FIRE SAFETY STUDY,

PORT KEMBLA ETHANOL TERMINAL,

MANILDRA

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Manildra, Port Kembla Ethanol Terminal
Fire Safety Study

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Revision History

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G	23/4/22	LPG Cylinders and Berth Fire Protection Included	Manildra
H	14/5/22	Appendices Updated	Manildra

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EXECUTIVE SUMMARY

The Manildra Group is a wholly Australian owned business and the largest processor of wheat in Australia. It manufactures a wide range of wheat-based products for food and industrial markets both locally and internationally.

The Manildra Group owns the Shoalhaven Starches factory located on Bolong Road, Bomaderry, which produces a range of products for the food, beverage, confectionary, paper and motor transport industries including starch, gluten, glucose and ethanol.

Manildra propose to construct a beverage grade ethanol storage and handling facility at Port Kembla, NSW. The beverage grade ethanol will be transferred via road tankers from the Bomaderry facility to the Port Kembla facility and stored within six tanks. The beverage grade ethanol can then be transferred to a ship, or to Isotanks and road tankers for delivery to the market.

As part of the project requirements, a Fire Safety Study (FSS) is required. This report details the results of the study.

Summary of Main Findings and Recommendations:

The main fire protection features are summarised as follows for the proposed terminal:

- Fire water is to be supplied from two tanks and two diesel pumps;
- Fire water will be piped to tank cooling sprays, hydrants, monitors and hose reels;
- Fire water will also be used for foam generation for tank foam pourers, automatic foam deluges over the road tanker gantry area and the pump bund, and two fixed monitors; and
- Fire extinguishers.

Based on the assessment in this FSS, the following recommendation is made:

- Provide at least two portable monitors (foam compatible) for the site.

GLOSSARY

ADG	Australian Dangerous Goods (code)
API	American Petroleum Institute
AS	Australian Standard
BCA	Building Code of Australia
BLEVE	Boiling Liquid Expanding Vapour Explosion
CIA	Chemical Industries Association
DG	Dangerous Good
DN	Diameter Nominal
DoP	Department of Planning
EPA	Environment Protection Authority
FRNSW	Fire and Rescue NSW
FSS	Fire Safety Study
HAZAN	Hazard Analysis
HAZOP	Hazard and Operability Study
HIPAP	Hazardous Industry Planning Advisory Paper
HSE	Health and Safety Executive (UK)
IBC	Intermediate Bulk Container
ISGOTT	International Safety Guide for Oil Tankers and Terminals
LEL	Lower Explosive Limit
LPG	Liquefied Petroleum Gas
NFPA	National Fire Protection Association
P&ID	Piping and Instrumentation Diagram
PFAS	Per and Poly Fluoroalkyl Substances
PHA	Preliminary Hazard Analysis
PLC	Programmable Logic Controller
RP	Recommended Practice
SEP	Surface Emissive Power
UEL	Upper Explosive Limit

REPORT

1 BACKGROUND AND OBJECTIVES

The Manildra Group is a wholly Australian owned business and the largest processor of wheat in Australia. It manufactures a wide range of wheat-based products for food and industrial markets both locally and internationally.

The Manildra Group owns the Shoalhaven Starches factory located on Bolong Road, Bomaderry, which produces a range of products for the food, beverage, confectionary, paper and motor transport industries including starch, gluten, glucose and ethanol.

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As part of the project requirements, a Fire Safety Study (FSS) is required. Manildra requested that Pinnacle Risk Management prepare the FSS for the proposed ethanol terminal. This FSS has been prepared in accordance with the guidelines published by the Department of Planning (DoP) Hazardous Industry Planning Advisory Paper (HIPAP) No 2 ((Ref 1) and the New South Wales Government's Best Practice Guidelines for Contaminated Water Retention and Treatment Systems (Ref 2).

A key aspect of HIPAP 2 is that the fire safety system should be based on specific analysis of hazards and consequences, and that the elements of the proposed or existing system should be tested against that analysis.

Due to the flammable nature of ethanol, guidance on fire safety measures have been taken from relevant Australian Standards, National Fire Protection Association (NFPA) Standards and Codes, as well as other industry and International Standards and Codes of Practice.

The objective of this study is to ensure that the fire prevention, detection, protection and fighting measures are appropriate for the specific fire hazards and are adequate to meet the extent of potential fires at the Manildra Port Kembla ethanol facility.

Drawings showing the proposed fire protection systems are shown in Appendix A.

The scope of this study is:

- Identification of fire and explosion hazards at the terminal, wharflines and berth;

- Analysis of the potential fire and explosion consequences (as appropriate) of the identified potentially hazardous scenarios associated with the terminal operations; and

- Identification of fire prevention, detection and protection measures required as a result of the potential hazardous events.

2 SITE DESCRIPTION

The site for the proposed terminal is on Foreshore Road, Port Kembla (see Figure 1). This is currently a greenfield site adjacent to the harbour. The site is approximately 15,000 m^2.

The site is surrounding by the following land uses:

- The harbour to the north;
- A vacant Lot to the east;
- Ixom to the south. Ixom services at this site include:
  - Sulphuric acid manufacturing, recycling and supply services to the Australian oil refining industry via a purpose-designed spent acid regeneration plant;
  - Import / export and bulk supply of concentrated sulphuric acid to industrial and power generation customers both locally and overseas;
  - Manufacture of specific grades of sulphuric acid and sulphur-based chemicals for the water treatment industry;
- A sewerage pumping station to the immediate west of the site boundary; and
- Port Kembla train station and steel equipment suppliers further to the west.

A storm water channel runs along the western boundary to the harbour. The Lot to the west of this channel is currently vacant.

The nearest residential area is to the south-west at approximately 600 m from the terminal, i.e. the suburb of Port Kembla.

Security of the site will be achieved by a number of means. This will include site personnel and security patrols by an external security company. The site will operate 7 days per week (24 hours per day). Also, the site will be fully fenced and non-operating gates are locked. Security cameras will be installed for Shoalhaven Starches personnel to view site activities.

The site is planned to be unmanned except when the required maintenance activities are to be performed, Isotank loading and shipping operations. Road tankers drivers could be at the site 24/7.

The main natural hazard for the site is flooding. The main controls for this event are:

- The site will be raised/filled to ensure that all buildings including the workshop, offices load in/out gantry and wash bund will have finished surface levels above the 1% Annual Exceedance Probability flood level

(3.0 m above the Australian Height Datum – the recommended worst-case for design purposes), thereby protecting major equipment and buildings and achieving an adequate degree of flood immunity; and

- The main tank compound floor is anticipated to be approximately 3.0 m above the Australian Height Datum and protected by the proposed 1.8 m high bund wall which will prevent any flood waters from entering the tank compound.

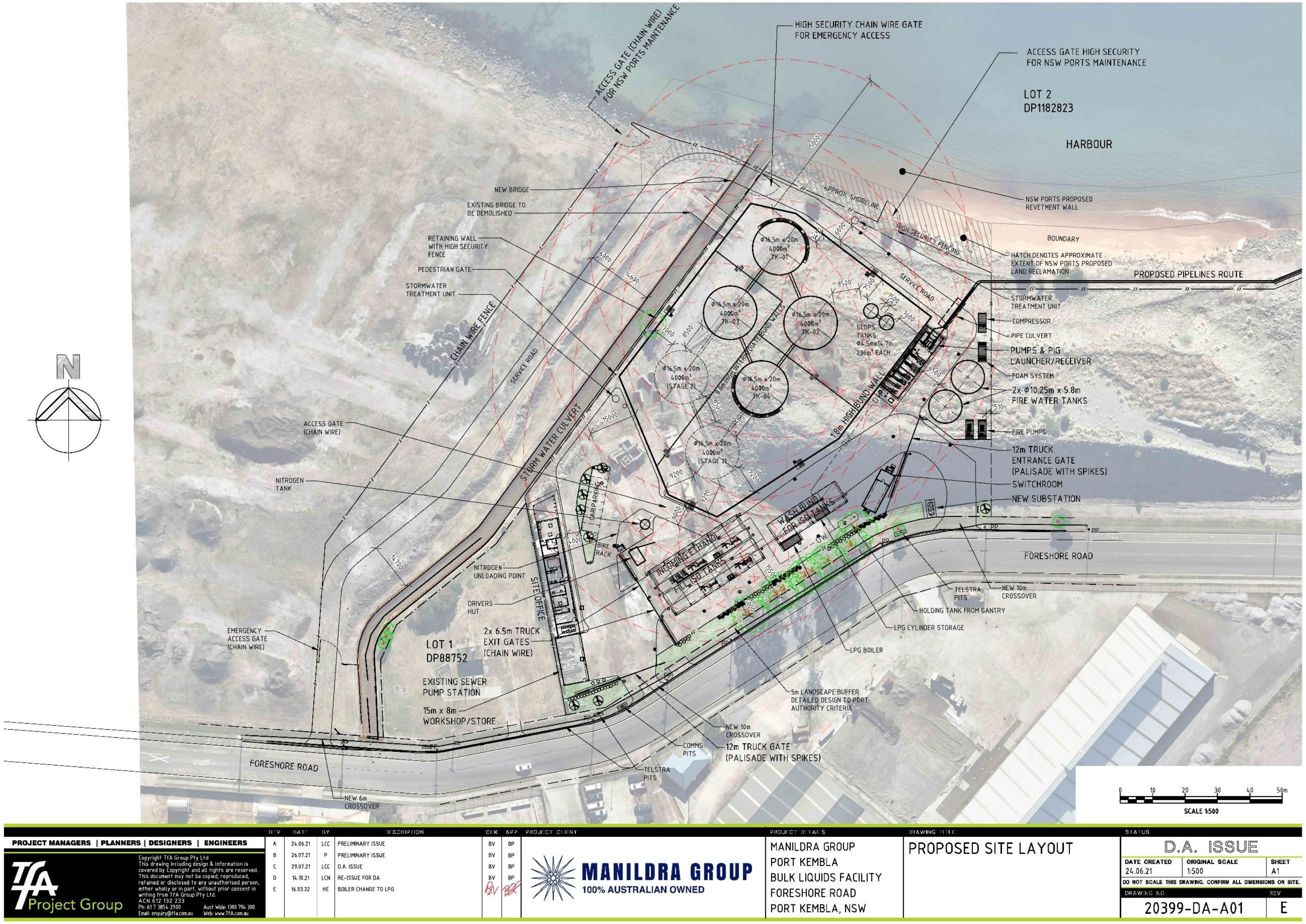
No other significant external events are considered high risk for this site.

A layout drawing showing the proposed terminal layout is shown in Figure 2.

Figure 1 - Site Location

Reference: Google Maps

Figure 2 - Site Layout



3 PROCESS DESCRIPTION

3.1 ETHANOL OPERATIONS

Ethanol is a Dangerous Good Class 3, Packing Group 2, flammable liquid.

The facility is to include the following:

- In-loading of beverage grade ethanol into the storage tanks from road tankers (singles and doubles);
- Ethanol storage in 6 x 4 ML stainless steel, fixed roof tanks;
- Ethanol loadout to vessels moored at berth 206 at approximately 1,000 m^3 per hour. Typical shipments are 5 ML to 10 ML;
- Flushing and pigging of the wharf supply and return pipelines to the slops tanks; and
- Outloading to Isotanks and road tankers for local markets at up to 200 m^3 per hour.

A process flow diagram is provided in Appendix B.

The road tanker in-loading will be automated so that truck drivers can operate the system. The road tanker drivers will be inducted and have swipe cards to enter the site through the automatic entrance gate. The road tankers will be parked at the dedicated in-loading bay. This will include containment (for at least the largest compartment), an automatic foam deluge system, a safety shower / eyewash station, dry-break couplings, a transfer control system with a 3 minute deadman's button and a Scully system for earthing.

