACK.
- EXTERNAL HYDRANTS SHALL BE DUAL OUTLET C/W QRT CONNECTIONS, CAPS, ANTI-VANDAL COVERS AND FINAL LOCATIONS SHALL BE COORDINATED WITH OTHER SERVICES AND EQUIPMENT SO AS NOT TO OBSTRUCT ACCESS AND MAINTENANCE.
- HYDRANTS ARE TO BE PROTECTED BY BOLLARDS APPROPRIATELY LOCATED.
- INGROUND ISOLATION VALVES ARE TO BE PROVIDED AND LOCATED TO THE REQUIREMENTS OF AS2419.1, AND SHALL BE INSTALLED WITH PIPEWORK TO PROTECT THE SPINDLE FROM INGRESS OF DIRT AND A NUMBERED ACCESS COVER FOR IDENTIFICATION.
- ANY ABOVE GROUND ISOLATION VALVES SHALL BE OF THE MONITORED CLASS A TYPE AND CONNECTED BACK TO THE MFDCIE PANEL.
- ABOVE GROUND PIPEWORK SHALL BE OF GALVANISED STEEL TO AS1074. PROVIDE LOCATION IDENTIFICATION SIGNAGE WITHIN A CLEARLY VISIBLE LOCATION.
- ALL UNDER GROUND STEEL PIPEWORK, STEEL PIPE FITTINGS AND VALVES SHALL BE DENSO WRAPPED AS PER AS2419.1 TO 200mm ABOVE GRADE.
- ALL HYDRANT RISERS SHALL BE GALAVANISED STEEL PIPE TO MINIMUM 0.5m PAST FIRST ELBOW BELOW GRADE.
- ALL HYDRANT RISERS SHALL HAVE CAST CONCRETE THRUST BLOCK ON FIRST BELOW GRADE ELBOW, MINIMUM 0.9m CUBE WITH SL81 MESH REINFORCEMENT, MINIMUM 50mm COVER.
- A FIRE BRIGADE BOOSTER CABINET, C/W PLINTH, AND HOUSING A DUAL BOOSTER AND TANK SUCTION CONNECTION AND REMOTE PUMP START AND RUN CONTROLS IS TO BE PROVIDED, THE LOCAL FIRE BRIGADE IS TO BE CONSULTED TO DETERMINE WHETHER A SINGLE LARGE BORE CONNECTION TYPE AND SIZE, 2 OFF SMALL BORE (65mm) TANK SUCTION CONNECTIONS OR BOTH ARE OPERATIONALLY REQUIRED.
- INCLUSION IS TO BE MADE FOR EXTERNAL SIGNAGE, BLOCK PLANS, AND TEST AND WORKING PRESSURE SIGNAGE.
- YARD WITHIN FENCED PLANT AREAS WILL BE KEPT CLEAR OF VEGETATION AND COMBUSTIBLE MATERIALS UNLESS OTHERWISE SPECIFICALLY NOMINATED.

## FIRE HOSE REELS

1. ALLOW FOR FIRE HOSE REELS TO BE PROVIDED TO ELECTROLYSER HALL, WORKSHOP AND IF REQUIRED BASED ON HAZARDS, TO PROTECT STORAGE AREAS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS IN ACCORDANCE WITH AS 1940.
2. FIRE HOSE REELS SHALL BE 36m X 19m DIA, INSTALLED WITHIN A PROPRIETARY CABINET AND IN ACCORDANCE WITH AS2441, AND SHALL INCLUDE FOR LOCATION SIGNAGE WITHIN A CLEARLY VISIBLE LOCATION. POSITION THE FIRE HOSE REELS WITH CONSIDERATION GIVEN TO ACCESS AND OTHER SERVICES.
3. ALLOW TO PROVIDE SUITABLE TAIL END FOAM CREATION FACILITIES IF REQUIRED BY AS 1940.

## PORTABLE FIRE EXTINGUISHERS

1. ALL PLANTROOMS AND WORKSHOPS ARE TO BE PROVIDED WITH 4.5kg ABE DRY POWDER PORTABLE FIRE EXTINGUISHERS LOCATED ADJACENT TO ENTRY, WITHIN 5m. TRAVEL DISTANCE FROM EXTINGUISHER TO THE HAZARD TO BE NO MORE THAN 15m.
2. DIESEL TANKS AND PUMPS AND GENERATOR ROOMS ARE TO BE PROVIDED WITH 9.1L FOAM PORTABLE FIRE EXTINGUISHERS LOCATED ADJACENT TO AND EXTERNAL TO ENTRY, WITHIN 5m. TRAVEL DISTANCE FROM EXTINGUISHER TO THE HAZARD TO BE NO MORE THAN 15m.
3. ELECTRICAL AND MECHANICAL SWITCHBOARDS ARE TO BE PROVIDED WITH 5kg CARBON DIOXIDE PORTABLE FIRE EXTINGUISHERS LOCATED BETWEEN 2m AND 15m FROM THE BOARD.
4. ELECTRICAL SWITCHROOMS ARE TO BE PROVIDED WITH 5kg CARBON DIOXIDE PORTABLE FIRE EXTINGUISHERS LOCATED ADJACENT TO ENTRY, WITHIN 5m. TRAVEL DISTANCE FROM EXTINGUISHER TO THE HAZARD TO BE NO MORE THAN 15m.
5. STORAGE AREAS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS ARE TO HAVE EXTINGUISHERS PROVIDED IN ACCORDANCE WITH AS 1940 DEPENDANT ON LIQUIDS STORED AND QUANTITIES.
6. ANY OTHER BUILDING AREAS ARE TO BE PROVIDED WITH ABE DRY POWDER EXTINGUISHERS WITH A TRAVEL DISTANCE OF NOT MORE THAN 15m FROM ANY POINT ON THE FLOOR TO AN EXTINGUISHER IN LINE WITH PRIMARY EXTINGUISHER PROTECTION.
7. ALL PORTABLE FIRE EXTINGUISHERS ARE TO BE WALL MOUNTED, INSTALLED IN ACCORDANCE WITH AS 2444 AND WITH ALL STATUTORY SIGNAGE.

## TESTING & CERTIFICATION

1. SUBMIT A COMMISSIONING TEST REPORT AS NOMINATED IN APPENDIX F OF AS1670.1, AND AS1851.
2. SUPPLY ALL SKILLED LABOUR AND ASSISTANCE FOR TESTING, OPERATION AND ADJUSTING THE SYSTEMS AND EQUIPMENT, AND FOR FULLY INSTRUCTING THE PRINCIPAL OR HIS REPRESENTATIVE IN THE OPERATION OF THE SYSTEM AND EQUIPMENT. ALL TESTS SHALL BE MADE IN THE PRESENCE OF THE PRINCIPAL AND APPROPRIATE CERTIFIER. GIVE NOT LESS THAN SEVEN DAYS' NOTICE IN WRITING TO THESE PARTIES BEFORE MAKING ANY TESTS.
3. TESTING OF THE DETECTION AND ALARM SYSTEMS SHALL BE IN ACCORDANCE WITH AS1670.1 & AS1670.4. TEST THE CONNECTION OF THE DETECTION SYSTEM TO THE BUILDING FDCIE PANEL VERIFICATION OF ALL INTERFACES TO ENSURE CORRECT FIRE MODE OPERATION IN ACCORDANCE WITH BASE BUILDING REQUIREMENTS.
4. TESTING OF THE EMERGENCY WARNING AND INTERCOM SYSTEM TO BE INCLUDED FOR ALL INTERFACING AND FOR CORRECT SOUND PRESSURE LEVELS.
5. ENSURE THAT ALL TESTING IS IN ACCORDANCE WITH AS1851.
6. PROVIDE INDEPENDENT CERTIFICATION FOR ALL SYSTEMS INSTALLED, INCLUDING; FIRE DETECTION & ALARM SYSTEMS, FIRE HYDRANT & HOSE REEL SYSTEM.
7. PROVIDE INSTALLER'S LETTERS OF COMPLIANCE FOR ALL WORKS CARRIED OUT, INCLUDING BUT NOT LIMITED TO; FIRE SPRINKLERS, FIRE DETECTION, PORTABLE FIRE EXTINGUISHERS, AND SEALING OF PENETRATIONS.

## EVACUATION DIAGRAMS

1. PREPARE, SUPPLY, AND INSTALL NEW EVACUATION DIAGRAMS FOR EACH OF THE DETAILED BUILDINGS. DIAGRAMS ARE TO BE LAMINATED, FRAMED AND MOUNTED TO THE WALL. ALL DIAGRAMS ARE TO BE AS PER THE REQUIREMENTS OF AS3745, AND AS A MINIMUM SHALL REFLECT THE SAME DETAIL AS CURRENTLY DISPLAYED ON THE CURRENT DIAGRAMS.
2. DIAGRAMS SHALL BE SUBMITTED FOR APPROVAL, PRIOR TO INSTALLATION.

## SHOP DRAWINGS

1. SHOP DRAWINGS ARE TO BE SUBMITTED FOR APPROVAL PRIOR TO COMMENCING INSTALLATION.
2. SHOP DRAWINGS AND SAMPLES SHALL INCLUDE BUT SHALL NOT NECESSARILY BE LIMITED TO THE FOLLOWING:
    - PDF's OF ALL EQUIPMENT TECHNICAL DATA
    - DETECTION AND ALARM SYSTEM LAYOUTS AND SCHEMATICS
    - PUMPS AND TANK
    - SITE WIDE FIRE HYDRANT SYSTEM INCLUDING HOSE COVERAGE PLANS AND SCHEMATICS
    - FIRE HOSE REEL SYSTEMS INCLUDING HOSE COVERAGE PLANS
    - FIRE EXTINGUISHERS
    - BUILDER'S WORK REQUIRED

VERIFICATION OF HYDRAULIC CALCULATIONS AS PER HYENA CALCULATIONS OR SIMILAR ARE REQUIRED PRIOR TO ORDERING OF PUMPS AND TANK.

## AS BUILT DRAWINGS

PROVIDE AS BUILT DOCUMENTATION IN ACCORDANCE WITH THE CONTRACT. AS BUILT DOCUMENTATION TO INCLUDE ALL HYDRANTS, HOSE REELS, DETECTORS, SPEAKERS, AND FIELD DEVICES IN THE AFFECTED AREAS WITHIN 30 DAYS OF PRACTICAL COMPLETION. THE DRAWINGS SHALL ACCURATELY SHOW THE FULL EXTENT OF THE HYDRANT, DETECTION & ALARM SYSTEMS, ON PLANS SUFFICIENT TO FULLY DESCRIBE THE WORK UNDERTAKEN. DRY FIRE AS INSTALLED DRAWINGS ARE TO BE PROVIDED FOR THE FDCIE PANEL.

## PRACTICAL COMPLETION

1. PRACTICAL COMPLETION OF THE PROJECT WILL NOT BE GRANTED UNTIL THE FOLLOWING HAVE BEEN PROVIDED AND APPROVED:
    - INDEPENDENT THIRD PARTY CERTIFICATION OF THE FIRE ALARM (DETECTION AND EMERGENCY WARNING), FIRE HYDRANT & FIRE HOSE REEL, AND PUMPS & TANK SYSTEMS (DEFECT FREE)
    - INSTALLERS STATEMENT OF COMPLIANCE FOR ALL WORKS UNDERTAKEN I.E. FIRE HYDRANT, FIRE HOSE REEL, PUMPS & TANK, FIRE DETECTION, EMERGENCY WARNING, PORTABLE FIRE EXTINGUISHERS, AND PENETRATIONS. LETTER/S TO SPECIFY COMPLYING AUSTRALIAN STANDARDS, AND BE DATED AND SIGNED.
    - COMMISSIONING AND TESTING DOCUMENTS AS PER AS1670 AND AS1851
    - OPERATION & MAINTENANCE MANUALS
    - SYSTEM BLOCK PLANS (HYDRANT AND DRY FIRE) HAVE BEEN SUBMITTED AND APPROVED
    - AS-INSTALLED DRAWINGS HAVE BEEN SUBMITTED AND APPROVED
    - EVACUATION DIAGRAMS HAVE BEEN SUBMITTED AND APPROVED
    - ALSO REFER TO THE CONTRACT CONDITIONS
    - DEFECTS LIABILITY
2. ALL FIRE PROTECTION SERVICES INSTALLATION WORKS SHALL BE CARRIED OUT TO A HIGH QUALITY OF WORKMANSHIP AND INSTALLATION PRACTICE AND SHALL BE GUARANTEED AGAINST DEFECTS FOR A PERIOD OF 12 MONTHS FROM THE DATE OF ISSUE OF THE CERTIFICATE OF PRACTICAL COMPLETION.
3. DURING THIS PERIOD REPLACE ALL DEFECTIVE EQUIPMENT, FIXTURES, AND MATERIALS AT NO ADDITIONAL COST.
4. INCLUDE FOR AS1851 TESTING AND PREVENTATIVE MAINTENANCE DURING WARRANTY PERIOD

## OPERATION AND MAINTENANCE MANUALS

OPERATION AND MAINTENANCE MANUALS ARE TO BE PROVIDED IN ACCORDANCE WITH THE CONTRACT. ENSURE THAT COPIES OF ALL TEST REPORTS, CERTIFICATION CERTIFICATES, AND AS INSTALLED DOCUMENTATION ARE INCLUDED IN THE MANUALS.
MANUALS ARE TO BE PRESENTED IN INDEXED FORMAT, THREE (3) COPIES EACH AS FOLLOWS:

- HARD COPY, 3 RING BINDERS
- ELECTRONIC COPY

## SYSTEM BLOCK PLANS

PROVIDE SYSTEM BLOCK PLANS MOUNT AT THE FDCIE PANEL.