When the required preparation requirements and interlocks are complete then the transfer pumps can be operated to transfer the ethanol into the storage tanks. Road tanker drive-away protection includes gates and a traffic light system (green / red lights for go / no-go indication for the driver).

The design of the storage tanks includes the following:

- 16.5 m diameter with a 20 m wall height (designed to API 620);
- Stainless steel construction (painted exterior);
- Frangible roofs;
- Pressure and vacuum relief valves plus emergency fire relief as per the requirements of AS1940;

- Nitrogen padding above the liquid to minimise the risk of an internal explosion. The nitrogen will be supplied from a cryogenic tank and vaporiser;

- Foam piped into the tanks above max liquid level, i.e. via foam pourers;

- Radar level gauge with an independent high level trip (to prevent overfill);

- All tank control functions will be PLC (programmable logic controller) controlled;

- The tanks will be designed to operate within the under/over pressure range -2.0/+1.85kpa; and

- Concrete bunding (capacity as per AS1940).

In addition to the six ethanol storage tanks, there will be two slops tanks. Slops (waste ethanol streams) can be generated during road tanker transfers, maintenance, Isotank cleaning and pigging the wharflines. The slops tanks will be smaller than the main storage tanks (4.5 m diameter and 14.7 m high) but similarly designed. The slops will be transferred to a road tanker and reprocessed at the Shoalhaven Starches facility at Bomaderry.

Ethanol can be pumped from the storage tanks to the road tanker and Isotank loadout facility or to a ship. Tank-to-tank transfers and tank recirculation are also potential modes of operation.

The Isotanks are cleaned using steam from a package boiler. The fuel for the boiler is proposed to be from (up to) five 210 kg LPG (liquefied petroleum gas) cylinders.

Out-loading to road tankers and Isotanks is performed in a dedicated transfer bay adjacent to the in-loading transfer bay. The out-loading transfer bay will include containment (for at least the largest compartment), an automatic foam deluge system, a safety shower / eyewash station, dry-break couplings, a transfer control system with a 3 minute deadman's button and a Scully system for earthing as per the in-loading bay. It will also include a vapour connection to a scrubber so that ethanol vapours are not released to the environment during out-loading. Effluent from the scrubber will be sent to the slops system.

As out-loading to an Isotank involves connecting transfer spool pieces and separate high level protection then this operation will be performed by a Manildra operator.

Outloading to ships will require additional operators, e.g. to supervise the terminal and berth operations as well as performing line walking to check for leaks. The ship export pumps will be variable speed drive and ramp up and down when starting and stopping. The transfers to the ship at the berth will be via hoses. To avoid any potential ethanol losses, a return wharfline will also be included in the design to return waste ethanol to the slops tanks.

The wharfline and return line will be pigged to ensure the lines rest on nitrogen. These lines will be 300 mm diameter. They will run along the wharf and adjacent to the harbour to connect to the site.

All equipment in contact with ethanol will be manufactured from stainless steel. Non-destructive testing will be performed on all critical pipes, e.g. the wharflines.

The terminal design includes actuated, fail closed valves on the inlet and outlet lines for all tanks. These close on a terminal emergency.

The proposed fire detection and protection systems include:

- Leak detection at the pumps and in the switchroom;
- Foam pourers to the tanks (above liquid level);
- Fire extinguishers and hose reels;
- Automatic foam deluge at the transfer bays and over the pumps; and
- Two 100% firewater pumps, each supplied by two shared tanks, supplying firewater to hydrants, monitors and water sprinklers as per the Australian Standards for terminals and berths.

Firewater in the tank farm will be contained in the bunds and pumped to the slops tank for offsite disposal at the Shoalhaven Starches facility.

The fire protection requirements for the berth (Ref 3) are proposed to be compliant to the Australian Standards and ISGOTT 6, i.e.:

1. 2 foam extinguishers;

2. 1 fixed and 1 portable water/foam monitors, one on either side of the shore manifold. Each monitor will be capable of supplying up to 2,700 L/min;

3. 4 new dual fire hydrants with isolation valves along the water main (every 90 m) with isolation valves downstream;

4. Foam concentrate storage requirements of 450L for initial response, 3,240 L for 60 minutes of operation and 8,100 L for reserve stocks (contingency for disaster combat); and

5. Foam proportioner up to 2,700 L/min.

To ensure adequate water supply to meet the above requirements, it is proposed to upgrade the current 2 x DN100 fire water mains currently on the jetty with:

1. A new DN200 fire water main aboveground along jetty from shore to berth; and

2. A new DN250 polyethylene underground water mains from the DN150 water supply connection point (provided by Sydney Water approximately 250 m from the jetty.

The potential transport movements are as follows:

- In-loading is approximately 250 million litres per year. If there is an average of 74,000 L per road tanker then this equates to approximately 3,380 loads into the facility per year or 65 loads per week;
- Isotanks and road tanker outloading is approximately 50 million litres per year or 1,000 loads out, i.e. approximately 20 loads per week; and
- A ship transfer every one to two weeks for the remaining ethanol (approximately 200 million litres per year).

3.2 BUILDINGS

There are a number of buildings throughout the site along the southern boundary. These include:

- Workshop / Office / Laboratory / Sensory Room;
- Truck Loading / Unloading Gantry;
- Isotainer Wash Bay; and
- Electrical Switchroom.

Each year an Annual Compliance Statement will be completed. This will include information on the fire detection and protection measures for each building such as:

- A list of fire extinguishers and their locations;
- Structural integrity reviews;
- Fire water pump performance test results;
- Foam storage quantities; and
- The adequacy of fire cabinets.

The fire safety measures for these buildings will be designed and checked to comply with the requirements of the Building Code of Australia (BCA). No further assessment of the site buildings is therefore performed in this report on the ethanol storage and handling facilities on the site.

4 HAZARD IDENTIFICATION

The facility handles and stores ethanol as shown in Table 1. Ethanol is a Dangerous Good Class 3 flammable liquid. It is soluble in water.

Ethanol's flammability limits are LEL (lower explosive limit) 3.5% and UEL (upper explosive limit) 19%. The control measures regarding safe handling and storage of ethanol are similar to other Class 3 materials, e.g. elimination of ignition sources, including static. It burns with a near colourless flame. The vapour is heavier than air and can accumulate in low points. Explosions of confined vapours are possible. Ethanol combustion produces carbon dioxide and carbon monoxide. Fires involving ethanol are normally extinguished with alcohol resistant foam.

LPG is also proposed to be stored in (up to) five 210 kg cylinders for the boiler. It is a Class 2.1 Dangerous Good (flammable gas).

When released from pressurised, ambient temperature storage to atmosphere, LPG will flash, generating larger volumes of vapour and some liquid which will evaporate quickly. The flammability range is typically 2% to 9.4% v/v in air. The vapours are heavier than air and may accumulate in confined, unventilated places (and thereby create a confined explosion hazard).

LPG ignition can lead to jet fires, flash fires or vapour cloud explosions (although unconfined explosions are not credible for this storage given the relatively small quantity stored in an open area). The LPG cylinders can BLEVE (boiling liquid expanding vapour explosion) when subjected to radiant heat from a nearby fire.

Products of combustion include carbon monoxide and carbon dioxide.

The credible, significant fire and explosions hazardous events for the storage and processing facilities are summarised in the Hazard Identification Word Diagram (see Table 2). The diagram shows the causes and consequences of the events, together with major preventative and protective features.

Information for the development of the potential hazardous events was obtained from:

- The Preliminary Hazard Analyses;
- The HAZOP study on the terminal; and
- Manildra's and Pinnacle Risk Management's experience in the industry.

Table 1 - Hazardous Materials Summary

Substance	Maximum Storage Quantity	Dangerous Goods Classification	Storage Method
Ethanol (Bulk Tanks x6)	24,000,000 L	3. Flammable	Above-Ground Fixed Roof Tanks
Ethanol (Slops Tanks x2)	480,000 L	3. Flammable	Above-Ground Fixed Roof Tanks
LPG	1,050 kg	2.1 Flammable	In cylinders; each containing up to 210 kg

There will also be some minor quantities of diesel (a combustible liquid), e.g. for the fire water pumps.

Table 2 – Hazard Identification Word Diagram

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
Terminal and Shipping				
1.	Loss of containment into the tanks' bunded area	Overfilling a tank. Tank failure, e.g. weld defect. Pipe failure, e.g. weld defect, flange failure. Drain valve left open or passing. Valve leak. Loss of containment from the scrubber system, e.g. due to overfilling	Pool fire if ignited. This can propagate to the adjacent tanks. Delayed ignition can result in a vapour cloud flash fire or explosion (if confinement exists). Impact to people (radiant heat) and property	Two level instruments installed on each tank to prevent overfill including an independent high level trip. These will trip a failed closed, actuated valve on the inlet to each tank. Tanks designed to API 620. Pipes designed to AS4041. Regular maintenance and inspection procedures. Tank and site fire protection facilities including foam pourers. Earthing of all tanks, no splash filling, hazardous area assessment and ignition control procedures, e.g. Authority to Work Permits - hot work permits. Training and procedures to ensure valves in the correct position following maintenance. Maintenance of all equipment

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
2.	Tank top fire	Lightning strike, hot work	Tank top fire if ignited. This can propagate to the adjacent tanks. Impact to people (radiant heat) and property	Tanks designed to API 620. Tanks to have frangible roofs. Tanks to be nitrogen padded to lower the risk of an internal explosion with a subsequent tank top fire. Operator response to the low tank pressure alarm. Tank and site fire protection facilities including foam pourers. Earthing of all tanks, no splash filling and ignition control procedures, e.g. hot work permits
3.	On-site pipe failure external to the tanks' bunded area, e.g. failure of a pipe to the load-out gantry	Pipe defect, flange failure or impact	Spillage of ethanol. Fire if ignited. Impact to people (radiant heat) and property	Regular maintenance and inspection procedures. Emergency isolation valves. Firefighting system (including foam). Stainless steel pipes designed to AS4041. Pipes to be located on a piperack to avoid impact damage. Pipes to be fully welded where possible. Control of ignition sources, e.g. permits to work and hazardous area assessment

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
4.	Leak during unloading or loading of a road tanker or Isotank	Failure of transfer hose. Leak from valves or fittings. Road tanker or Isocontainer overfill	Spillage of ethanol. Fire if ignited at the transfer bays. Impact to people (radiant heat) and property	High level of surveillance via cameras and use of flame detection and shutdown systems. Drivers are well trained (DG licenced) so as to minimise the chance of error and ensure quick response to leaks. Transfer bays fitted with automatic foam deluge system. Remote spill containment pit to avoid collection of flammables in the loading bay. Control of ignition sources, e.g. permits to work and hazardous area assessment. Scully truck and dedicated Isotank overfill shutdown systems. Manildra operators will perform the Isotank loading activity. All equipment including the transfer hoses (loading arms) will be included in the preventative maintenance system

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
5.	Road tanker drive-away incident (i.e. driver does not disconnect the hose and drives away from the loading bay)	Failure of procedures and hardware interlocks	Spillage of ethanol. Fire if ignited. Impact to people (radiant heat) and property	Driver training. Driver not in cab during filling. Gates and a traffic light system to be installed at each transfer bay. These systems will include interlocks with the Scully and hoses via position switches. Road tanker bays fitted with automatic foam deluge system. “Dry-break” hose couplings
6.	Leak at the ethanol pumps in the pump bunded area	Pump seal, shaft or casing failures (as well as the piping failures listed in Item Number 3 above)	Leak of ethanol in the pump bay. Fire if ignited. Impact to people (radiant heat) and property	Condition monitoring and preventative maintenance of the pumps. Leak detection system and alarm. Fire detection with automatic foam deluge over the pumps. Pumps in contained area to lower the likelihood of propagation