- PROVIDE FOR SIDE WIDE FIRE HYDRANT BLOCK PLANS AT THE FIRE BRIGADE BOOSTER CABINET AND AT THE FDCIE PANEL.
- BLOCK PLANS ARE TO BE LAMINATED AND FRAMED AND BE FADE RESISTANT.



| REV | AMENDMENT DETAILS | DESIGN | CHK'D | DRAWN | CHK'D | APP'D | DATE |
|---|---|---|---|---|---|---|---|
| B | ISSUED FOR MILESTONE 3 | KPB | IM | KPB | SHB | SHB | 01/05/25 |
| A | ISSUED FOR REVIEW | KPB | IM | KPB | SHB | SHB | 04/04/25 |

VENA ENERGY AUSTRALIA

UGL
ABN 96 096 365 972
40 Miller Street
North Sydney NSW 2060
www.ugllimited.com
A MEMBER OF THE CIMIC GROUP CIMIC



| | |
|---|---|
| DESIGNED | KPB |
| CHECKED | IM |
| DRAWN | KPB |
| CHECKED | SHB |
| APPROVED | SHB |

A3 N.T.S. CONFIRM SCALE 100mm ON A3

VENA ENERGY GLADSTONE PROJECT
HYDROGEN PRODUCTION PLANT
STAGE 1: FEED STUDY 50MW ELECTROLYZER
FIRE SERVICES FUNCTIONAL SPECIFICATION

| Client | UGL DRAWING No. | SHEET | REV |
|---|---|---|---|
| VENA ENERGY | 17695-FIRE-SPC-1001 | 01 | B |

# VENA EUROA HYDROGEN PROJECT

# Process Safety Specification

# 50MW Hydrogen Production Facility

# UGL Project TC-17695

CLIENT: VENA ENERGY AUSTRALIA

Document: 17695-PROC-RPT-1003

| Rev | Date | Prepared By | Checked by | Approved by | Status |
|---|---|---|---|---|---|
| A | 16/07/24 | BW | KB, SHB | | Draft |
| B | 7/8/2024 | BW | SHB | SHB | Issued For Use |
| C | 14/10/2024 | IM/BW | SHB | SHB | Issued For Use |
| D | 28/03/2024 | BW | IM | SHB | Issued For HAZOP |

PLANS AND DOCUMENTS referred to in the SDA APPROVAL

Queensland Government

SDA approval: AP2023/015

# Contents

# 1 Purpose

The Vena Euroa Hydrogen Project involves the construction of a 50MW hydrogen production plant, hydrogen storage and tube trailer filling facilities.

Process safety is the management of the integrity of operating systems by applying inherently safer design principles, engineering and disciplined operating practices. It deals with the prevention and mitigation of incidents that have the potential for a loss of control of a hazardous material or energy. Such loss of control may lead to severe consequences with fire, explosion, and may ultimately result in loss of life, serious injury, extensive property damage, environmental impact and lost production with associated financial and reputational impacts.

The purpose of this specification is to detail the process safety considerations for the design of the facility.

# 2 Definitions

## 2.1 Definitions

- AS – Australian Standard
- BPCS – Basic Plant control system
- CEB – Chemically enhanced backwash
- CHAIR – Construction Hazard Assessment Implementation Review
- CHAZOP – Control Hazard and operability study
- CIP – Clean In place
- Company – UGL
- ESD – Emergency Shutdown
- FEED – Front End Engineering & Design
- FMEA – Failure Mode and Effects Analysis
- HAZOP – Hazard and operability study
- ISD – Inherently Safer Design
- LOPA – Layers of Protection Analysis
- MSDS – Material Safety Data Sheets
- PCBU – Person Conducting a Business or Undertaking
- PCM – Power Conversion Module
- PLC – Programmable Logic Controller
- QRA – Quantative Risk Assessment
- SI – International System of Units
- SIS – Safety Instrumented System
- SIL – Safety Integrity Level
- SIF – Safety Instrumented Function
- UGL – UGL Engineering Pty Ltd
- VENA – Vena Energy Australia

# 3 Scope

The scope of this specification is to outline the process to identify the risks and determine the approach to process safety relating to the hydrogen production facility. Process safety will be integrated into the design process through both the FEED and detailed design processes.

Whilst the process hazards associated with the production, storage and handling of hydrogen are predominantly associated with explosion and fire risks with hydrogen gas, other risks will also be considered during the design process including:

- Storage and handling of compressed gasses
- Storage and handling of asphyxiant gasses (nitrogen and hydrogen)
- Dangerous goods handling such as water treatment plant chemicals
- Electrical safety and earthing
- Lightning
- Traffic management

# 4 General

## 4.1 WHS ACT 2011

The guiding principle of the Queensland WHS Act 2011 is that all people are given the highest level of health and safety protection from hazards arising from work, so far as is reasonably practicable.

Section 22 of the WHS Act requires that designers must ensure, so far as is reasonably practicable that the plant is designed to be without risks to the health and safety of persons:

a) who, at a workplace, use the plant, substance or structure for a purpose for which it was designed; or
b) who handle the substance at a workplace; or
c) who store the plant or substance at a workplace; or
d) who construct the structure at a workplace; or
e) who carry out any reasonably foreseeable activity at a workplace in relation to:
    i) the manufacture, assembly or use of the plant for a purpose for which it was designed, or the proper storage, decommissioning, dismantling or disposal of the plant; or
    ii) the manufacture or use of the substance for a purpose for which it was designed or the proper handling, storage or disposal of the substance; or
    iii) the manufacture, assembly or use of the structure for a purpose for which it was designed or the proper demolition or disposal of the structure; or
    iv) Inspection, operation, cleaning, maintenance or repair of plant.
f) who are at or in the vicinity of a workplace and who are exposed to the plant, substance or structure at the workplace or whose health or safety may be affected by a use or activity referred to in paragraph (a), (b), (c), (d) or (e).

The term 'reasonably practicable' means what could reasonably be done at a particular time to ensure health and safety measures were in place. In determining what is reasonably practicable, there is a requirement to weigh up all relevant matters including:

- the likelihood of a hazard or risk occurring (i.e. the probability of a person being exposed to harm)
- the degree of harm that might result if the hazard or risk occurred (i.e. the potential seriousness of injury or harm)
- what the person concerned knows, or ought to reasonably know, about:
    - the hazard or risk and
    - ways of eliminating or minimising it
- the availability of suitable ways to eliminate or minimise the hazard or risk
- the cost of eliminating or minimising the hazard or risk.

Ordinarily, cost will not be the key factor in determining what it is reasonable for a duty holder to do unless it can be shown to be 'grossly disproportionate' to the risk. If the risk is particularly severe, a PCBU (Person Conducting a Business or Undertaking) will need to demonstrate that costly safety measures are not reasonably practicable due to their expense and that other less costly measures could also effectively minimise the risk.

## 4.2 Storage And Handling of Chemicals

Chemicals used and stored on site are included in Table 4-1. The storage of chemicals will be within bounded areas in accordance with relevant Australian standards.

Table 4-1- Chemicals

| Chemical | Use | Area | Comment |
| --- | --- | --- | --- |
| Nitrogen Liquid | Maintenance and safety purging, continuous purging and nitrogen blanketing | Bulk nitrogen storage | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Sodium Hydroxide Solution | Water Treatment chemical<br>(pH adjustment- Clean In place (CIP) Chemically enhanced backwash (CEB) and Water, | Water treatment Plant | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Citric Acid Solution | Water Treatment chemical<br>(CIP) | Water treatment Plant | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Sodium Hypochlorite Solution | Water Treatment chemical<br>(Disinfection) | Water treatment Plant | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Coagulant solution | Water Treatment chemical<br>(Coagulation) | Water treatment Plant | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Biocide | Water Treatment chemical<br>(CIP) | Water treatment Plant | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Anti-scalant | Water Treatment chemical<br>(CIP) | Water treatment Plant | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Polymer | Water Treatment chemical<br>(Coagulation) | Water treatment Plant | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Corrosion Inhibitor | Cooling/Chilling chemical | Cooling/Chilling circuits | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| **Chemicals for water polishing** | **PLUG TO ADVISE** | | |

## 4.3 Pressurised Gasses

Pressurised gasses stored on site are detailed in Table 4-2. Vessels for the storage of pressurised gasses will be designed in accordance with AS1210.

Venting and relief systems are further detailed in the Process Venting and Relief Philosophy (17695-PROC-RPT-1002)

Table 4-2- Pressurised Gasses

| Chemical | Use | Area | Comment |
|---|---|---|---|
| Hydrogen | Product | Electrolysis, compression, storage and dispensing | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Oxygen | Byproduct from hydrogen production | Electrolysis | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Nitrogen | Maintenance and safety purging, continuous purging and nitrogen blanketing | Nitrogen storage Electrolysis, compression, storage and dispensing | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Carbon Dioxide | Chilling gas | Dispensing chillers | Refer Typical Safety Data Sheet included in Appendix A2 for further details |
| Compressed Air | Instrument air | All | Refer Typical Safety Data Sheet included in Appendix A2 for further details |

Particular risks associated with the storage and handling of hydrogen is further detailed in section 4.4.

## 4.4 Hydrogen Properties

Hydrogen has unique physical and chemical properties that make it an attractive option for energy storage, transport, and use. However, hydrogen also poses fire/explosion risks due to its high flammability. Hydrogen is a colourless, odourless, and tasteless gas that is highly flammable in air and can ignite at concentrations as low as 4%. It has the lowest density of all gases and is fourteen times lighter than air. Hydrogen occurs in nature in the form of diatomic molecules ($H_2$) and can be obtained from various sources such as natural gas, water, and biomass.

Hydrogen can form a flammable mixture with air, which can cause explosions if ignition occurs. Hydrogen reacts with oxygen to form water, which is a reaction that releases a significant amount of energy.

Hydrogen is a very light gas that diffuses rapidly in air and can easily spread over large distances. This behaviour is quite positive in terms of the risk effect since the dispersion of hydrogen in air is very effective and hydrogen can rapidly reduce its concentration. However, this poses a risk of explosion since hydrogen concentrations may reach the flammable range very close to the source point in the first moment of the gas release. Whilst not toxic, hydrogen is an asphyxiant.

In addition, hydrogen flames are transparent and difficult to detect, therefore, it is more difficult to identify and mitigate hydrogen flames, at least in the early stages. Moreover, due to its low molecular weight, hydrogen molecules can easily penetrate materials such as metals and plastics, thus activating cracking or embrittlement phenomena which cause accidental $H_2$ release. This can pose a risk if not assessed during material of construction choices and if hydrogen leaks occur from vessels as it can rapidly spread and accumulate in enclosed spaces.

Other hydrogen gas properties are:

- Low ignition energy;
- High reactivity due to its chemical and physical properties;
- Wide flammability limits: 4%–75% in air

- Deflagration-to-detonation transition: the transition can easily occur and is often observed in the case of a large-scale system;
- High burning velocity: the laminar burning velocity is significantly higher than that of many other fuels.
- Hydrogen is colorless, odorless, and tasteless
- High reactivity with materials (embrittlement): significant investments are needed on material investigation.
- Low gas density and diffusivity: in the case of release, it can stratify in the upper part of confined spaces.

## 4.5 Design Standards

All relevant Australian Standards, codes, regulations and by-laws will be applied to engineering design activities. All project standards are treated as controlled documents and latest current issues will be utilised. The Project will be based on Australian codes and standards, where an Australian code or standard does not exist, International Standards will apply.

Order of precedence:

- Australian Standards and Codes.
- American Standards and Codes; and
- British Standards and Codes.
- Other international codes and standards.

A list of applicable standards is included in APPENDIX 1- Design Standards

# 5 Process Design Safety

## 5.1 Hazard And Risk Identification

During the feed and detailed design phases a number of tools will be utilised to identify Hazards and assess risks associated with the process. The tools to be utilised are detailed in Table 5-1.

Table 5-1- Investigations, Studies and Workshops

| Investigation | Description | FEED Study | Detailed Design |
|---|---|---|---|
| **HAZOP (Hazard and Operability Study)** | Structured technique performed by a multidisciplinary team to prompt a detailed analysis of process design to identify potential deviations from intended design and function | ✓ | ✓ |
| **CHAZOP (Control Hazard and operability study)** | Control Hazard and Operability Study is a procedure for carrying out the safety and reliability analysis of existing or planned control and computer systems. | | ✓ |
| **CHAIR. (Construction Hazard Assessment Implementation Review)** | Construction Hazard Assessment Implication Review is a tool to assist designers, constructors, clients and other key stakeholders to come together to reduce construction, maintenance, repair and demolition safety risks associated with design. | ✓ | ✓ |
| **FMEA (Failure Mode and Effects Analysis)** | Takes a selected part of a system, usually a piece of hardware, and examines every failure mode of every item and every element within it; consequences for each failure mode are determined to evaluate the adequacy of the response to the failure | | ✓ |

| Investigation | Description | FEED Study | Detailed Design |
|---|---|---|---|
| **LOPA (Layers of Protection Analysis)** | Analytical procedure that draws on fault and event tree analysis to examine the independent protection layers in a plant and the actions should a specific unwanted event occur | | ✓ |
| **SIL Assessment (Safety Integrity Level Assessment)** | Relative level of risk reduction provided by a safety instrumented function (SIF) expressed as the probability that the safety instrumented system (SIS) will perform its safety function | | ✓ |
| **Fire and Explosion Risk Assessment** | Fire & Explosion Risk Assessment (FERA) is a structured and systematic process to identify and assess risks from fire and explosion hazards. The results of this assessment are used to ensure safe facility layouts, specify passive and active fire protection requirements, and provide input for Escape and Evacuation Risk Assessment (EERA), Emergency Systems Survival Assessment (ESSA), Building Risk Assessment (BRA) and Quantitative Risk Assessment (QRA) studies. | ✓ | ✓ |
| **Hazardous Area Classification study** | The Hazardous Area Classification Study involves the assessment of the areas of the plant where an explosive atmosphere may exist. Hazardous zones are 3 dimensional spaces where an explosive atmosphere exists and are classified in accordance with AS/NZS IEC 60079.10.1:2022 Explosive atmospheres and the electrical equipment permitted within the zoned area are identified.<br>The hazardous area zones and flammable material properties are used to define the appropriate equipment for use with the hazardous zones. | ✓ | ✓ |
| **QRA Quantitative Risk Analysis** | Quantitative assessment of risks associated with fire and explosions to classify activities and inventories; to estimate consequences to people and to property from accidental releases of potentially hazardous material and energy; and to assess the risk to people and to neighbouring (on and off site) plant and facilities to allow decisions around buffer distances and layout of plant and equipment to be made. The purpose of the Consequence and Risk Assessment is to simulate over pressure and radiation contours that demonstrate that major incident hazards and risks associated with the project have been identified and can be managed appropriately | ✓ | ✓ |
| **Safety Separation Distance application** | Safety separation distances are safe distances between equipment to prevent a fire or explosion in one piece of equipment propagating to another potential resulting in cascading failures.<br>Separation distances are defined by:<br>• NFPA 2 (Hydrogen Technologies Code)<br>• Quantitative Risk Assessment (QRA)<br>• Other standards including AS2067 (Substations and high voltage installations exceeding 1kV a.c)<br>• Hazardous Area Classification | ✓ | ✓ |

| Investigation | Description | FEED Study | Detailed Design |
|---|---|---|---|
| | The definition of safety separation distances allows the plant layout to be developed and any additional fire and explosion controls required to be developed (e.g. fire walls) | | |

## 5.2 Control Of Risk

Control of risks to prevent and mitigate hazardous incidents is the overall objective of hazard identification, risk assessment and safety-related management. The priority for control actions is:

- Elimination through design
- Prevention
- Evaluation and assurance
- Mitigation.

Prevention and mitigation are achieved through passive, active and administrative barriers applied within a systematic approach to the process safety and OHS management.

### 5.2.1 Elimination through Design

Inherently Safer Design (ISD) is based on the premise that it is better to remove the hazard or reduce the magnitude of the hazard than to control it with equipment and procedures. While there are several ways of categorising ISD strategies, including:

- Minimisation
- Substitution
- Moderation
- Simplification

it is usually not possible to target all hazards in a plant equally. For example, to allow for a reduced inventory of a hazardous chemical, the design may require processing at a higher temperature and pressure; in this case the higher temperature and pressure is accepted to reduce the risk of a hazardous inventory. Another scenario is that there may be two possible solvents for a process – one flammable with low toxicity, the other with low flammability but high acute toxicity. The hazard and ISD strategy selected will often represent a compromise based on intensive risk assessment that considers the life cycle of the plant and the technology available at the time.

#### 5.2.1.1 Minimisation

Reducing the hazardous energy by reducing the size of the equipment inventory (intensification of the process) is inherently safer as the consequences of a loss of containment will be correspondingly reduced. Use of smaller units also enables implementation of other design safety features such as stronger containment. Process conditions in smaller containers are more uniform so there will be better process control and improved safety. As smaller equipment is cheaper to build there are also financial benefits.

#### 5.2.1.2 Substitution

Substitution of a less-hazardous chemical or process reduces the overall hazards but must usually be considered at the design stage. Examples of such substitutions are the use of an aqueous solution as a solvent in a purification process rather than a flammable solvent such as toluene or methanol, and cleaning with detergent and water rather than a solvent. Substitution for safety reasons is often linked with strategies to reduce environmental impact of chemicals and chemical processing.

#### 5.2.1.3 Moderation

Sometimes referred to as attenuation, changing a material or process to moderate a hazard can reduce the consequences of a loss of control. Moderation involves using processes requiring less-hazardous operating conditions, i.e. reaction conditions closer to ambient temperature and atmospheric pressure. This may be achieved by:

- Dilution with a less-hazardous material, reducing the impact of a loss of containment and, in some cases, increasing the stability of the chemical.
- Refrigeration (e.g. storing liquefied natural gas under refrigeration at atmospheric pressure thus reducing the need for pressure containment).
- Changing physical characteristics (e.g. handling and transporting a chemical in crystalline form rather than as a fine or combustible dust).
- Use of a catalyst to allow a lower operating temperature.

#### 5.2.1.4 Simplification

For a complex process or plant that is usually more difficult to operate and less tolerant of errors, at the design stage the emphasis should be on the simplest design possible to eliminate a hazard or minimise the need for complex control and safeguard systems. Some general principles are:

- Use of stronger (higher pressure rated) equipment to reduce the need for complex pressure relief systems, instrumentation and interlocks.
- Elimination of seldom-used piping.
- Processes tolerant to variations in operating parameters and feedstock changes.
- Making incorrect operation impossible (e.g. use of selective couplings to prevent inadvertent cross-connection of utilities such as nitrogen and breathing air systems) .
- Good human factor design to ensure equipment operates the way people expect it to operate and provides feedback to confirm proper operation (Mannan, 2012).

### 5.2.2 Layers of protection

A single safety measure alone can eliminate risk, where the level of risk cannot be reduced to an acceptable level by a safety measure additional protective layers of safety measures may be required such that if one protection layer fails, successive layers can take the process to a safe state. As the number of protection layers and their reliability increases, the safety of overall process increases. A typical example of the safety protection systems is shown in Table 5-2.

**Table 5-2 Layers of protection**

| Layer of protection | Protection measure | Examples | Safeguards |
|---|---|---|---|
| Layer 1 | Process design | Design to standards, inherently safer design | |
| Layer 2 | Basic controls | Process controls, process alarms (yellow), operator supervision | |
| | Critical alarms | Process alarms (red), operator intervention<br>Safety Instrument System | Preventive safeguards |
| Layer 3 | Automatic actions | Shutdown, emergency shutdown (ESD)<br>Safety Instrument System | |
| Layer 4 | Physical protection | Relief valves, rupture discs, fire and gas system | |
| | | Firewalls, dikes, berms, bunds (local containment) | Mitigative safeguards |

Layer of Protection Analysis (LOPA) is a method whereby all known process hazards and all known layers of protection are closely scrutinized. Each non-SIS safety measure is assigned its own hazard risk reduction factor. For each process hazard where the LOPA study concludes that existing non-SIS protection cannot reduce risk to an acceptable or tolerable level, a Safety Instrumented System i.e., SIS is required. Not all process hazards will require the use of a SIS.

During the FEED phase a Layers of Protection analysis (LOPA) will not be undertaken for the whole of plant system, however safety critical systems have been identified and additional layers of protection have been applied. A full LOPA will need to be undertaken for the integrated system during the detailed design phase.

The first layer of protection is the safety of the design itself. The FEED design has been developed in accordance with the processes outlined in this specification and considers:

- Hazards identified during the pre-feed HAZOP.
- Risks identified during the design process.
- HAZOP
- CHAIR

The second layer of protection is the Control System. The plant is equipped with a PLC based BPCS (Basic Plant control system) with various parameter measurement instruments and control elements such as control valves to ensure the steady state operation of the system and to manage process upsets.

The third layer of protection is the Automated Safety System. The plant has an independent Safety Instrumented System (SIS). If there is any process upset which cannot be controlled by the BPCS or is caused by failure / errors in the BPCS, then the system is taken to the safe state. The SIS consists of parameter measurement instruments independent of the control instruments. Once the trip(s) on the safety instrument is triggered, the system is taken to a safe state by tripping the PCM (Power Conversion Module) to stop further production of hydrogen and then depressurized with the help of a network of blowdown valves. Critical instruments, equipment and controllers are SIL (Safety Integrity Level) rated and are hard-wired to and from the SIS to increase their reliability and ultimately improving the reliability of the system.

It is expected the process area that contains the systems is equipped with hydrogen gas detectors and/or flame detection to warn operators and shut down the system in case of a hazardous situation due to a hydrogen leak or fire.

An H2 in O2 analyzer is also provided to continuously monitor the hydrogen content on the anode side of the electrolyser stack to ensure that there is no membrane failure or large hydrogen carry-over.

The fourth layer of protection is the Mechanical Safety Devices. The plant is equipped with pressure safety valves and rupture discs to ensure that the system is depressurized to safe pressure levels in case the other layers of protection fail. The pressure safety valves are designed to relieve the pressure safely which might be the result of various cases as follows:

- Fire Case
- Blocked Outlet
- Liquid Overfilling
- Gas Blowby
- Membrane rupture
- Control valve / actuated valve failure
- Reverse flow due to check valve / actuated valve failure, etc.

### 5.2.3 Safety Instrument System (SIS)

The safety instrumented system (SIS) is an engineered set of hardware and software controls which provides a protection layer preventing unsafe operations or dangerous conditions from occurring.

The safety instrumented system consists of instruments, controllers and controls which meet a defined safety integrity level (SIL) requirement.

The safety integrity level is used to define the reliability of a specific safety instrumented function (SIF) which is implemented by a safety instrumented system.

### 5.2.4 Safety Integrity Level (SIL)

Each hazard that requires the use of the safety instrument system must be assigned a target safety integrity level. A formal SIL study is not proposed for the FEED stage of the project and will occur during the detailed design phase.

SIL means Safety Integrity Level that comes from standard IEC 61511 – Safety Instrumented System for the process industry sector, to quantify safety performance requirements for hazardous operations.

There are four SIL Levels (SIL1 – SIL4). A higher SIL level means a greater process hazard and a higher level of risk reduction required from the SIS.

Each SIF serves as a layer of protection to bring the effective hazard frequency below the acceptable hazard frequency. To do this, each SIF must have a minimum risk reduction factor. The difference between the acceptable hazard frequency and the frequency of hazard determined after applying non-SIS protection layers should be the minimum risk reduction factor or target SIL level of the SIF.