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
7.	Fire / explosion within the drainage system	Spill or release of ethanol with subsequent ignition	Potential for an internal explosion in the underground tanks (primarily TK-1601 as TK-1602 will be used for stormwater storage and handling). Potential for a flame to travel throughout the drainage piping system (this may result in multiple confined explosions in the drainage pipework)	Control of ignition sources, e.g. permits to work and hazardous area assessment. Flame arrestors to be installed on the underground tanks' vents. Flame traps to be installed in the drainage piping system
8.	Loss of containment of ethanol during pipeline pigging	Opening the pig hatch with too much ethanol inside. Leaving a pig hatch drain and/or vent valve open	The loss of containment could occur at the terminal or at the berth. Fire if ignited. Impact to people (radiant heat) and property. Environmental impact if ethanol is spilt into the harbour	The pig hatches and operations are to be as per industry good practice. Only appropriately trained operators will perform the pigging operations. Procedures for pigging to include the required sequence for valve operation to avoid leaving a drain or vent valve open. Control of ignition sources, e.g. permits to work and hazardous area assessment. The pig hatches will be bunded. Fire protection at the site and berth will include hydrants and extinguishers

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
9.	Loss of containment from the wharflines	Third Party interference. Pipe defect, flange failure or impact. Lightning strike Hammer / surge	The loss of containment could between the terminal and the berth, or at the berth. Fire if ignited. Impact to people (radiant heat) and property. Environmental impact if ethanol is spilt into the harbour or to the ground	The wharflines will be cleared of ethanol using pigs and they will rest on nitrogen. Line-walking during wharfline transfers. Regular maintenance and inspection procedures. Emergency isolation valves and operator response, e.g. closing the shore isolation valves. Mobile firefighting equipment in a trailer (to be positioned at the berth during ship transfers) . Stainless steel pipes designed to AS4041 and AS2885. Pipes to be fenced and barriers installed to avoid impact damage. Pipes to be fully welded where possible. Surge study to be performed on the wharflines, e.g. to ensure the actuated valves do not close too quickly. Control of ignition sources, e.g. permits to work, pipeline earthing and hazardous area assessment. Emergency response include spill equipment

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
10.	Loss of containment from the ship transfer system	Ship hose failure, e.g. due to wear and tear. Ship pulls away from the berth. Ship transfer hoses flanges not adequately connected. Leak when using the stripping pump for clearing the ship's hoses	Potential for a loss of containment into the harbour hence environmental impact and fines. As ethanol is miscible with water, it will not pool on top of the water so a floating fire is not credible as is the case for petroleum products such as gasoline. If ethanol is released onto the berth then there is the potential for a fire if ignited. Impact to people (radiant heat) and property	Shipping hoses to be included in the hose register for routine testing and inspection. Standard international good practice for berthing a ship, e.g. securing the ship to the berth using ropes. Hoses inspected and pressure tested prior to ethanol transfer. Emergency response by the supervisors using radios and the process shutdown button. Trained personnel. Hoses to be included in the preventative maintenance system for routine pressure and electrical continuity tests. Emergency response includes firewater protection at the berth and a mobile trailer with equipment response equipment. Berth surrounded by a bund 300 mm high. Drain blocking fitting inserted into the berth drain during the time hoses are being connected, ethanol is being loaded or hoses are being disconnected

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
Boiler				
11.	Explosion within the boiler	LPG continues to flow when the burners are offline and the furnace is still hot	Buildup of flammable vapour in the furnace. If ignited, there is the potential for an internal explosion, i.e. damage to the furnace and boiler	Burner management system will be certified to Australian Standards which will include the need for adequate LPG isolation and air purging prior to startup
12.	Loss of containment of LPG from the supply pipe or cylinders	Corrosion or weld defect, gasket failure, valve leak, impact	If ignited, potential for a flash and/or jet fire which can impact personnel and equipment. A release from a 25 mm hole occurs (largest pipe size and assuming 25C saturated pressure), if ignited, will result in a jet fire of approximately 26 m, i.e. insufficient length to reach the ethanol tanks or the nearest adjacent property. If a jet fire impinges on the LPG cylinders or there is excessive radiant heat from an ethanol pool fire then the cylinders can BLEVE. Historically, this is a low likelihood event. For example, Ref 4 quotes a BLEVE likelihood of $5x10^{-7}$ times per year.	The piping and equipment items are to be compliant with the Australian Standards, e.g. AS1596. The LPG pressure will be reduced (via a regulator) at the cylinders and the supply pipe will be relatively small, i.e. 25 mm diameter (limits the flowrate if a release occurs). The LPG cylinders are to be located in an open area away from potential vehicle impacts and also in an area were the potential radiant heat from an ethanol pool fire is less than 10 kW/m^2. The LPG supply pipe is to be pressure tested following construction and protected against corrosion by painting. Control of ignition sources, e.g. permits to work and hazardous area assessment

5 CONSEQUENCE ANALYSIS

5.1 POOL FIRE MODELLING

The following pool fire scenarios have been modelled:

- Bund fire (compound and an intermediate bunded area);
- Road tanker transfer bay fires;
- Pump and pig hatch bund fire; and
- Representative tank top fires.

There are no credible explosion events with adverse off-site impacts. As ethanol is a flammable liquid then pool fires are the credible hazardous events with the potential for off-site impact.

Fires at the berth are not modelled as there is a generous separation distance to the land users (i.e. no credible risk of adverse radiant heat impact from a berth fire). Any ethanol that is potentially released into the harbour during ship transfers will immediately mix and dilute with the water, i.e. a floating pool fire scenario is not credible.

Potential fires associated with releases from the wharflines are not modelled as the likelihood of these events is very low given that these pipelines will contain nitrogen for the majority of the time and the release quantity will vary.

The fire prevention, detection and protection controls for both the berth and the wharflines are, however, included in this FSS.

Therefore, the credible hazardous events associated with the proposed terminal are largely pool fires due to potential losses of containment being ignited. The potential pool fire events associated with the equipment, tanks and bunds are detailed in Table 3. This data is used in the fire modelling. A discussion on burndown rates and surface emissive powers (SEP) is given below.

Burndown Rates:

For burning liquid pools (Ref 5), heat is transferred to the liquid via conduction, radiation and from the pool rim.

Wind can also affect the burning rate (experiments have shown both an increase and decrease in burning rates due to the effects of wind) but also can affect flame stability (and hence average flame emissive power) (Ref 6). Therefore, average reported values for burndown rates are used in this study.

For very large pool fires with diameters greater than 5 to 10 m, there is some evidence of a decrease in burning rate.

Experimental data for the ethanol burndown rate is 1 mm/min (Refs 6 and 7).

The burning rate is used in the determination of flame height. Normally, the higher the burning rate, the higher the estimated flame height.

Surface Emissive Power:

Surface emissive power can be either derived by calculation or by experimentation. Unfortunately, experimental values for surface emissive powers are limited.

When calculated, the results can be overly conservative, particularly for large diameter fires, as it is assumed that the entire flame is at the same surface emissive power. This is not the case for large diameter fires as air entrainment to the centre of the flame is limited and hence inefficient combustion occurs.

For ethanol, a literature search (Refs 8 and 9) indicates the following data:

SEP's of 50kW/m^2 for large fires (pool diameter => 25 m) and 60 kW/m^2 for pool fires less than 25 m in diameter appear reasonable.

The distances to specified radiant heat levels for the potential fire scenarios are shown in Table 3. The distances were calculated using the View Factor model for pool fires (Refs 6 and 7). Graphical representations of the estimated radiant heat contours are shown in Appendix C.

The modelling in this FSS was performed using a wind speed of 2 m/s. This typically achieves a 45 degree wind tilt and hence provides greater impact distances (e.g. when compared to the modelling in the PHA (Ref 10)).

Table 3 – Fire Scenarios Calculation Data and Results

Note that "Eq. D" is the equivalent diameter of the fire (4 x the fire area / the fire perimeter) and "SEP" is the surface emissive power (i.e. the radiant heat level of the flames).

Item No.	Item Description	Width, m	Length, m	Eq. D, m	Tank Height, m	Liquid Density, kg/m^3	SEP, kW/m^2	Distance to Specified Radiant Heat Level, m (from base of flame)				Maximum Ground Level Radiant Heat, kW/m^2 (for tank fires only)
								23 kW/m^2	12.6 kW/m^2	4.7 kW/m^2	3 kW/m^2	
1	Compound fire	-	-	74	-	790	50	14	26	50	64	-
2	Intermediate Bund Fire (for comparison to the compound fire) – Bund Closest to the Fire Water Tanks	-	-	41	-	790	50	10	17	31	39	-
3	Fire at the road tanker transfer bay (Note 2)	7	32	7	-	790	60	5	6	9	11	-
4	Fire at the pump and pig hatch bund (Note 2)	7.4	25	7.4	-	790	60	4	6	9	11	-
5	Tank top fire	-	-	16.5	20	790	60	7	11	17	21	Less than 3 kW/m^2
6	Slops tank top fire	-	-	4.5	14.7	790	60	3	4	7	8	Less than 3 kW/m^2

Notes for Table 3:

1. The bund fires include releases from piping leaks which ignite as well as releases from tank failures.
2. Modelled as a channel fire, i.e. flame height estimated based on width.
3. Modelling performed at 2 m/s wind speed.

The values of interest for radiant heat (DoP, HIPAP No. 4 and ICI HAZAN Course notes) are shown in Table 4.

Table 4 - Radiant Heat Impact

HEAT FLUX (kW/m^2)	EFFECT
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 15-30 seconds and second degree burns after 30 seconds. Glass breaks
12.6	30% chance of fatality for continuous exposure. High chance of injury Wood can be ignited by a naked flame after long exposure
23	100% chance of fatality for continuous exposure to people and 10% chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure Unprotected steel will reach thermal stress temperatures to cause failure
35	25% chance of fatality if people are exposed instantaneously. Storage tanks fail
60	100% chance of fatality for instantaneous exposure

For information, further data on tolerable radiant heat levels is shown in Table 5.

Table 5 – Layout Considerations – Tolerable Radiant Heat Levels

Plant Item	Tolerable Radiant Heat Level, kW/m^2	Source
Drenched Storage Tanks	38	Ref 7
Special Buildings (Protected)	25	Ref 7
Cable Insulation Degrades	18-20	Ref 7
Normal Buildings	14	Ref 7
Vegetation	12	Ref 7
Plastic Melts	12	Ref 7
Escape Routes	6	Ref 7
Glass Breakage	4	Ref 11
Personnel in Emergencies	3	Ref 7
Plastic Cables	2	Ref 7
Stationary Personnel	1.5	Ref 7

5.2 PROPAGATION ANALYSIS

Tank Top Fires – Items 5 and 6 in Table 3:

Propagation of a fire event can occur if equipment is subjected to approximately 23 kW/m^2 or higher for a prolonged exposure period, i.e. the exposed equipment could fail due to high temperature creep, typically after at least 10 minutes of exposure.

Historical evidence shows that tanks fires in terminals can propagate from tank-to-tank even when the separation distances are compliant with the relevant codes and standards. One reference (Ref 12) quotes a study on large diameter, external floating roof tanks (wind speed of 4 m/s) and the estimated average time for the fire to propagate from one tank to an adjacent tank (see Table 6).