# A1 APPENDIX 1- Design Standards

The following table contains a list of standards which may be utilized in hydrogen plant design. Additional or alternative standards will likely be required and considered.

| Source | Number | Year | Description |
|---|---|---|---|
| AS | 1020 | 2023 | The control of undesirable static electricity |
| | | | |
| AS | 1170.0 | 2002 | Structural design actions - General principles |
| AS | 1170.1 | 2002 | Structural design actions - Permanent, imposed and other actions |
| AS | 1170.2 | 2021 | Structural design actions - Wind actions |
| AS | 1170.4 | 2007 | Structural Design Actions Part 4: Earthquake Actions in Australia |
| AS | 1171 | 1998 | Non-destructive testing – Magnetic particle testing of ferromagnetic products, components and structures |
| AS | 1200 | 2015 | Pressure equipment |
| AS | 1210 | 2010 | Pressure Vessels |
| AS | 1554 | - | Structural steel welding - Set |
| AS | 1657 | 2018 | Fixed platforms, walkways, stairways and ladders — Design, construction and installation |
| AS | 1796 | 2022 | Welder Certification |
| AS | 2030.1 | 2009 | Gas Cylinders, Part 1 - General Requirements |
| AS | 2030.4 | 1985 | The verification, filling, inspection, testing and maintenance of cylinders for storage and transport of compressed gases, Part 4: Welded cylinders - Insulated |
| AS | 2030.5 | 2009 | Gas cylinders, Part 5: Filling, inspection and testing of refillable cylinders |
| AS | 2177 | 2006 | Non-destructive testing – Radiography of welded butt joints in metal – Methods of test |
| AS | 2337.1 | 2004 | Gas cylinder test stations, Part 1: General requirements, inspection and tests - Gas cylinders |
| AS | 2337.3 | 2020 | Gas cylinder test stations, Part 3: Transportable gas cylinders - Periodic inspection and testing of composite cylinders (ISO 11623:2015, MOD) |
| AS | 2885.0 | 2018 | Pipelines - Gas and liquid petroleum - Part 0: General requirements |
| AS | 3000 | 2018 | Electrical installations (known as the Australian/New Zealand Wiring Rules) |
| AS | 3452.2 | 2023 | Non-destructive testing – penetrant testing – testing of penetrant materials |
| AS | 3788 | 2024 | Pressure equipment - In-service inspection |
| AS | 3892 | 2001 | Pressure Equipment – Installation |
| AS | 3920 | 2015 | Pressure equipment - Conformity assessment |
| AS | 3992 | 2020 | Pressure Equipment – Welding and Brazing Qualification |
| AS | 4037 | 1999 | Pressure Equipment – Examination and Testing |
| AS | 4041 | 2006 | Pressure Piping |
| AS | 4332 | 2004 | The storage and handling of gases in cylinders |
| AS | 4343 | 2014 | Pressure Equipment - Hazard Levels |
| AS | 4458 | 1997 | Pressure Equipment – Manufacture |
| AS | 4481 | 1997 | Pressure Equipment - Inspection Bodies and Personnel |
| AS | 4484 | 2016 | Gas Cylinders for industrial, scientific, medical and refrigerant use - Labelling and colour coding |
| AS | 4564 | 2020 | General-purpose natural gas |

| Source | Number | Year | Description |
|---|---|---|---|
| SA | TS 5359 | 2022 | The storage and handling of hydrogen |
| AS | 14687 | 2020 | Hydrogen fuel quality - Product Specification |
| AS | SA TR 15916 | 2021 | Basic considerations for the safety of hydrogen systems |
| AS | 16110.1 | 2020 | Hydrogen generators using fuel processing technologies |
| AS | 16111 | 2020 | Transportable gas storage devices - Hydrogen absorbed in reversible metal hydride |
| AS | 19880.1 | 2023 | Gaseous hydrogen - Fueling stations, Part 1: General requirements (ISO 19880-1:2020, MOD) |
| AS | 19880-3 | 2020 | Gaseous hydrogen - Fueling stations Part 3 Valves |
| AS | ISO 19880-5 | 2021 | Gaseous hydrogen - Fueling stations Part 5 Dispensing hoses and assemblies |
| AS | ISO 19880-8 | 2021 | Gaseous hydrogen - Fueling stations Part 8 Fuel quality control |
| AS | ISO 19881 | 2020 | Gaseous hydrogen - Land Vehicle fuel containers |
| SA | TS 19883 | 2020 | Safety of pressure swing adsorption systems for hydrogen separation and purification |
| AS | 22734 | 2020 | Hydrogen generators using water electrolysis - Industrial, commercial, and residential applications |
| AS | 26142 | 2020 | Hydrogen detection apparatus - Stationary applications |
| AS | 60079.0 | 2019 | Explosive atmospheres – Equipment – General requirements |
| AS | 60079.10.1 | 2022 | Explosive atmospheres, Part 10.1: Classification of areas - Explosive gas atmospheres |
| AS | 60079.14 | 2022 | Explosive atmospheres Design selection, erection and initial inspection |
| AS | 60079.29.1 | 2017 | Explosive atmospheres - Gas detectors - Performance requirements of detectors for flammable gases |
| AS | 60079.29.2 | 2016 | Explosive atmospheres - Gas detectors - Selection, installation, use and maintenance of detectors for flammable gases and oxygen |
| AS | 60529 | 2004 | Degrees Of Protection Provided by Enclosures (IP Code) |
| AS | TR 61508.0 | 2006 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Functional safety and AS 61508 |
| AS | 61508.1 | 2011 | Functional safety of electrical/electronic/programmable electronic safety-related systems - General requirements |
| AS | 61508.2 | 2011 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Requirements for electrical/electronic/programmable electronic safety-related systems |
| AS | 61508.3 | 2011 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Software requirements |
| AS | 61508.4 | 2011 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Definition and abbreviations |
| AS | 61508.5 | 2011 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Examples of methods for the determination of safety integrity levels |
| AS | 61508.6 | 2011 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Guidelines on the application of AS 61508.2 and AS 61508.3 |
| AS | 61508.7 | 2011 | Functional safety of electrical/electronic/programmable electronic safety-related systems - Overview of techniques and measures |
| AS | 61511.1 | 2018 | Functional safety - Safety instrumented systems for the process industry sector, Part 1: Framework, definitions, system, hardware and application programming requirements |

| Source | Number | Year | Description |
|---|---|---|---|
| AS | 61511.2 | 2018 | Functional safety—Safety instrumented systems for the process industry sector Part 2: Guidelines for the application of AS IEC 61511.1 |
| AS | 61511.3 | 2018 | Functional safety—Safety instrumented systems for the process industry sector Part 3: Guidance for the determination of the required safety integrity levels |
| AS | 62282.2.100 | 2022 | Fuel cell technologies Part 2.100: Fuel cell modules - Safety |
| AS | 62282.3.100 | 2021 | Fuel cell technologies Part 3.100: Stationary fuel cell power systems - Safety |
| AS | 62282.3.300 | 2021 | Fuel cell technologies Part 3.100: Stationary fuel cell power systems - Installation |
| AS | 80079.20.1 | 2019 | Explosive atmospheres, Part 20.1: Material characteristics for gas and vapour classification - Test methods and data |
| AS | HB225 | 2023 | Guideline for blending hydrogen into pipelines and gas distribution networks |
| CSA | HGV 4.8 | 2012 | Hydrogen gas vehicle fueling station compressor guidelines |
| ASME | B1.20.1 | 2013 | Pipe Threads, General Purpose (Inch) |
| ASME | B16.11 | 2021 | Forged Fittings, Socket-Welding & Threaded |
| ASME | B16.20 | 2023 | Metallic Gaskets for Pipe Flanges Ring-Joint, Spiral-Wound, and Jacketed |
| ASME | B16.47 | - | Large Diameter Steel Flanges Series B |
| ASME | B16.5 | 2020 | ASME Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard |
| ASME | B16.9 | 2018 | Factory –Made Wrought Butt-welding Fittings |
| ASME | B31.3 | 2022 | Process Piping |
| ASME | B31.12 | 2023 | Hydrogen Piping and Pipelines |
| ASME | B36.10 | 2022 | Welded and Seamless Wrought Steel Pipe |
| ASME | B36.19 | 2022 | Stainless Steel Piping |
| ASME | BPVC Sections II, V, VIII, IX | - | ASME Boiler and Pressure Vessel Code<br>Section II – Material Specifications<br>Section V – Non-Destructive Examination<br>Section VIII – Rules for Construction of Pressure Vessels<br>Section IX – Welding, Brazing and Fusing Qualifications |
| ASME | STP-PT-006 | 2007 | Design Guidelines for Hydrogen Piping and Pipelines |
| API | 14C | 2017 | Analysis, design, installation and testing of basic surface safety system for offshore production platforms |
| API | 14E | 1991 | Recommended Practice for Design and Installation of Offshore Products Platform Piping Systems |
| API | 520 | 2020 | Sizing, Selection, and Installation of Pressure Relieving Device |
| API | 521 | 2020 | Pressure-relieving and Depressuring Systems |
| API | 537 | 2017 | Flare Details for General Refinery and Petrochemical Service |
| API | 614 | 2022 | Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries, Sixth Edition |
| API | 617 | 2022 | Axial and Centrifugal Compressors and Expander-compressors |
| API | 618 | 2007 | Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services |
| API | 619 | 2010 | Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries |
| API | 682 | 2014 | Pumps-Shaft Sealing Systems for Centrifugal and Rotary Pumps |
| API | 692 | 2018 | Dry Gas Sealing Systems for Axial, Centrifugal, and Rotary Screw Compressors and Expanders |
| CGA | G-5 | 2017 | Compressed Gas Association - Hydrogen, 8th Edition |
| CGA | G-5.3 | 2017 | Compressed Gas Association - Commodity Specification for Hydrogen, 7th edition |

| Source | Number | Year | Description |
|---|---|---|---|
| CGA | G-5.4 | 2019 | Compressed Gas Association - Standard for Hydrogen Piping Systems at Consumer Locations, 6th edition |
| CGA | G-5.5 | 2021 | Compressed Gas Association - Hydrogen Vent Systems, 4th edition |
| CGA | G-5.6 | 2005 | Compressed Gas Association - Hydrogen Pipeline Systems, 1st edition |
| CGA | G-5.7 | 2014 | Compressed Gas Association - Carbon Monoxide and Syngas Pipeline Systems, 2nd edition |
| CGA | G-5.8 | 2007 | Compressed Gas Association - High Pressure Hydrogen Pipeline Systems at Consumer locations, 1st edition |
| CGA | P-8.10 | 2021 | Compressed Gas Association - Industrial Gas Pipeline Integrity Management, 1st edition |
| CGA | H-3 | 2019 | Standard for Cryogenic Hydrogen Storage |
| CGA | H-4 | 2020 | Terminology Associated with Hydrogen Fuel Technologies |
| CGA | H-5 | 2020 | Standard for Bulk Hydrogen Supply Systems (an American National Standard) |
| CGA | H-7 | 2024 | Standard Procedures for Hydrogen Supply Systems |
| CGA | H-11 | 2020 | Safe Startup and Shutdown Practices for Steam Reformers |
| CGA | H-13 | 2023 | Hydrogen Pressure Swing Adsorber (PSA) Mechanical Integrity Requirements |
| CGA | H-17 | 2023 | Guideline for Small Scale Hydrogen Production |
| CGA | PS-46 | 2024 | CGA Position Statement on Roofs Over Hydrogen Storage Systems |
| IOGP | S-722 | 2020 | JIP33, Supplementary Specification to API 537 |
| IOGP | S-722Q | 2020 | JIP33, Quality Requirements for Flare Package |
| EIGA | DOC 15 | 2021 | Gaseous Hydrogen Installations |
| EIGA | DOC 63 | 2014 | Prevention of Tow-Away Incidents |
| EIGA | DOC 75 | 2021 | METHODOLOGY FOR DETERMINATION OF SAFETY AND SEPARATION DISTANCES |
| EIGA | DOC 100 | 2020 | HYDROGEN CYLINDERS AND TRANSPORT VESSELS |
| EIGA | DOC 121 | 2014 | Hydrogen Pipeline Systems |
| EIGA | DOC 122 | 2018 | Environmental Impacts of Hydrogen Plants |
| EIGA | DOC 134 | 2021 | POTENTIALLY EXPLOSIVE ATMOSPHERES EU DIRECTIVE 1999/92/EC |
| EIGA | DOC 187 | 2014 | GUIDELINE FOR THE LOCATION OF OCCUPIED BUILDINGS IN INDUSTRIAL GAS PLANTS |
| EIGA | DOC 211 | 2017 | Hydrogen Vent Systems for Customer Applications |
| EIGA | DOC 244 | 2023 | RECIPROCATING CRYOGENIC PUMPS AND PUMP INSTALLATIONS FOR HYDROGEN AND LIQUEFIED NATURAL GAS |
| EIGA | DOC 250 | 2024 | STANDARD PROCEDURES FOR HYDROGEN SUPPLY SYSTEMS |
| EIGA | DOC 251 | 2024 | OVERVIEW OF HYDROGEN PRODUCTION METHODS |
| AIAA | G095A | 2017 | Guide to Safety to Hydrogen and Hydrogen Systems |
| ISO | 7866 | 2012 | Gas cylinders - Refillable seamless aluminum alloy gas cylinders - Design, construction and testing |
| ISO | 9223 | 2012 | Corrosion of metals and alloys - Corrosivity of atmospheres - Classification, determination and estimation |
| ISO | 9809-01 | 2019 | Gas cylinders - Design, construction and testing of refillable seamless steel gas cylinders and tubes - Part 1: Quenched and tempered steel cylinders and tubes with tensile strength less than 1 100 Mpa |
| ISO | 9809-02 | 2019 | Gas cylinders - Design, construction and testing of refillable seamless steel gas cylinders and tubes - Part 2: Quenched and tempered steel cylinders and tubes with tensile strength greater than or equal to 1 100 Mpa |

| Source | Number | Year | Description |
|---|---|---|---|
| ISO | 9809-03 | 2019 | Gas cylinders - Design, construction and testing of refillable seamless steel gas cylinders and tubes - Part 3: Normalized steel cylinders and tubes |
| ISO | 9809-04 | 2021 | Gas cylinders - Design, construction and testing of refillable seamless steel gas cylinders and tubes - Part 4: Stainless steel cylinders with an Rm value of less than 1 100 Mpa |
| ISO | 11114-4 | 2017 | Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 4: Test methods for selecting steels resistant to hydrogen embrittlement |
| ISO | 11119.1 | 2020 | Gas cylinders - Design, construction and testing of refillable composite gas cylinders and tubes - Part 1: Hoop wrapped fiber reinforced composite gas cylinders and tubes up to 450 |
| ISO | 11119.2 | 2020 | Gas cylinders - Design, construction and testing of refillable composite gas cylinders and tubes - Part 2: Fully wrapped fiber reinforced composite gas cylinders and tubes up to 450 l with load-sharing metal liners |
| ISO | 11119.3 | 2020 | Gas cylinders - Design, construction and testing of refillable composite gas cylinders and tubes - Part 3: Fully wrapped fiber reinforced composite gas cylinders and tubes up to 450 l with non-load-sharing metallic or non-metallic liners or without liners |
| ISO | 11119.4 | 2020 | Gas cylinders - Refillable composite gas cylinders - Design, construction and testing - Part 4: Fully wrapped fiber reinforced composite gas cylinders up to 150 l with load-sharing welded metallic liners |
| ISO | 11515 | 2022 | Gas cylinders - Refillable composite reinforced tubes of water capacity between 450 l and 3000 l - Design, construction and testing |
| ISO | 12944-1 | 2017 | Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 1: General introduction |
| ISO | 15649 | 2001 | Petroleum and natural gas industries - Piping |
| ISO | 17268 | 2020 | Gaseous hydrogen land vehicle refueling connection devices |
| ISO | 19880-1 | 2020 | Gaseous hydrogen - Fueling stations - Part 1: General Requirements |
| ISO | 19884 | 2018 | Draft Document - Gaseous hydrogen - Cylinders and tubes for stationary storage |
| ISO | 22734 | 2019 | Hydrogen generators using water electrolysis. Industrial, commercial, and residential applications |
| ISO | 26142 | 2010 | Hydrogen detection apparatus. Stationary applications |
| NFPA | 2 | 2023 | Hydrogen Technologies Code |
| NFPA | 55 | 2023 | Compressed Gases and Cryogenic Fluids Code |
| NFPA | 56 | 2023 | Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems |
| NFPA | 67 | 2019 | Guide on Explosion Protection for Gaseous Mixtures in Pipe Systems |
| WRC | 107/537 | - | Local Stresses in Spherical and Cylindrical Shells due to External Loadings |
| WRC | 297 | - | Local Stresses in Spherical and Cylindrical Shells due to External Loadings on Nozzles – Supplement to WRC Bulletin No. 107 |
| EN | 10204 | 2004 | Metallic Products – Types of Inspection Certificates |
| BSI | PD 5500 | 2021 | UK National Specification for unfired pressure vessels |
| EU | 2014/68/EU | 2016 | The Pressure Equipment Directive (PED)(2014/68/EU) applies to the design, manufacture and conformity assessment of stationary pressure equipment with a maximum allowable pressure greater than 0,5 bar. |
| FM | 7-91 | 2024 | Property Loss Prevention Data Sheets - Hydrogen |
| UL | 2075 | 2013 | Gas and Vapor Detectors and Sensors |

# VENA EUROA HYDROGEN PROJECT

# Stormwater Management Plan

# 50MW Hydrogen Production Facility

# UGL Project TC- 17695

CLIENT: VENA ENERGY AUSTRALIA

Document: 17695-CIVIL-RPT-1001

| Rev | Date | Prepared By | Checked by | Approved by | Status |
|---|---|---|---|---|---|
| A | 09/09/2025 | CG | | | Issued For Review |
| B | 10/9/2025 | CG | SHB | SHB | Issued For Use |
| | | | | | |
| | | | | | |

PLANS AND DOCUMENTS
referred to in the
SDA APPROVAL

Queensland
Government

SDA approval: AP2023/015

# Table of Contents

# 1 Introduction

## 1.1 General

Vena Energy Australia (VENA) are proposing the Euroa Hydrogen Project at a designated site in Aldoga in the Gladstone region. The Euroa Hydrogen Project is an integrated hydrogen electrolysis, hydrogen compression and distribution facility located within the 'High Impact Industry' precinct with the Gladstone State Development Area (GSDA) Development Scheme area which intends to support the emerging hydrogen industry within the Gladstone region.

The project seeks to create an integrated hydrogen production and supply chain solution that will cater to the domestic and international market. The commercial business model for the domestic facility involves the production of hydrogen for transportation and heavy industry purposes.

The Euroa Hydrogen Facility is outlined as follows:

- A hydrogen production rate at the meter of the dispenser unit of approximately 17,280 kg/day resulting in a nominal 50 MW hydrogen gas electrolysis facility including water purification, de-oxidation, dehydration, and hydrogen gas compression, storage and dispensing components.
- Electricity requirements sourced from the existing electricity grid.
- Water supply sourced from a newly constructed raw water connection pipeline infrastructure which connects to Boat Creek to East End water pipeline of Gladstone Area Water Board's (GAWB) water pipeline network.
- The 50MW hydrogen gas electrolyser facility will produce up to 900kg/hr of hydrogen gas at a pressure of 37 bar(g).
- The hydrogen gas will be compressed and stored on site; the quantity is 8,000 kg at 400 bar(g). Maximum design storage pressure 450 bar(g).
- Stored hydrogen is further compressed as required and dispensed into tube trailers rated at 517 bar(g).
- The facility will produce and distribute approximately 17,280 kg of compressed hydrogen gas per day.
- Four pressurised hydrogen tube trailer loading bays are provided to facilitate distribution of 17,280 kg/day of compressed gas into tube trailers.
- Hydrogen gas from various relief and blowdown valves at the electrolyser, storage compression, storage receivers and dispensing will be piped to the flare system. Intermittent and smaller hydrogen gas relief and bleed flows will be directly vented to atmosphere.

# 2 Definitions

- Company – UGL
- FEED – Front End Engineering & Design
- GAWB – Gladstone Area Water Board
- GPT – Gross Pollutant Trap
- UGL – UGL Engineering Pty Ltd
- VENA – Vena Energy Australia
- WPU – Water Polishing Unit
- WTP – Water Treatment Plant

# 3 Reference Documents

[1]. 17695-CIVIL-DRG-1001-02: Hydrogen Production Plant Stage 1: FEED Study 50MW Electrolyser Lot 1 - Hydrogen Plant Slab and Footing Plan

[2]. 17695-CIVIL-DRG-1001-03: Hydrogen Production Plant Stage 1: FEED Study 50MW Electrolyser Lot 1 - Hydrogen Plant Stormwater Plan

[3]. 17695-CIVIL-DRG-1001-04: Hydrogen Production Plant Stage 1: FEED Study 50MW Electrolyser Pavement and Stormwater Details

[4]. 17695-CIVIL-DRG-1001-05: Hydrogen Production Plant Stage 1: FEED Study 50MW Electrolyser Lot 1 - Hydrogen Plant Pavement Plan
[5]. 17695-CIVIL-DRG-1001-08: Hydrogen Production Plant Stage 1: FEED Study 50MW Electrolyser Hydrogen Plant Stormwater Plan Lot 2 & 3 275/33kV Substation
[6]. 17695-CIVIL-DRG-1001-09: Hydrogen Production Plant Stage 1: FEED Study 50MW Electrolyser Hydrogen Plant Pavement Plan Lot 2 & 3 - 275/33kV Substation

# 4 Purpose

## 4.1 General

The purpose of this Stormwater Management Plan is to provide a preliminary strategy for the management of overland flows and detention of stormwater runoff from the site to support the FEED study. The preliminary plan identifies key drainage zones, surface treatments, and pollution control measures. It is noted that a flood study has yet to be undertaken in subsequent design phases of the project.

# 5 Site description

## 5.1 General

The proposed site is located approximately 18km west of the Gladstone CBD in the Aldoga locality within the Gladstone region (refer to Figure 1). It comprises of three (3) freehold lots off Euroa Circuit, Aldoga, formally described as Lot 1, 2 and 3 on SP245955, total site area of approximately 26Ha.

The site fronts Euroa Circuit along all site boundaries. The new Euroa Circuit Road features a new intersection connection to Aldoga Road, which intersects with Gladstone Mount Larcom Road (state-controlled road) enabling the site to have industrial standard access to the wider state-controlled road including the Bruce Highway.

The site has been previously cleared of vegetation with previous earthworks creating several pads across site that were created as part of the previous uses over the site, which primarily were for the laydown, storage and construction yards associated with the LNG pipeline projects in the area. As a result, the site is clear of any notable biodiversity attributes and is relatively flat, thus has minimal ecological or topographical constraints.

The subject site has several advantages, including the proximity to the GAWB's Boat Creek to East End water pipeline running alongside Aldoga Road which will provide the necessary water inputs for the plant through a newly constructed extension pipeline which runs to the southern frontage of the site. Additionally, there is a new electrical transmission infrastructure currently being constructed across Euroa Circuit connecting to the nearby Larcom Creek substation and the national electricity grid (refer to Figure 1).

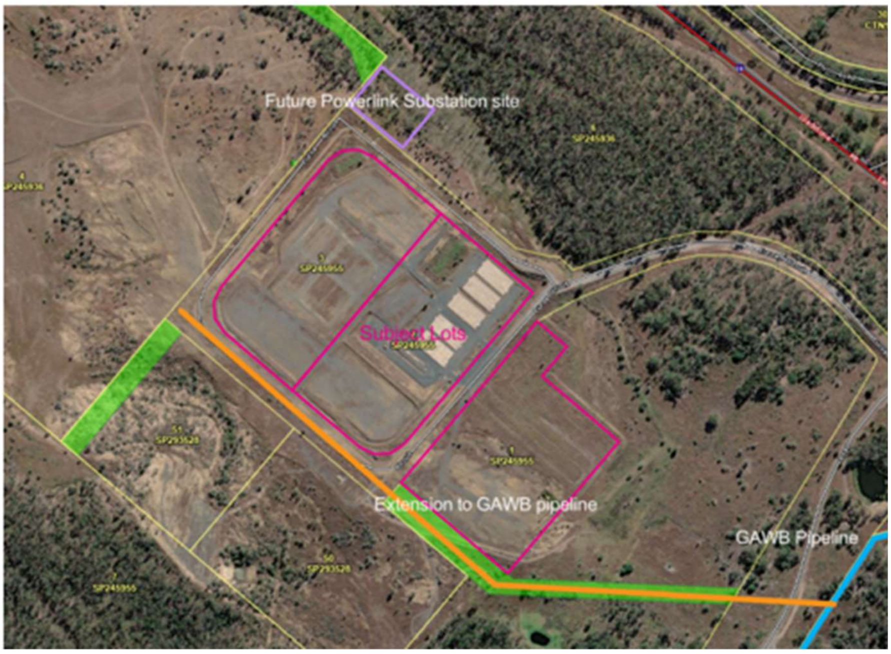



Figure 1 – Site Location

## 5.2 Site Hydrology Overview

The site is built up on earthworks platforms on Lots 1 and 3 to prevent the site from flooding. The final platform level and overall site hydrology are subject to a flood study that will be undertaken in subsequent design phases of the project.

# 6 Wastewater Collection Description

## 6.1 System Overview

The purpose of the wastewater system is to collect process fluids and stormwater falling on those catchments from different locations throughout the facility. Processing equipment is located on concrete pads that are bunded and drain spillages and rainwater into a separate oily water sewer system. The waste process fluids and associated stormwater are gravity fed into pump sumps, strategically located throughout the facility.