Table 6 – Tank Fires Propagation Time

Intertank Separation	Propagation Time (Hours)
0.5 Tank Diameter	1.5 (Note 1)
1.0 Tank Diameter	3.0
2.0 Tank Diameter	17

Note 1: The propagation time will increase to 2.8 hours when there is no wind or when water sprays are used on the tank at risk.

Others notes for the above table include:

- ➢ Smaller diameter tanks at normal separations are at greater risk of propagation than larger diameter equivalent tanks; and
- ➢ Lower volatility fuels allow more response time for fire fighters

AS1940 requires a tank separation distance of 0.5 x diameter for tanks between 6 to 20 m. Therefore, unless a potential tank fire is extinguished reasonably quickly with the available fire protection facilities then propagation to an adjacent tank is possible.

Bund Fires - Items 1 and 2 in Table 3:

Propagation from large bund fires is generally possible due to a number of reasons, e.g. high surface emissive power (non-soot producing materials such as ethanol), flame drag, wave action taking both product and flames over bund walls and failure of the containment integrity. Given the relatively high surface emissive power for ethanol then propagation is possible due to prolonged exposure *without* emergency response cooling and equipment protection.

Based on the radiant heat contours in Appendix C, it is possible that propagation can occur from these potential events to other tanks and equipment within the site, i.e. piping, the transfer pumps, the pig hatches and possible the transfer bays equipment.

With respect to propagation to adjacent tanks due to a potential bund fire, the higher the received radiant heat, the shorter the propagation time. Hence, given the results in Table 3 and shown in Appendix C, propagation from an ethanol bund fire is expected in a shorter time as the radiant heat on adjacent tanks is estimated to exceed 23 kW/m^2, in particular, when flame drag in windy conditions is taken into consideration.

Fortunately, the likelihood of these events is low (approximately 6×10^{-6} per year, Ref 13). As determined in the PHA (Ref 10), the risk of these major events and hence propagation is not considered intolerable.

Smaller Area Fires - Items 3 and 4 in Table 3:

From the results shown in Table 3 and Appendix C, propagation from a fire in the pump and pig hatches bund or in the road tanker transfer bay is not expected. This is due to the separation distances provided between these areas and other equipment on the site.

Potential fires at the pump and pig hatches bund or in the road tanker transfer bay, whilst historically of a relatively higher likelihood when compared to bunds, will have automated foam deluge system installed.

Personnel Impact from Potential Radiant Heat:

For assessment of the effects of radiant heat, it is generally assumed that if a person is subjected to 4.7 kW/m^2 of radiant heat and they can take cover within approximately 20 seconds then no serious injury, and hence fatality, is expected. However, exposure to a radiant heat level of 12.6 kW/m^2 can result in fatality for some people for limited exposure durations. Therefore, for the larger fires, appropriate emergency response actions are required to minimise the potential for harm to people. This should include moving people away from such releases to a safe distance. See Table 7 for further information regarding the impact of radiant heat on people.

Table 7 – Estimated Effects of Radiant Heat on People

Radiant Heat (kW/m2)	Impact
37.5	100% lethality in 1 minute
25	1% lethality in 10 seconds
15.8	100% lethality in 1 minute (as above), significant injury in 10 seconds
12.5	1% lethality in 1 minute, first degree burns in 10 seconds
10.4	Pain after 3 seconds of exposure (CIA, Guidance for the Location and Design of Occupied Buildings on Chemical Manufacturing Sites, 1998)
6.3	Emergency actions lasting 1 minute can be performed by personnel without shielding but with appropriate clothing (API RP 510)
4.7	Emergency actions lasting several minutes can be performed by personnel without shielding but with appropriate clothing (API RP 510)
2.1	Minimum to cause pain after 1 minute

For the potential fires that can occur in the terminal, the results shown in Table 3 and Appendix C indicate that the 4.7 kW/m^2 radiant heat contours for the larger potential fires do extend off-site. Therefore, if people are unable to escape then burn injuries can be expected.

Shielding from radiant heat from these fires is possible by remaining indoors. Escape from the radiant heat is also possible via a vehicle (i.e. protection is afforded by the vehicle roof and panels). However, from the available details of the adjacent areas to the terminal, it does not appear that there are any unprotected areas where people are likely to congregate nor could be trapped in the event of a larger fire. As shown in the PHA (Ref 10), the risk associated with all potential fire events at the terminal is not intolerable.

6 FIRE PREVENTION STRATEGIES / MEASURES

As identified in Section 4 of this report, prevention of losses of containment on the site is of paramount importance. The preventative measures proposed for the terminal (as shown in Table 2) are as follows plus some additional proposed preventative measures:

Hardware:

- Two level instruments installed on each tank to prevent overfill including an independent high level trip. These will trip a failed closed, actuated valve on the inlet line to each tank;
- Earthing of all tanks and no splash filling;
- Hazardous area assessment with compliant electrics and instrumentation;
- Tanks to be nitrogen padded to lower the risk of an internal explosion with a subsequent tank top fire;
- Emergency isolation valves, e.g. on the tank inlet and outlet pipes;
- On-site pipes to be located on piperacks to avoid impact damage;
- Pipes to be fully welded where possible;
- High level of surveillance via cameras, and use of flame detection and shutdown systems;
- Scully truck and dedicated Isotank overfill shutdown systems;
- Gates and a traffic light system to be installed at each transfer bay to lower the risk of drive away incidents. These systems will include interlocks with the Scully and hoses via position switches;
- Dry-break hose couplings;
- Leak detection system and alarm, e.g. for the transfer pumps;
- Flame arrestors to be installed on the underground tanks' vents;
- Flame traps to be installed in the drainage piping system;
- The wharflines are to be fenced and barriers installed to avoid impact damage;
- Burner management system will be certified to Australian Standards which will include the need for adequate diesel isolation and air purging prior to startup;
- LPG industry standard cylinders to be used for supplying LPG to the boiler;

- Pipework designed to relevant codes and Australian standards, e.g. AS4041 and AS1596;
- Pressure relief devices, e.g. for thermal overpressure protection;
- Tanks designed to relevant codes and Australian standards, e.g. API620; and
- All piping and equipment items handling and storing ethanol are stainless steel to reduce the risk of corrosion.

Procedural:

- Clearance to work protocols including a hot work permit system;
- Regular maintenance and inspection procedures for the equipment;
- Training and procedures to ensure valves in the correct position following maintenance;
- Operator response to alarms;
- Manildra operators will perform the Isotank loading activity;
- Only appropriately trained operators will perform the pigging operations;
- The wharflines will be cleared of ethanol using pigs and they will rest on nitrogen;
- Line-walking during wharfline transfers;
- Surge study to be performed on the wharflines, e.g. to ensure the actuated valves do not close too quickly;
- Standard international good practice for berthing a ship, e.g. securing the ship to the berth using ropes;
- Shipping hoses inspected and pressure tested prior to ethanol transfer;
- Site sirens sound to warn site personnel of emergency and hence all hot work will cease;
- Vehicles not left unmanned in the transfer bays;
- Training for relevant equipment, e.g. boiler operation;
- Modification management system acts to ensure that changes are reviewed prior to approval;
- Standard operating instructions;
- Incident reporting and investigation system; and
- Regular auditing and housekeeping.

7 FIRE DETECTION AND PROTECTION

7.1 DETECTION

Fire detection throughout the site is via both automated systems and by sight, e.g. operators and drivers when present.

The main release or fire detection systems include:

- Gas detectors are to be installed at the ethanol transfer pumps with automated foam deluge (using flame detectors);
- The foam system for the road tanker loading bays will be automatically initiated should a fire occur (infra-red detectors as per the Shoalhaven Starches site);
- Break glass alarms are to be located around the site and all fire alarms will be connected to the Fire Brigade emergency response system; and
- Smoke and thermal detectors in the buildings including the switchroom. These are to be alarmed to the Fire Brigade with automatic call-out.

7.2 PROTECTION

7.2.1 Overview

For bulk flammable liquids storage and handling facilities, the main means of fire protection is a combination of fire water and foam systems. The requirements are detailed in:

- AS1940 (the Australian Standard for the Storage and Handling of Flammable and Combustible Liquids); and
- NFPA (National Fire Protection Association) 11 (Standard for Low, Medium and High Expansion Foam Systems).

In summary, should a fire occur in the terminal then people are required to initiate and/or use the following main fire protection systems:

- Hydrants (water);
- Foam pourers directly to the tanks containing flammable liquids; and
- Monitors (water and foam).

The higher likelihood fire events, i.e. a pump fire and a fire in the road tanker loadout bay, will include automatic foam suppression systems as the terminal is unmanned. The lower likelihood events, i.e . tank top fire and bund fires, will require personnel to go to the site (if not already there) to assess the scenario and then determine the appropriate fire response actions. Site induction will be provided to the local fire brigade so that they can also initiate the required response as well.

There will also be an automatic foam deluge system for the road tanker transfer areas and the transfer pumps.

7.2.2 Proposed Terminal Fire Water and Foam Storage and Reticulation

The fire water protection systems will include the following:

- Two new firewater storage tanks located along the eastern boundary of the site. Each tank will store 400 m^3. A new connection to the water mains and individual automatic level control valves will be provided with a minimum makeup rate of 3,600 LPM. By installing two tanks, it is possible to perform maintenance on one tank with some fire water still available from the other tank;

- Two new fire water pumps. The pumps will be diesel driven and housed in a building located near the fire water tanks. Each pump will be able to deliver the design flow of 12,000 LPM. There will also be an electric jockey pump to supply small fire water demands (10 LPM). The main fire water pumps are sized for a discharge pressure of 1,000 kPag such that the minimum residual pressure in the hydrant ring main will exceed 700 kPag as required by AS 2419.1;

- Hydrant ring main. The hydrant ring main will be DN300. Each hydrant riser will be fitted with dual landing valves and fittings to match the Fire and Rescue NSW (FRNSW) equipment. The hydrant installation will be designed in accordance with Australian Standard AS2419.1, Fire Hydrant Installations, Part 1: System design, installation and commissioning. As some of the fire water supply piping is above ground and it is within 150 m of the tanks to be protected then the hydrants are to be installed not more than 60 m apart as per the requirements of AS2419;

- The twin hydrants are to be designed to supply a minimum of 10 L/s through each outlet. All fire hydrants are to be capable of flowing at least 10 L/s at a minimum of 700 kPag as per the requirements of AS2419;

- The hydrants will be located such that every part of each storage, process and plant will be within reach of a 10 m hose stream issuing from a nozzle at the end of a 60 m length of hose connected to a hydrant outlet as per AS2419.1;

- Fire brigade suction and booster connections at an area of hardstand near the fire water pumps. These will include four DN150 Storz suction connections and two quadruple inlet brigade booster connections (to suit DN65 hoses);

- The site's fire protection equipment is to be maintained by an external fire protection company (to the requirements of AS 1851, Maintenance of Fire Protection Equipment); and

- New fire alarm and fire indication panel system including manual fire alarm call points.

All firefighting foams will be stored in containers within the foam house near the fire tanks to east of the site. This store will include secondary containment for potential loss of foam from any container. The type of foam will be a 3/3 alcohol resistant foam suitable for the application required. Under the Environment Protection Authority (EPA) regulations, firefighting foams are expected to be PFAS (per and polyfluoroalkyl substances) free unless needed for 'catastrophic fires'. As such, the site will store non PFAS (fluorine free) firefighting foam for all applications for which this foam has been shown to have adequate efficacy. This will be applied to the truck loading bays, transfer pumps, monitors at the tank bund and the marine berth area.