There are 7 sumps with associated pumps through the plant:

1. Electrolyser Area Sump (hydrogen condensate drains)
2. Electrolyser Area Sump (oxygen condensate drains)
3. Dispensing Compressor Area Sump
4. Main Compressor Area Sump
5. Utility Island Area Sump
6. Chiller Area Sump
7. Workshop Area Sump

The collected oily water will be pumped into three wastewater tanks. They are:

1. A tank dedicated to the electrolyser area wastewater tank which is fed from the electrolyser area sump.
2. A tank dedicated to the workshop area wastewater tank which is fed from the workshop area sump.
3. The other four sumps will be pumped out to the utility island wastewater tank.

When the wastewater tanks reach full capacity, a wastewater collection road tanker is to empty the tank contents and dispose the oily water offsite to a licenced trade waste facility.

# 7 Stormwater Collection Strategy

The Lot 1 site is graded to allow the collection of stormwater into kerbs and gutters and direct the flow into a stormwater pipe network that ultimately discharges the stormwater through a gross pollutant trap into the existing receiving stormwater course at the northeastern side of the site. The substation platform in Lot 3 discharges into an existing sedimentation basin before overflowing into the existing receiving stormwater course.

All roads are bitumen sealed. Other areas of the site are either bunded with concrete bunds to retain spillages from processing plant areas and routed to the oily water system or covered with blue metal or grassed to avoid sediment erosion from storm events ([1], [4], [6]).

The stormwater catchment strategy is designed to manage runoff from various functional zones across the site. The system integrates surface grading, conveyance infrastructure, and treatment elements to ensure effective drainage and environmental protection.

Conveyance systems include:

- Swales: used to collect and direct runoff towards treatment or discharge points. They are located where the area is unsealed or landscaped to slow runoff and promote infiltration.
- Kerbs and gutters: used to contain and isolate runoff and protect infrastructure. They are located where the area is paved or hardstand (e.g. vehicular traffic areas)
- Strip Drains: used in high-traffic areas such as tube trailer bays to rapidly collect surface runoff and direct it into pits.

There is a swale system that surrounds both sites Lot 1 and Lots 2 & 3 that acts as a diversion drain preventing stormwater flows originating external to the site from entering the site.

Conveyance systems discharge into pits, which are connected via underground pipes connecting a pit-to-pit stormwater network, that directs flow to the end-of-line treatment.

End-of-line treatment includes:

- Gross Pollutant Trap (GPT) Lot1: used to capture litter, coarse sediments, and floating debris before discharge.
- Sedimentation Pond Lot 3: used to treat runoff from the substation platform by allowing fine particles to settle.
- Anti-scour Pads: installed at discharge points to prevent erosion and protect downstream water courses.

These features are intended to manage sediment, hydrocarbons, and debris, supporting the site's environmental protection objectives.

In Lot 1, stormwater from electrolyser and balance of plant block and compression, storage and dispensing block is conveyed as indicated in Table 1, flowing towards the swales located in the central area which separates both blocks.

All stormwater from the pit-to-pit network is ultimately directed to a single Gross Pollutant Trap (GPT) in the northeastern side of the Lot 1 site. An anti-scour pad is installed at the GPT outlet to prevent erosion and protect downstream stormwater course.

In Lot 2 & 3, stormwater runoff from the 275/33kV substation is directed via the pit-to pit network to the sedimentation pond in the eastern side. Anti-scour pads are installed at the stormwater pipes discharge into the sedimentation pond.

Catchment zones are delineated based on functional use, surface grading, and infrastructure layout. Table 1 summarises each zone.

**Table 1 – Stormwater Main Zones**

| Catchment | Infrastructure | Surface Type | Primary Conveyance | Run off Treatment |
|---|---|---|---|---|
| Electrolyser, WPU, purification & associated electrical equipment | Electrolyser Building,<br>Electrolyser area switch rooms, auxiliary transformers, electrolyser rectifiers<br>Water polishing unit, Purification<br>Electrolyser chillers<br>Wastewater | Blue Metal | Swale<br>Kerb & gutter | Conveyed through swales, kerb & gutter to pits and then piped towards the swale at the southwest. |
| Electrolyser cooling & hazardous goods store | Air cooled radiators and tank<br>Hazardous goods store | Blue Metal | Swale<br>Kerb & gutter | Conveyed through swales, kerb & gutter to pits and then piped towards the swale at the southwest. |
| Water treatment plant | Water treatment plant | Blue Metal | Swale<br>Kerb & gutter | Conveyed through swales, kerb & gutter to pits and then piped towards the swale at the southwest. |
| Warehouse | Warehouse & workshop building | Medium Duty Asphalt | Swale<br>Kerb & gutter | Conveyed through swales, kerb & gutter to pits and then piped towards parking area. |
| Parking | Parking | Medium Duty Asphalt | Swale<br>Kerb & gutter | Conveyed through swales, kerb & gutter to pits and then piped south. |
| Compression | Main compression<br>Dispensing compression<br>Chillers | Blue Metal | Swale | Conveyed through swales and pits, then piped towards the swale at the northeast. |
| Electrical equipment<br>Compression area | Compression area switch room, auxiliary transformers<br>Wastewater<br>Instrument Air | Blue Metal | Swale<br>Kerb & gutter | Conveyed through swales, kerb & gutter to pits and then piped towards the swale at the northeast. |
| Flare | Flare | Heavy Duty Asphalt | Swale | Conveyed through swales, kerb & gutter to pits and then piped towards the swale at the north. |
| Storage | Hydrogen ground storage | Blue Metal | Swale<br>Kerb & gutter | Conveyed through swales, kerb & gutter to pits and then piped towards the swale at the north. |
| Tube trailer bays | Tube trailer bays | Heavy Duty Asphalt | Strip Drains | Strip drains collect runoff and direct it into pits and then piped northeast. |

| Catchment | Infrastructure | Surface Type | Primary Conveyance | Run off Treatment |
|---|---|---|---|---|
| Tube trailer parking | Tube trailer parking | Blue Metal | Swale<br>Kerb & gutter | Conveyed through swales, kerb & gutter to pits and then piped northeast. |
| Substation | Substation | Blue Metal | Swale<br>Kerb & gutter | Conveyed into swales, kerb & gutter leading to pits connected to the pipe network. End of line treatment is the sedimentation pond. |

Regular inspection and maintenance of swales, pits, GPTs, and sedimentation ponds will be required to ensure continued performance and environmental compliance.

## 7.1 Stormwater Discharge from Site

Stormwater discharged from the GPT (Lot 1) and Sedimentation pond (Lot 2 & 3) flows from the site into the existing stormwater catchment and water courses, ultimately flowing to Larcom Creek. The proposed stormwater flows from

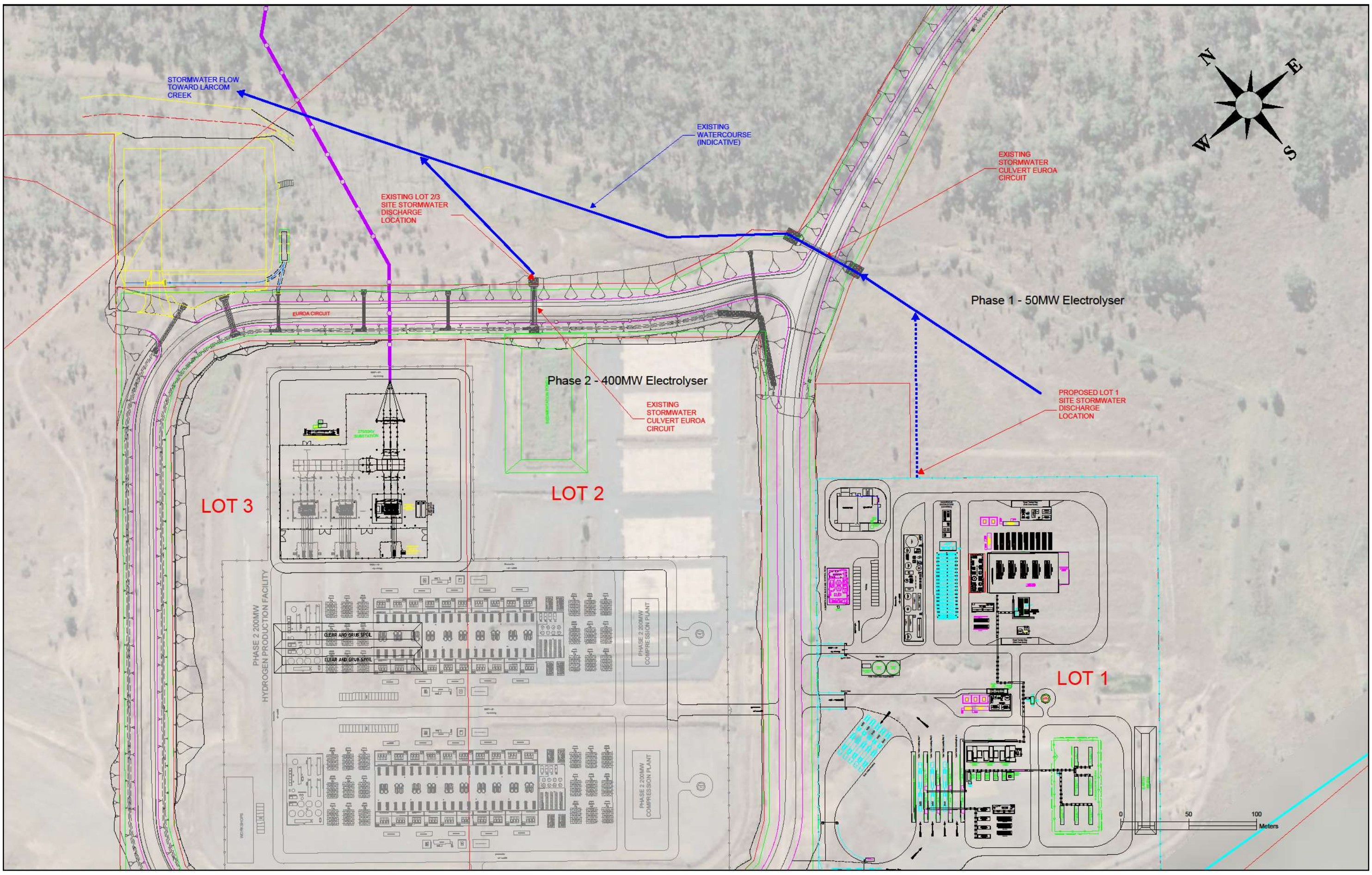



Figure 2 – Stormwater Discharge From Site

The proposed stormwater discharge from Lot 1 will be to the North East of the site and will flow into the existing stormwater catchment and water courses flowing through the existing Euroa Circuit culvert towards Larcom Creek.

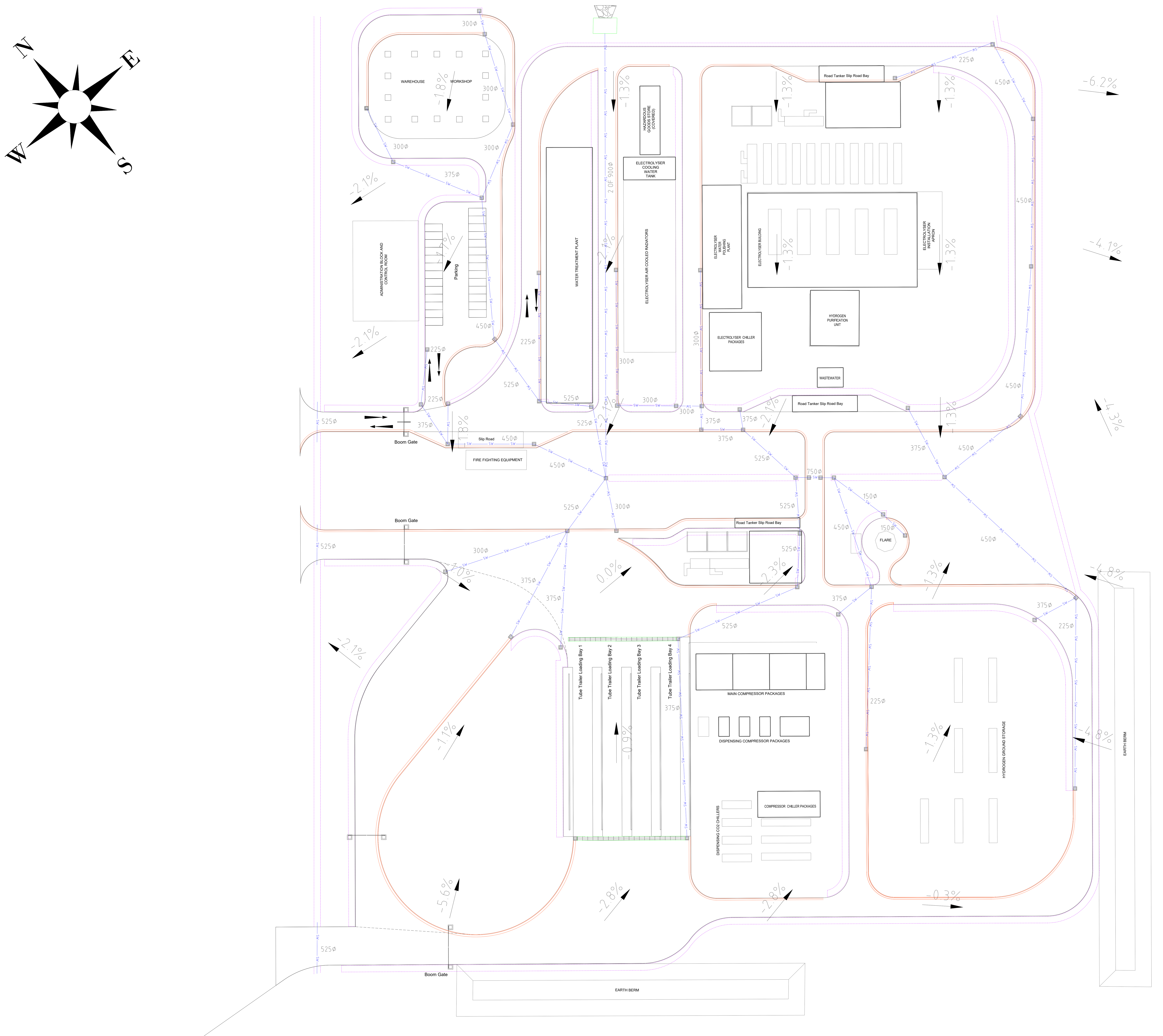
Stormwater discharge from Lot 2 & 3 will continue to be discharged from the site through the existing Euroa Circuit culvert towards Larcom Creek.

Whilst Hydrology investigations are required during future project development phases to determine any impacts to the downstream stormwater catchment, it is anticipated that the stormwater discharges from the site would not significantly alter the existing stormwater catchment

# 8 Appendices

## 8.1 Appendix 1 –LOT 1 HYDROGEN PLANT STORMWATER PLAN

Plot Date: 14/05/25 - 15:09 Cad File: C:\Users\svenhelmut.barthelme\UGL Limited\0000017695 Euroa Hydrogen Project - Tender Documents\FEED\17 Design\DP15 Civils, Structural and Stormwater\2.Design Process\AUTOCAD\17695-CIVIL-DRG-1001.dwg




## LEGEND

| | |
|---|---|
| SW | PROPOSED STORMWATER PIPES<br>UPVC TYPICAL UNO |
| | PROPOSED STORMWATER PIT - TO DETAIL |
| | GROSS POLLUTANT TRAPS |
| | ANTI-SCOUR PAD - TO DETAIL |
| | KERB AND GUTTER - TO DETAIL |
| | SWALE - TO DETAIL |
| | STRIP DRAIN |

NOTES:
ALL COMPLETE WITH VAPOUR BARRIER

0 30 60
Meters



| REV | AMENDMENT DETAILS | DESIGN | CHK'D | DRAWN | CHK'D | APP'D | DATE |
|---|---|---|---|---|---|---|---|
| B | ISSUED FOR MILESTONE 3 | IM | BW | IM | SHB | SHB | 14/05/2025 |
| A | ISSUED FOR REVIEW | IM | BW | IM | SHB | SHB | 02/05/2025 |

VENA ENERGY AUSTRALIA

UGL
ABN 96 096 365 972
40 Miller Street
North Sydney NSW 2060
www.ugllimited.com
A MEMBER OF THE CIMIC GROUP CIMIC

DOCUMENT STATUS: UNLESS THIS DOCUMENT BEARS A RED STAMP IT IS UNCONTROLLED AND MAY NOT BE THE LATEST ISSUE. THEREFORE, VERIFY STATUS BEFORE USE.

| | |
|---|---|
| DESIGNED | IM |
| CHECKED | SHB |
| DRAWN | IM |
| CHECKED | SHB |
| APPROVED | SHB |

A1 NTS

VENA ENERGY HYDROGEN PROJECT

HYDROGEN PRODUCTION PLANT
STAGE 1: FEED STUDY 50MW ELECTROLYZER
LOT 1 STORMWATER PLAN

| CLIENT | UGL DRAWING No | SHEET | REV |
|---|---|---|---|
| VENA ENERGY | 17695-CIVIL-DRG-1001 | 03 | B |

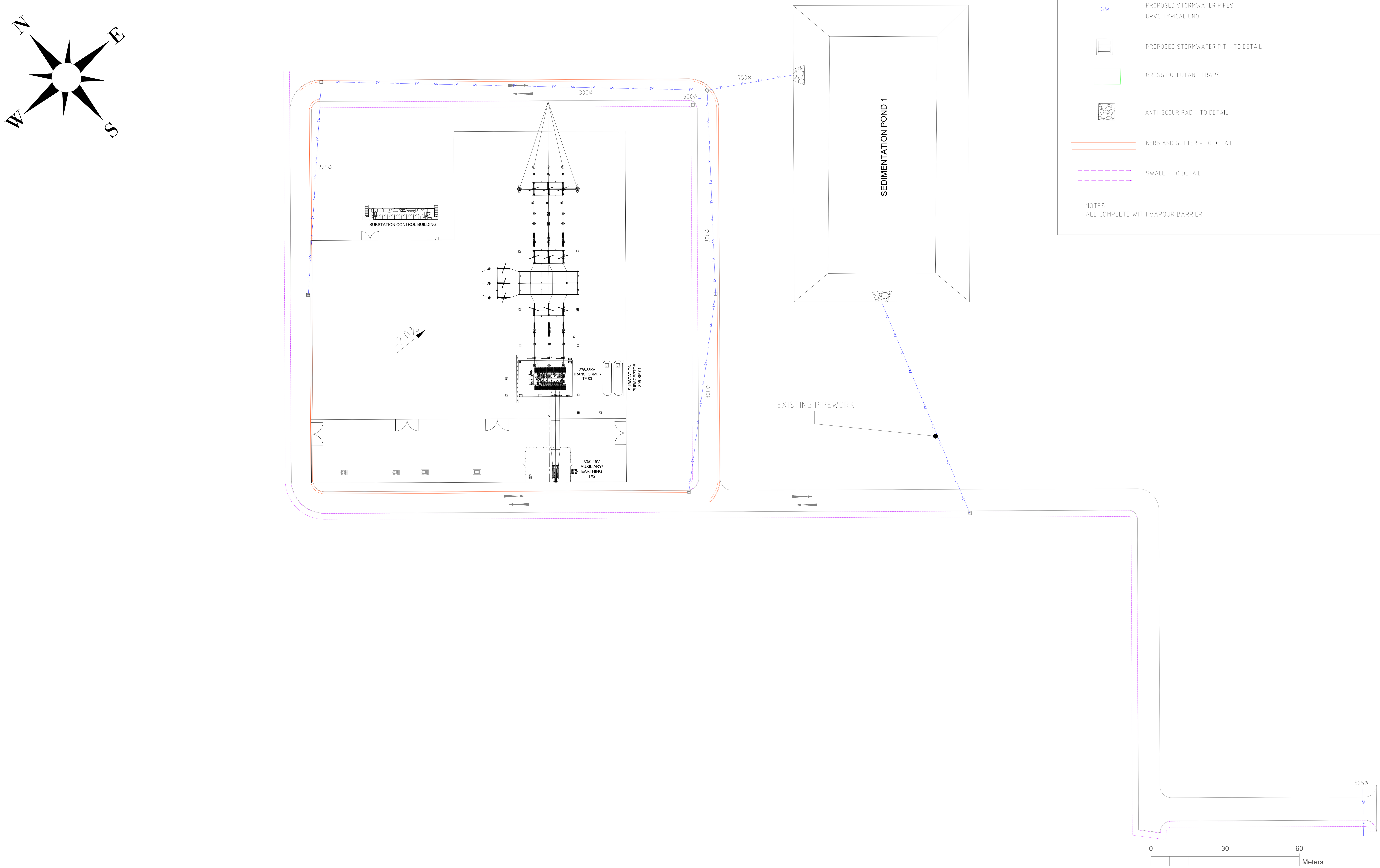
CONFIRM SCALE 100mm ON A1 ORIGINAL

## 8.2 Appendix 2 –LOT 2 & 3 275/33KV SUBSTATION STORMWATER PLAN

## LEGEND

| | |
|---|---|
| SW | PROPOSED STORMWATER PIPES UPVC TYPICAL UNO |
| | PROPOSED STORMWATER PIT - TO DETAIL |
| | GROSS POLLUTANT TRAPS |
| | ANTI-SCOUR PAD - TO DETAIL |
| | KERB AND GUTTER - TO DETAIL |
| | SWALE - TO DETAIL |

NOTES:
ALL COMPLETE WITH VAPOUR BARRIER






| REV | AMENDMENT DETAILS | DESIGN | CHK'D | DRAWN | CHK'D | APP'D | DATE |
|---|---|---|---|---|---|---|---|
| B | ISSUED FOR MILESTONE 3 | IM | SHB | IM | SHB | SHB | 14/05/2025 |
| A | ISSUED FOR REVIEW | IM | BW | IM | BW | SHB | 07/05/2025 |

VENA ENERGY AUSTRALIA

UGL
ABN 96 096 365 972
40 Miller Street
North Sydney NSW 2060
www.ugllimited.com
A MEMBER OF THE CIMIC GROUP CIMIC

| | |
|---|---|
| DESIGNED | IM |
| CHECKED | BW |
| DRAWN | IM |
| CHECKED | BW |
| APPROVED | SHB |

# VENA ENERGY HYDROGEN PROJECT

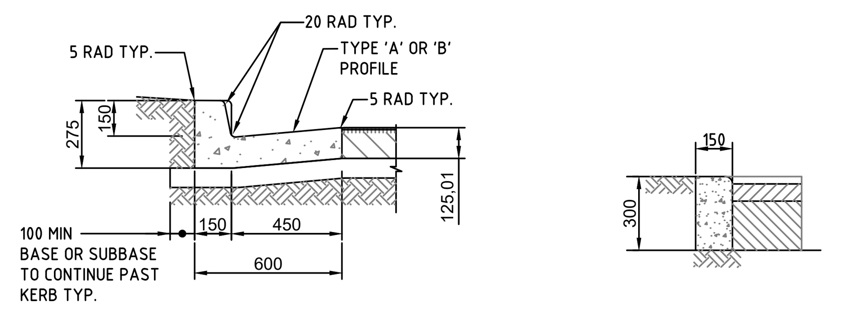
## HYDROGEN PRODUCTION PLANT
## STAGE 1: FEED STUDY 50MW ELECTROLYZER
## HYDROGEN PLANT STORMWATER PLAN
## LOT 2 & 3 275/33KV SUBSTATION

DOCUMENT STATUS: UNLESS THIS DOCUMENT BEARS A RED STAMP IT IS UNCONTROLLED AND MAY NOT BE THE LATEST ISSUE. THEREFORE, VERIFY STATUS BEFORE USE.

| SIZE | SCALE | CLIENT | UGL DRAWING No. | SHEET | REV |
|---|---|---|---|---|---|
| A1 | NTS | VENA ENERGY | 17695-CIVIL-DRG-1001 | 08 | B |

CONFIRM SCALE — 100mm ON A1 ORIGINAL

## 8.3 Appendix 3 – PAVEMENT AND STORMWATER DETAILS

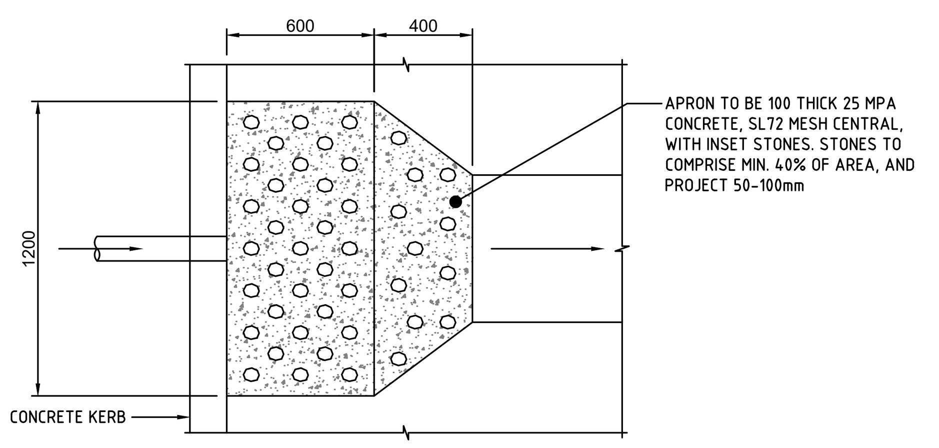



SLIP-FORMED KERB & GUTTER (K&G)