However, for the potential larger fires such as the large storage tanks, the use of PFAS free foam is still being trialled. As such it is proposed to use a current PFAS foam for this purpose unless evidence is provided that would prove efficacy for this application such as planned to be carried out by LASTFire in April 2022. To reduce environmental exposure, no PFAS foam will be used for testing, training or commissioning but only for an actual fire event. To achieve this the type of proportioner (FireDOS) will enable proof of foam mixing ratio without the need to transfer the foam into a water solution. All testing will be done using water only simulating foam/water pressures and only controlled samples will be produced in a contained area to provide foam test records.

In summary, the foam protection systems will include the following:

- A new foam generator installed in the pump house building. The foam solution capacity is made up of two applications. For tanks and monitors, there will be 3,000 litres (3 x 1,000 litre IBCs with secondary containment) with a minimum onsite quantity of 2,300 litres. The loading rack and pump shed deluge system will have 1,000 litres (one IBC with secondary containment) with a minimum on site quantity of 800 litres. Two separate solution lines will run from the foam house building to these applications;

- Foam systems for the fixed cone roof bulk ethanol tanks. The foam systems will be activated manually from a foam pilot station located adjacent to the foam house building;

- Foam-water deluge system for the loading gantry that is automatically initiated by one out of four flame detectors. The gantry foam system branches off the main foam solution header and is activated via a deluge valve; and

- Foam-water deluge system for the transfer pumps that is automatically initiated by one out of two flame detectors. The transfer pumps foam system branches off the main foam solution header and is activated via a deluge valve.

7.2.3 Terminal Design Basis

The individual design cases are:

- Bulk storage tank foam systems;
- Cooling water for a tank on fire;
- Loading gantry foam sprinkler system;
- Transfer pumps foam sprinkler system; and
- Two fixed monitors (water/foam) either side of the slops tanks.

These are individually detailed and then the design case is summarised at the end of this section. These calculations are preliminary and should not be used for final design purposes.

Bulk Storage Tank Foam Systems:

The following table summarises the fire water and foam estimates for the foam pourers in the bulk ethanol tanks. AS1940-2017 does not require direct foam injection for tanks with diameters less than 6 m. As the slops tanks have a diameter of 4.5 m then these tanks do not require foam injection. The discharge durations are from AS1940-2017 (Clause 11.16.4), i.e. 55 minutes for a Type II foam pourer (assumed). A 3% foam solution is also assumed for the purposes of estimating the foam and fire water rates and quantities.

For ethanol tanks, the design application rate is 6.5 LPM/m^2 (AS1940-2017 Table 11.6). These application rates are multiplied by the cross-sectional area of the tanks to yield the required foam solution rate, i.e. the bulk tanks have a diameter of 16.5 m which gives an area of 214 m^2. Hence, the foam application rate is 214 x 6.5 = 1,391 LPM.

Table 8 – Bulk Ethanol Tanks Foam Requirements

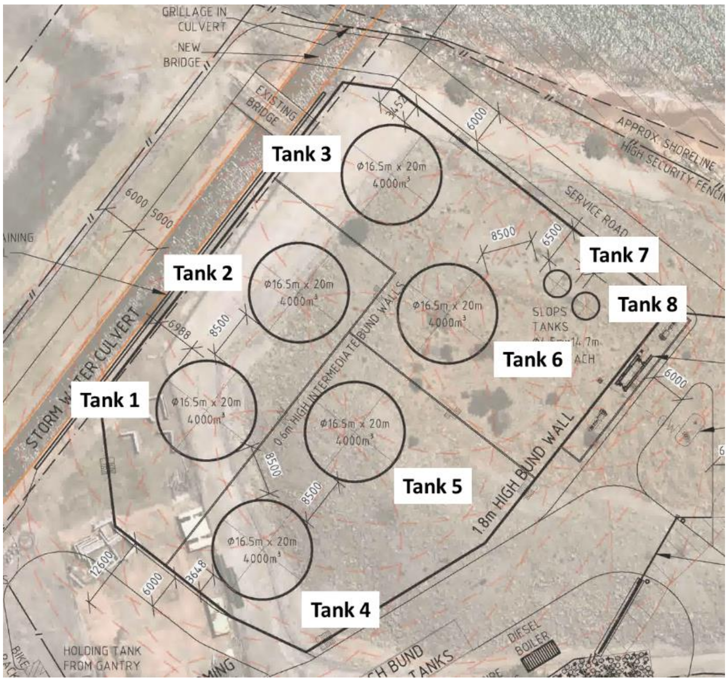
Discharge Duration (minutes)	Foam Solution (LPM)	Fire Water Requirement (LPM)	Foam Concentrate (LPM)	3% Foam Concentrate Requirement (L)
55	1,391	1,349	42	2,310

Cooling Water for a Tank on Fire:

This is a requirement of AS1940. The rates are determined using Appendix I of AS1940-2017. No allowance has been included for wastage (e.g. wind affecting the water density due to losses from spray) in the following estimates.

The tanks have been arbitrarily numbered for the purposes of performing these calculations as shown in the following figure.

Figure 3 – Arbitrary Tank Numbering



The highest demand for cooling water protection is when either Tank 2 or Tank 5 is on fire. The calculations are shown in Figure 4. For completeness, Tank 6 on fire is shown in Figure 5 as this includes the smaller slops tanks. Tank 6 does not need cooling water on the eastern side due to the adequate separation from the slops tanks.

Given the above estimates, the maximum cooling water rate is at least 7,172 LPM.

Loading Gantry Foam Sprinkler System (two transfer bays):

The foam application density of 6.5 LPM/m^2 and duration of 10 minutes is based on NFPA 16 for the vehicle transfer bays. It is assumed that a release has occurred and there is ethanol in both transfer bays, i.e. the following fire water and foam estimates are based on a combined fire in both transfers bays. The combined dimensions are taken to be 14 m x 32 m (= 448 m^2 area requiring protection).

Table 9 – Vehicle Transfer Bays Foam Sprinkler System Rates

Area (m^2)	Discharge Duration (minutes)	Application Density (LPM/m^2)	Foam Solution (LPM)	Foam Concentrate (LPM)	3% Foam Concentrate Requirement (L)
448	10	6.5	2,912	87	870

That is, the maximum fire water rate is 2,825 LPM (2,912 x 0.97) and the maximum foam quantity is 870 L.

Pumps Foam Sprinkler System (two transfer bays):

The foam application density of 6.5 LPM/m^2 and duration of 10 minutes is based on NFPA 16 is also used for the pump bunds. It is assumed that the pig hatch is separately bunded to the pumps. The estimated dimensions for the pump bund are taken to be 7.4 m x 25 m (= 185 m^2 area requiring protection).

Table 10 – Pump Bunds Foam Sprinkler System Rates

Area (m^2)	Discharge Duration (minutes)	Application Density (LPM/m^2)	Foam Solution (LPM)	Foam Concentrate (LPM)	3% Foam Concentrate Requirement (L)
185	10	6.5	1,200	36	360

That is, the maximum fire water rate is 1,164 LPM (1,200 x 0.97) and the maximum foam quantity is 360 L.

Figure 4 – Cooling Water Estimate for Tank 2 (or 5) on Fire

Cooling Water Estimates to AS1940 Appendix I (2017)

Total Capacity of Installation = 24480 **m3**

Tank on Fire		Tanks within 1.5D						Minimum Required Cooling Water		
Tank	**Diameter, D (m)**	**Tanks Affected**	**Diameter, d (m)**	**Height, h (m)**	**Shell-to-Shell Separation Distance, S (m)**	**S/D**	**W (L/min/m2)**	**Walls d x h x W L/min**	**Roof (if S=<D) 0.25 x d x d x W L/min**	**Total Cooling Water, L/min**
Middle Tank	16.5	1	16.5	20	8.3	0.50	4.5	1486	307	1793
(e.g. Tank 2)	16.5	3	16.5	20	8.3	0.50	4.5	1486	307	1793
	16.5	5	16.5	20	8.3	0.50	4.5	1486	307	1793
	16.5	6	16.5	20	8.3	0.50	4.5	1486	307	1793

AS1940 J2.3: **W =** **40**

AS1940 J2.2: **Total Cooling Water** **7172** **L/min**

Diameter of Largest Flammable Liquid Tank = **16.5** **m**

Total Cooling Water for J2.3: 660 **L/min**

Design Total Cooling Water Flow = **7172** **L/min**

Figure 5 – Cooling Water Estimate for Tank 6 on Fire

Cooling Water Estimates to AS1940 Appendix I (2017)

Total Capacity of Installation = 24480 **m3**

Tank on Fire		Tanks within 1.5D						Minimum Required Cooling Water		
Tank	**Diameter, D (m)**	**Tanks Affected**	**Diameter, d (m)**	**Height, h (m)**	**Shell-to-Shell Separation Distance, S (m)**	**S/D**	**W (L/min/m2)**	**Walls d x h x W L/min**	**Roof (if S=<D) 0.25 x d x d x W L/min**	**Total Cooling Water, L/min**
Tank 6	16.5	2	16.5	20	8.3	0.50	4.5	1486	307	1793
	16.5	3	16.5	20	8.3	0.50	4.5	1486	307	1793
	16.5	5	16.5	20	8.3	0.50	4.5	1486	307	1793
	16.5	7	4	18	8.3	0.50	4.5	324	18	342
	16.5	8	4	18	12.5	0.76	2.8	200	11	212

AS1940 J2.3: **W =** **40**

AS1940 J2.2: **Total Cooling Water** **5933** **L/min**

Diameter of Largest Flammable Liquid Tank = 16.5 **m**

Total Cooling Water for J2.3: **660** **L/min**

Design Total Cooling Water Flow = **5933** **L/min**

Foam Monitors:

It is recommended to have at least two monitors for any unique fire events at the site. It is not a code requirement to have these but is consistent with good practice, e.g. as used at the Shoalhaven Starches site.

An estimate of foam and fire water requirements are shown in the following table. These results are for two 1,900 LPM monitors in operation at the same time.

Table 11 – Foam Monitors Flowrates

Discharge Duration (minutes)	Foam Solution (LPM)	Foam Concentrate (LPM)	3% Foam Concentrate Requirement (L)
20	3,800	114	2,280

That is, the maximum fire water rate is 3,686 LPM (3,800 x 0.97) and the maximum foam quantity is 2,280 L.

The above individual events are summarised in Table 12.

Table 12 – Summary of Individual Fire Water Users

Event:	Fire Water Rates, L/min	Foam Concentrate Rates, L/min	Minimum Duration, minutes	Fire Water Quantity, L	Foam Quantity, L
Tank 2 on Fire:					
Fire water for foam	1,349	42	55	74,195	2,310
Fire water for cooling	7,172	-	90	645,480	-
AS1940 Clause 11.13.4.2	1,800	-	240	432,000	-
Total	10,321	42		1,152,000	2,310
Vehicle Transfer Bays					
Foam-water deluge	2,825	87	10	28,250	870
Allowance for three hoses	1,800		240	432,000	
Total	4,625			460,250	
Pump bund					
Foam-water deluge	1,164	36	10	11,640	360
Allowance for three hoses	1,800		240	432,000	
Total	2,964			443,640	
Foam Monitors	3,686	114	20	73,720	2,280
Allowance for three hoses	1,800		240	432,000	
Total	5,486			505,720	

Notes:

1. Hose duration conservatively set at 240 minutes (AS2419.1-2017 Clause 4.2.1.1) and this additional fire water requirement is allowed for in all fire cases.

In summary,

- The estimated largest fire water demand occurs during a tank-on-fire scenario (i.e. tanks 2 or 5 in Figure 3) of at least 10,321 LPM;
- The fire water storage should be at least 1,152,000 L; and
- The foam storage should be at least 2,310 L.

The above estimates do not allow for future modifications to the site or include losses due to wind.

To achieve the fire demand requirements it is proposed to install:

- 12,000 L/min fire pumps (above the minimum 10,321 LPM required);
- 2 x 400 kL tanks with a makeup water rate from the water mains of 3,600 L/min (or in 90 minutes 324 kL). This flow rate is the equivalent of six hoses in use simultaneously. The total water available will be well above the minimum required above; and
- Foam storage of 3,000 L for tanks and monitors (above the minimum 2,310 L required) and 1,000 L for deluge systems (above the minimum 800 L required).

7.2.4 Shipping Fire Protection

Manildra and NSW Ports have discussed and agreed that the berth fire protection equipment will be compliant with ISGOTT6 (the International Safety Guide for Oil Tankers and Terminals, Revision 6). The berth fire protection details are summarised as follows (from Section 3.1 with further details):

1. 2 x 9 kg foam extinguishers (AS 3846 requirement);
2. 2 x water / foam monitors, one on either side of the shore manifold (ISGOTT requirement):
    a. One fixed tower approximately 8 m high above berth level (remotely operated) to the south of the berth;
    b. One portable monitor on the berth (manually operated) to the north. This will be temporarily placed in position during shipping activity with a 100 mm hose connection;
    c. Each monitor will be capable of up to 2,700 L/min. This is the minimum AS 3846 requirement (1.5 x 1,800 L/min);
3. Four new dual fire hydrants with isolative valves along the water main (every 90 m) with isolation valves downstream (ISGOTT requirement). It is proposed to install an additional 100 mm Storz connection at each hydrant for the foam trailer connection;
4. Foam concentrate storage requirements as outlined below (AS 3846):
    a. 450 L for initial response (AS 3846);
    b. 3,240 L required for 60 min operation at 3% concentration (AS 3846, Appendix G);
    c. 8,100 L reserves stocks for 2.5 h operation at 3% concentration (AS 3846, Appendix G);

d. It is proposed to store 6,000 L of foam at the wharf in a poly tank and hold rest at Bulk Liquids Facility (3,000 L on a foam monitor trailer and 3,000 L in IBCs);

5. Foam proportioner up to 2,700 L/min:

   a. Isolation valves upstream and downstream of foam proportioner to enable water or foam streams; and

   b. The minimum foam solution rate will be 2,700 L/min.

To ensure adequate water supply to meet the above requirements, it is proposed to upgrade the current 2 x DN100 fire water mains currently on the jetty with:

1. A new DN200 fire water main aboveground along jetty from shore to berth; and

2. A new DN250 polyethylene underground water mains from the DN150 water supply connection point (provided by Sydney Water approximately 250 m from the jetty.

As ethanol is miscible in water and ethanol solutions need to be approximately 10% to burn then a floating ethanol pool fire is not credible. Ethanol fires are credible on the berth and ship if a loss of containment occurs and is ignited.

To supplement the above fire protection systems, NSW Ports have the following Svitzer tugs:

Svitzer Ruby

- A water capacity of 2,750 m^3/hr; and
- Foam discharge capabilities are up to 680 L/min (40.8 m^3/hr)

Svitzer Bass & Svitzer Flinders

- Firefighting capabilities of 600m^3/hr each.

For berths, the required fire protection systems are dependent on the location and size of the fire, e.g. on the ship or on the berth. The ships are also normally equipped with their own firefighting systems, e.g. cannons. Given the combination of AS 3846 and ISGOTT compliance, NSW Ports tugs and the ships typical systems then no further berth fire protection systems are deemed necessary.

8 FIRE SERVICES DRAWINGS

The drawings shown in Appendix A are provided to assist the reader with understanding of the fire protection system design. These drawings are selected only to suit the analysis in this Fire Safety Study.

Included in Appendix A are:

- A site layout drawing showing the overall fire water and foam supply systems;
- P&IDs for the fire water and foam tanks, piping systems and pumps; and
- A drawing showing the proposed fire protection for the berth.

9 FIRE FIGHTING WATER HYDRAULIC CALCULATIONS

The hydraulic model results for the worst-case fire scenario, i.e. tanks 2 or 5 on fire, are provided in Appendix D. The hydraulic model for the berth fire protection system is also included.

The site's system is being designed to supply at least the design case fire water rate of 10,321 LPM. The main fire water pumps are being sized for a discharge pressure of 1,000 kPag.

The requirements of AS 2419 are to be included in the system design, i.e.:

- Minimum pressure of 700 kPag in the ring main;
- A maximum velocity of 4 m/s in the ring main;
- The total hydraulic loss due to friction in pipes, valves and fittings between the inlet connection of the booster assembly and the outlet of the most hydraulically disadvantaged fire hydrant shall not exceed 150 kPa when the required number of most hydraulically disadvantaged fire hydrants are each discharging 10 L/s; and
- The maximum discharge pressure at any hydrant outlet under design flow conditions does not exceed 1,200 kPa.

10 CONTAMINATED FIRE FIGHTING WATER CONTAINMENT

Fire water containment for the terminal is largely provided by using the bunded volumes.

As per Clause 5.8.2 of AS 1940-2017, "The net capacity of a compound shall be at least 110% of the capacity of the largest tank or 25% of the total capacity of all tanks within the bund whichever is greater. If two or more tanks are operated as a single unit then the capacity of all tanks shall be used when calculating the capacity of the compound."

The largest tank is 4,000 m^3, therefore, using the 110% criterion requires a bund volume of at least 4,400 m^3.

The total capacity of all eight tanks is 6 x 4,000 m^3 + 2 x 240 m^3 = 24,480 m^3. Using the 25% criterion requires 24,480 m^3 x 0.25 = 6,120 m^3. AS this value is greater that the value derived from the 110% criterion then this is the required minimum volume of the tanks bund.

The bund capacity has been estimated as 7,057 m^3. Therefore, it meets the criteria from AS1940.

From Table 12, the design quantity of fire water that can enter the bund during a tank on fire scenario is 645 m^3 + 432 m^3 = 1,077 m^3. It is assumed that the foam solution remains within the tank on fire. As this quantity of fire water is less than the bund capacity of 7,057 m^3 then it will be contained. Should the tank fail then sufficient capacity still exists as a full tank contains 4,000 m^3, i.e. 1,077 m^3 + 4,000 m^3 = 5,077 m^3 which is still less than the bund capacity of 7,057 m^3.

For the vehicle transfer bays design case, the total foam solution flowrate is 2,912 L/min. For a 10 minute duration, this equates to a volume of approximately 29 m^3. The transfer bays spill tank has a volume of 30 m^3 (i.e. sufficient to contain an Isotank of 26 m^3). Therefore, sufficient capacity exists for capturing the transfer bays design foam flows. Similarly for the transfer pumps, the foam solution drains (design case is 12 m^3 - Table 12) to the spill tank.

From AS1940, Clause 5.8.6 (e), that the design capacity of the drainage system shall be at least the rate of supply of emergency water within the compound in as provided in Appendix I (i.e. tank cooling water flow). From Table 12, this flowrate is 7,172 L/min. Drainage valves (gravity) are provided for the compounds.

Other facilities to be provided to contain any liquid waste and potential spills in addition to bunding of all tanks and the transfer bays and transfer pumps include total site paving to the drainage system, a 30 m^3 underground spill containment tank, a stormwater holding tank and two 240 m^3 slops tanks. In addition, stormwater pits can be blocked to prevent flows during a spill event to help prevent off-site impact from contaminated surface water (e.g. firewater).

The containment philosophy has also been reviewed with respect to the NSW Government's "Best Practice Guidelines for Contaminated Water Retention and Treatment Systems" (Ref 14). As discussed above, there is provision to contain contaminated fire water within the site and as such, significant off-site consequences are not expected for fire durations as quoted in AS1940. However, a frequency based evaluation was undertaken and is discussed below.

The likelihoods of worst case scenarios such as tank and bund fires are reduced by such design and operating practices such as equipment designed to the relevant Australian or international standards, equipment supplied to the appropriate area classification, instrument and alarm testing and preventative maintenance of all equipment items. The following are indicative fire frequencies for ***flammable liquids*** (taken as the worst case contributors for fire water retention purposes):

Large bund fire	$2x10^{-5}$/yr (Ref 15)
Tank fire	$1.1x10^{-3}$/yr (Ref 16)

The tank fire frequency can be reduced by at least an order of magnitude as the tanks will be nitrogen padded (Ref 7), i.e. $1.1x10^{-4}$/yr or lower.

If a tank top fire does not escalate then all fire water should be readily contained within the bunded area as per the above analysis.

Given a conservative estimate of the probability of off-site fire water run-off effects of 1.0 during a large bund fire, the corresponding risk associated with the incident ($2x10^{-5}$/yr) falls below 100 per million per year (an upper range value of acceptability for catastrophic events in risk assessments). Hence, from a probabilistic analysis the calculated risk level for off-site impact from contaminated fire water from a bund fire is relatively low.

Any water contained during a fire would be subjected to tests to determine the degree and nature of contamination before being disposed of in an approved manner. It is Manildra's policy to prevent any discharges to the local environment.

Berth Spill Containment:

Berth 206 is approximately 30 m x 15 m surrounded by a bund 300 mm high, creating a bund capacity of approximately 135 m^3. At 1,000 m^3/hr transfer rate, the bunded area provides containment for a full flow release for eight minutes, i.e. this is sufficient time for the ship's crew to isolate the flow if a failure occurs. This wharf area drains to one point which discharges to the harbour under normal circumstances. A purpose designed drain blocking fitting will be inserted into the berth drain during the time hoses are being connected, ethanol is being loaded or hoses are being disconnected. Dry-break couplings will be used on all hose connections. Pneumatic pumps will be used to remove spilled ethanol from the wharf deck area (if any).

11 FIRST AID FIRE PROTECTION

Fire Extinguishers:

Portable fire extinguishers are first aid fire protection measures and will be provided according to the requirements AS1940, AS3846, AS1841.1 and AS1850. These enable operating and maintenance personnel, and drivers to extinguish small fires.

A number of fire extinguishers will be provided at strategic locations throughout the facility based on potential fire sources. These are not limited to the following:

- At least one powder-type extinguisher not less than 3 m nor more than 10 m from the flammable liquids pump bay areas; and

- One powder-type extinguisher for each ethanol transfer bay and one foam-type extinguisher for every two loading bays.

Portable fire extinguishers will be provided in the buildings as listed in Table E1.6 of the BCA (Building Code of Australia) and will be selected, located and distributed in accordance with Sections 1, 2, 3 and 4 of AS 2444.

The testing of the fire extinguishers will comply with AS 1850 (Portable Fire Extinguishers, Classification Rating and Fire Testing).

The fire extinguishers throughout the site, e.g. type and location, will be checked via the Annual Compliance Statements audits.

Hose Reels:

Hose reels are also a first aid fire protection measure providing an initial response in the early stages of small fires.

The design basis for fire hoses is as follows:

> *Clause E1.4 – Fire Hose Reels of the BCA requires that a fire hose reel system must be provided to serve the processing plants' buildings where one or more internal fire hydrants are installed or in a building with a floor area greater than 500 m^2.*

Hose reels will be located at selected locations to provide coverage for equipment that is not protected by the fire protection systems detailed in Section 7.2. Hose reels will be fitted with 30 m of 32 mm firm-type hoses and combination straight stream / fog nozzles will be provided as a means of quickly applying water in the incipient stage of a fire.