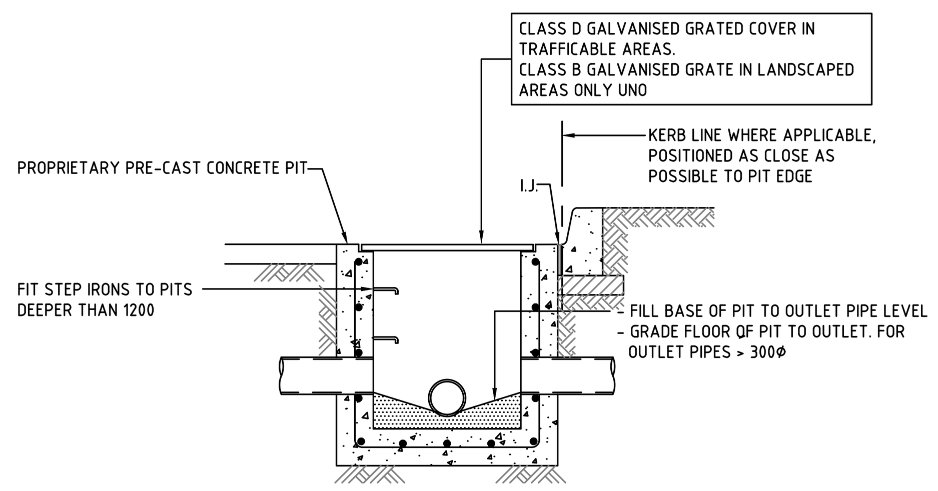
FLUSH KERB (FK)

## 01 TYPICAL KERB - KERB & GUTTER DETAILS

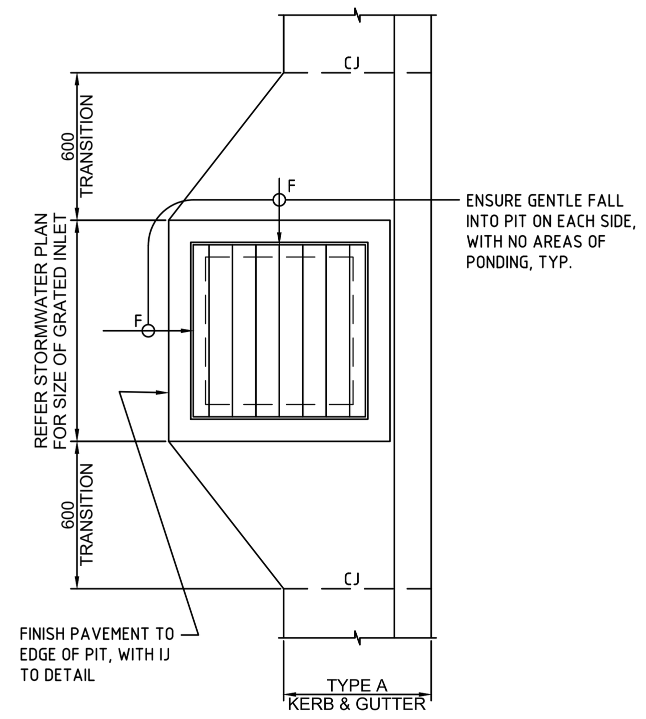
NOTE:
- PROVIDE RULED JOINTS AT 2m CENTRES MAX. TYP.




SWALE FLOW SPREADER PLAN

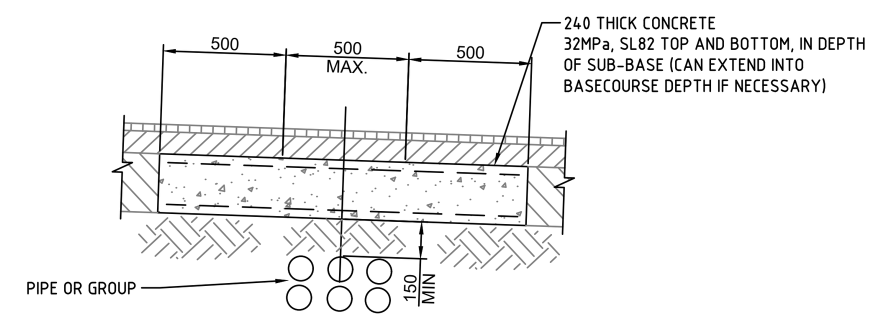



SECTION

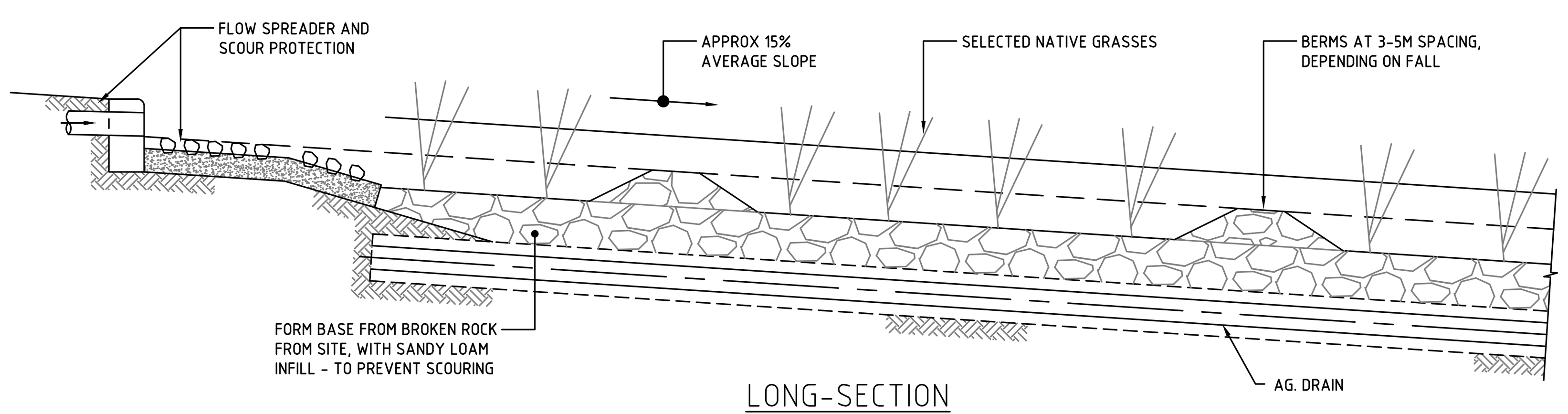



PLAN - PIT IN GUTTER

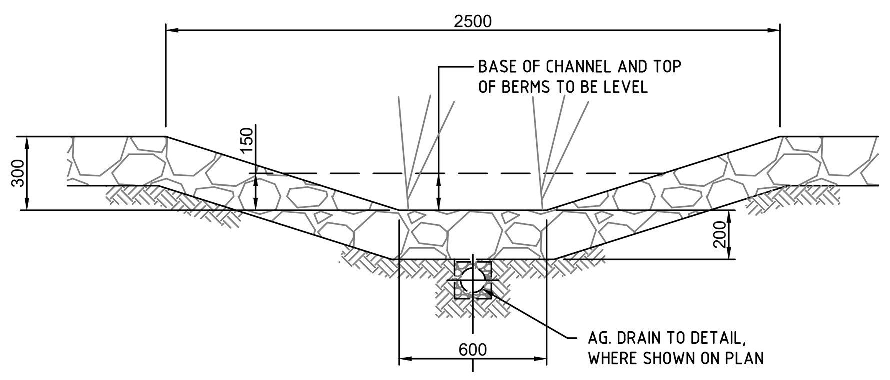
## 02 STORMWATER PIT (TYPICAL U.N.O)




## 04 PIPE PROTECTION DETAIL - UNDER ASPHALT ROADS

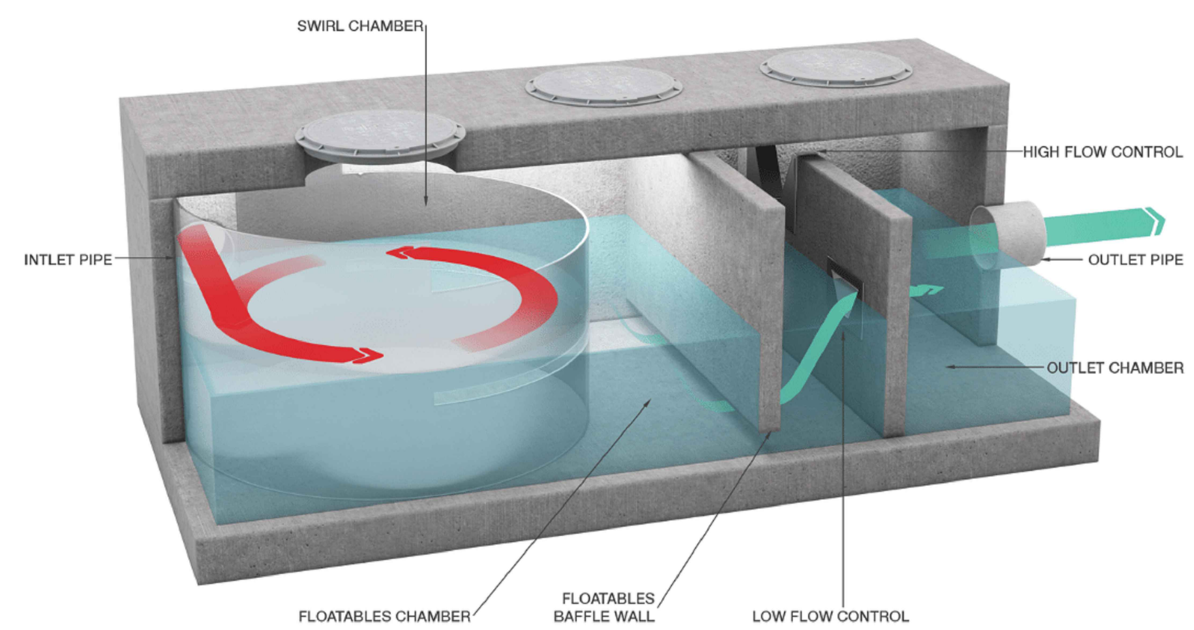



LONG-SECTION




CROSS-SECTION

## 03 GRASS SWALE DETAILS




| APPROXIMATE DIMENSIONS (M) | | | | | | |
|---|---|---|---|---|---|---|
| MODEL | L | x | W | x | D | |
| VX5000 | 4.4 | x | 2.5 | x | 2.0 | |
| VX9000 | 5.0 | x | 3.1 | x | 2.2 | |

## 05 GPT EXAMPLE - FROM OCEAN-PROTECT

REFER TO OCEAN-PROTECT WEBSITE/STAFF FOR MORE DETAILED INFORMATION



| REV | AMENDMENT DETAILS | DESIGN | CHK'D | DRAWN | CHK'D | APP'D | DATE |
|---|---|---|---|---|---|---|---|
| C | ISSUED FOR MILESTONE 3 | IM | BW | IM | BW | SHB | 12/05/2025 |
| B | UPDATED LOGO | IM | BW | IM | BW | SHB | 05/05/2025 |
| A | ISSUED FOR REVIEW | IM | BW | IM | BW | SHB | 02/05/2025 |

Taylor Civil & Structural
CONSULTING ENGINEERS
2/187 CONCORD ROAD
NORTH STRATHFIELD, NSW, 2137
admin@taylorcivil.com.au
PH: (02) 9799 6822
A.C.N. 058 341 861

VENA ENERGY AUSTRALIA

UGL
ABN 96 096 365 972
40 Miller Street
North Sydney NSW 2060
www.ugllimited.com
A MEMBER OF THE CIMIC GROUP CIMIC

| | |
|---|---|
| DESIGNED | IM |
| CHECKED | BW |
| DRAWN | IM |
| CHECKED | BW |
| APPROVED | SHB |

DOCUMENT STATUS: UNLESS THIS DOCUMENT BEARS A RED STAMP IT IS UNCONTROLLED AND MAY NOT BE THE LATEST ISSUE. THEREFORE, VERIFY STATUS BEFORE USE.

A1 NTS

VENA ENERGY HYDROGEN PROJECT
HYDROGEN PRODUCTION PLANT
STAGE 1: FEED STUDY 50MW ELECTROLYZER
PAVEMENT AND STORMWATER DETAILS

| CLIENT | UGL DRAWING No. | SHEET | REV |
|---|---|---|---|
| VENA ENERGY | 17695-CIVIL-DRG-1001 | 04 | C |

CONFIRM SCALE    100mm ON A1 ORIGINAL