Hose reels and fittings will comply with AS 1221 and will be installed in accordance with the requirements of AS 2441. All hose couplings will be compatible with FRNSW couplings.

First Aid Fire Protection Information:

Operating and maintenance personnel will be trained in the use of fire extinguishers and the operation of the site alarm, fire water and foam systems, and handheld hoses and monitor usage. Procedures will be written and will include actions to be taken in the event of a loss of containment of flammable and/or combustible material so as to minimise the risk of fire, and for actions to take if a fire does start.

The site will rely on the professional Fire Brigade resources for significant firefighting.

All fire protection equipment will be maintained to AS 1851.

Warning signs (including exit signs and first aid firefighting equipment use instruction signs) will be provided at the appropriate locations.

The fire indication panel is to be located in the operations building and also replicated to the Shoalhaven Starches Ethanol Control Room.

12 CODES AND REFERENCES

Codes and standards to be used in the design of the fire prevention, detection and protection systems are summarised in Table 13.

Table 13 – Codes and Standards

Code	Description
ADG	The Australian Dangerous Goods Code
API 2350 2012	Overfill Protection for Storage Tanks in Petroleum Facilities 4th Edition
API 2210 2000	Flame Arresters for Vents of Tanks Storing Petroleum Products
API 2000 2009	Venting Atmospheric and Low Pressure Storage Tanks
AS 1221:1997	Fire Hose Reels
AS 1603:2018	Automatic Fire Detection and Alarm Systems (including manual call points and smoke detectors)
AS 1670 (series)	Automatic Fire Detection and Alarm Systems
AS 1841:2007	Portable Fire Extinguishers – Specific Requirements for Foam Type Extinguishers
AS 1850:2009	Portable Fire Extinguishers – Classification, Rating and Performance Testing
AS 1851 2012	Routine Service of Fire Protection Systems and Equipment
AS 1940 2017	The Storage and Handling of Flammable and Combustible Liquids
AS 2118.1 2017	Automatic Fire Sprinkler Systems – General Requirements
AS 2293:2018	Emergency Escape Lighting and Exit Signs
AS 2304 2019	Water Storage Tanks for Fire Protection Systems
AS 2419 (series)	Fire Hydrant Installations
AS 2441:2005	Installation of Fire Hose Reels
AS 2444:2001	Portable Fire Extinguishers and Fire Blankets
AS 2941 2013	Fixed Fire Protection Installations – Pumpset Systems
AS 3846:2005	The Handling and Transport of Dangerous Cargoes in Port Areas
AS 4118:1996	Fire Sprinkler Systems – Components
DG Act 2008	Dangerous Goods Safety Act
DG Regulations 2018	Dangerous Goods Safety Regulations
EI IP-MCSP-P19 2012	Model Code of Safe Practice Part 19: Fire Precautions at Petroleum Refineries and Bulk Storage Installations
ISGOTT6	International Safety Guide for Oil Tankers and Terminals, Revision 6
NFPA 11 2016	Standard for Low, Medium, and High-Expansion Foam
NFPA 15 2017	Standard for Water Spray Fixed Systems for Fire Protection

Code	Description
NFPA 16 2015	Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems
NSW DoP HIPAP No. 1 2011	Emergency Response Guidelines
NSW DoP HIPAP No. 2 2011	Fire Safety Study Guidelines

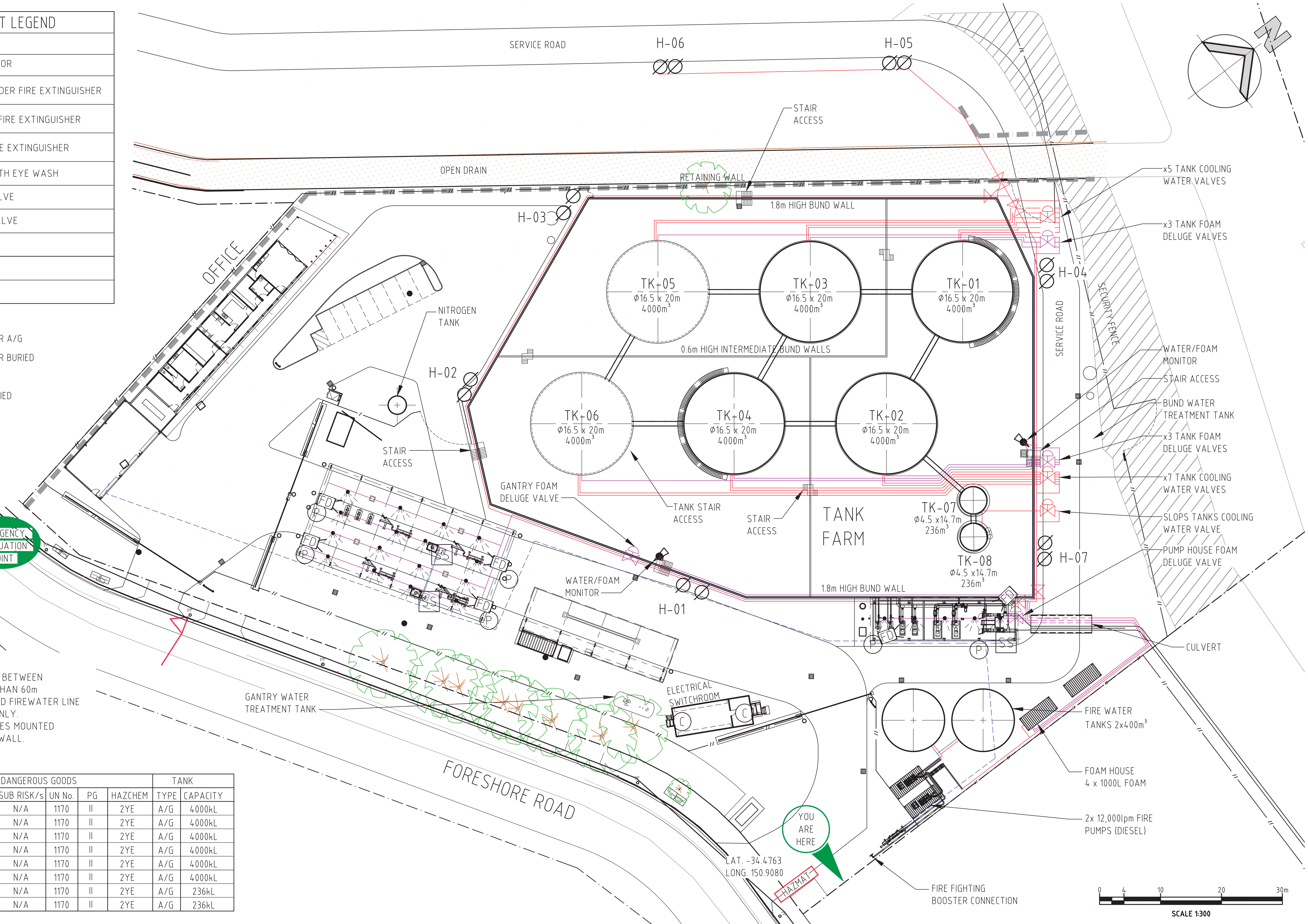
13 APPENDIX A – FIRE PROTECTION DRAWINGS

FIRE FIGHTING EQUIPMENT LEGEND

∅	FIRE HYDRANT
	WATER/FOAM MONITOR
P	9KG PORTABLE POWDER FIRE EXTINGUISHER
C	5KG PORTABLE CO2 FIRE EXTINGUISHER
F	PORTABLE FOAM FIRE EXTINGUISHER
SS	SAFETY SHOWER WITH EYE WASH
	ISOLATING GATE VALVE
	DELUGE CONTROL VALVE
HAZMAT	HAZMAT BOX
FD	FLAME DETECTOR
	SPRAY NOZZLE

LEGEND:

- POTABLE WATER A/G
- POTABLE WATER BURIED
- FIREWATER A/G
- FIREWATER BURIED
- FOAM A/G
- FOAM BURIED



NOTES:

1. MAXIMUM LENGTH OF PIPING BETWEEN HYDRANTS MUST BE LESS THAN 60m
2. POTABLE WATER AND BURIED FIREWATER LINE ROUTE SHOWN INDICATIVE ONLY.
3. ALL DELUGE CONTROL VALVES MOUNTED EXTERNALLY BEHIND BUND WALL.

BULK STORAGE

TANK No.	DANGEROUS GOODS						TANK	
	NAME	CLASS	SUB RISK/s	UN No.	PG	HAZCHEM	TYPE	CAPACITY
TK-0100	ETHANOL	3	N/A	1170	II	2YE	A/G	4000kL
TK-0200	ETHANOL	3	N/A	1170	II	2YE	A/G	4000kL
TK-0300	ETHANOL	3	N/A	1170	II	2YE	A/G	4000kL
TK-0400	ETHANOL	3	N/A	1170	II	2YE	A/G	4000kL
TK-0500	ETHANOL	3	N/A	1170	II	2YE	A/G	4000kL
TK-0600	ETHANOL	3	N/A	1170	II	2YE	A/G	4000kL
TK-0700	SLOPS	3	N/A	1170	II	2YE	A/G	236kL
TK-0800	SLOPS	3	N/A	1170	II	2YE	A/G	236kL

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REV	DATE	BY	DESCRIPTION	CHK	APP
A	07.08.21	LCC	D.A. ISSUE	BV	BP
B	14.10.21	LCC	RE-ISSUE FOR D.A.	BV	BP
C	27.10.21	LCN	SECONDARY ISSUE FOR DA	BV	

PROJECT CLIENT: MANILDRA GROUP — 100% AUSTRALIAN OWNED

PROJECT DETAILS: MANILDRA GROUP, PORT KEMBLA, BULK LIQUIDS FACILITY, FORESHORE ROAD, PORT KEMBLA, NSW

DRAWING TITLE: PROPOSED FIRE SERVICES AND MANIFEST LAYOUT

STATUS: D.A. ISSUE

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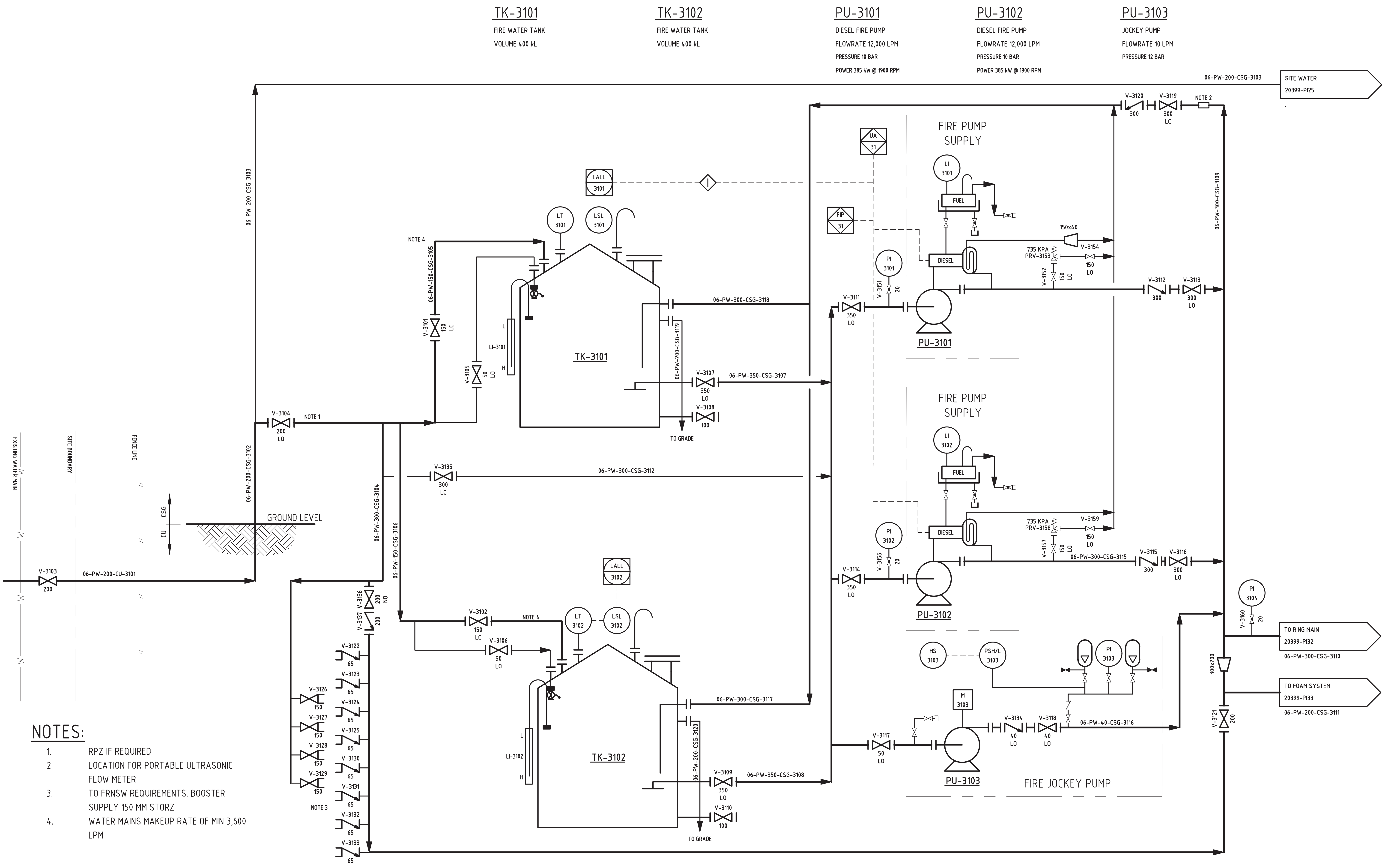

NOTES:

1. RPZ IF REQUIRED
2. LOCATION FOR PORTABLE ULTRASONIC FLOW METER
3. TO FRNSW REQUIREMENTS. BOOSTER SUPPLY 150 MM STORZ
4. WATER MAINS MAKEUP RATE OF MIN 3,600 LPM

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A	10.08.21	HE	ISSUE FOR INFORMATION	BV	
B	27.10.21	LCN	ISSUED FOR DA	BV	
C	21.01.22		ISSUED FOR REVIEW	BV	KS

PROJECT CLIENT: MANILDRA GROUP — 100% AUSTRALIAN OWNED

PROJECT DETAILS: MANILDRA GROUP PORT KEMBLA BULK LIQUIDS FACILIY FORESHORE ROAD PORT KEMBLA, NSW

DRAWING TITLE: P&ID FIRE WATER TANKS & FIRE PUMPS

STATUS: REVIEW ISSUE

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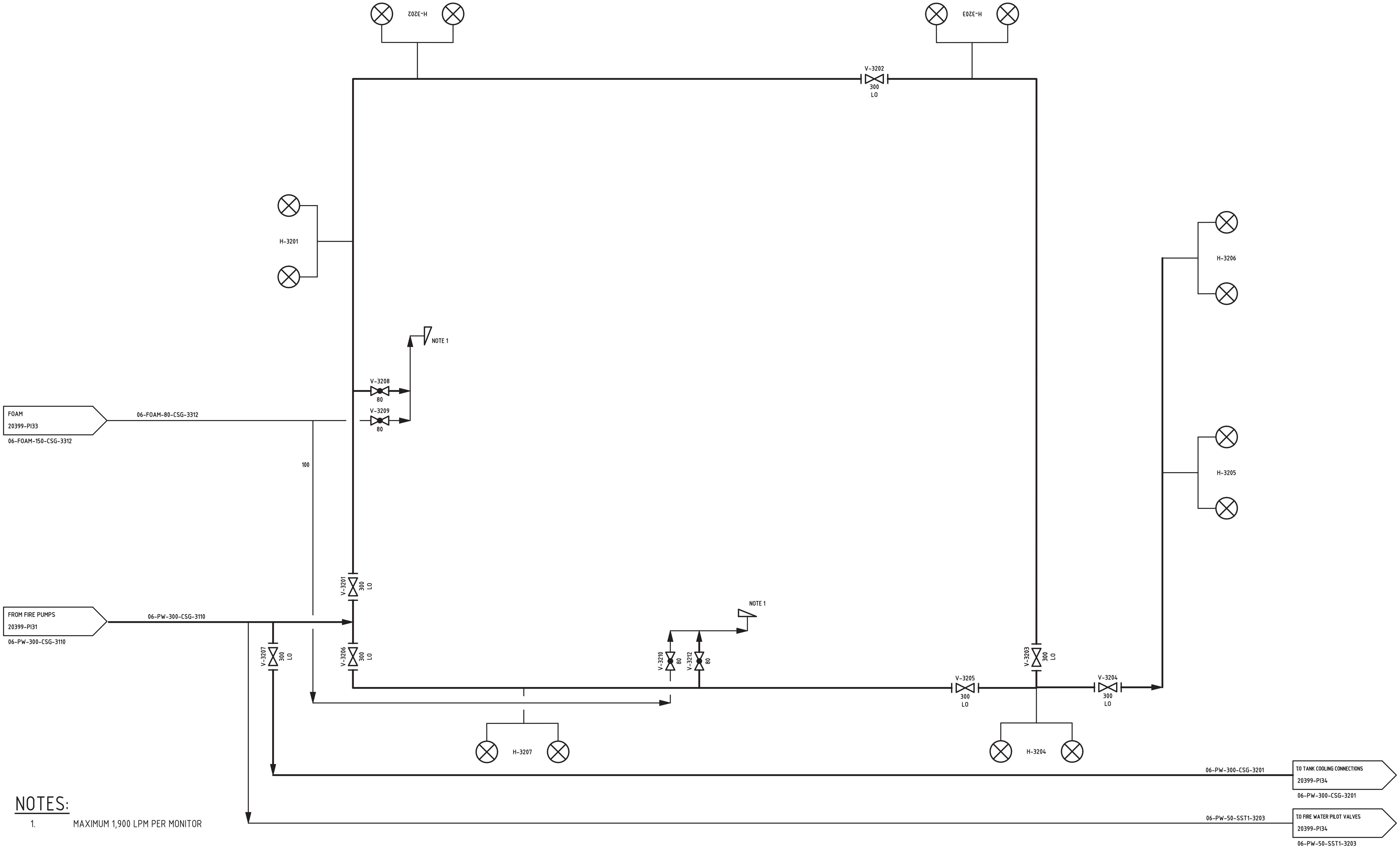

NOTES:

1. MAXIMUM 1,900 LPM PER MONITOR

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C	21.01.22	HE	ISSUED FOR REVIEW	BV	KS

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PROJECT DETAILS:
MANILDRA GROUP
PORT KEMBLA
BULK LIQUIDS FACILIY
FORESHORE ROAD
PORT KEMBLA, NSW

DRAWING TITLE:
P&ID
FIRE WATER RING MAIN

STATUS: REVIEW ISSUE

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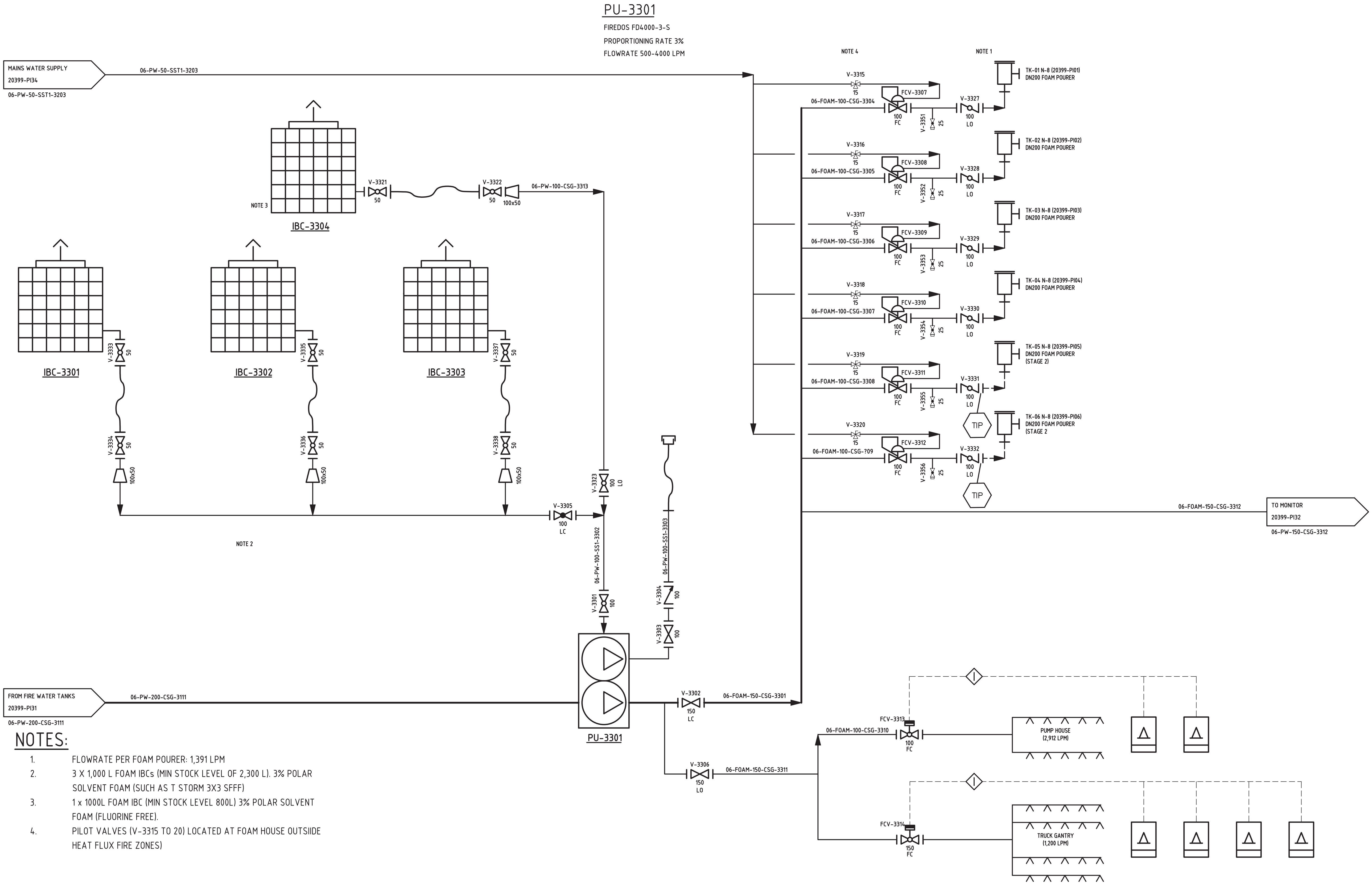

NOTES:

1. FLOWRATE PER FOAM POURER: 1,391 LPM
2. 3 X 1,000 L FOAM IBCs (MIN STOCK LEVEL OF 2,300 L). 3% POLAR SOLVENT FOAM (SUCH AS T STORM 3X3 SFFF)
3. 1 x 1000L FOAM IBC (MIN STOCK LEVEL 800L) 3% POLAR SOLVENT FOAM (FLUORINE FREE).
4. PILOT VALVES (V-3315 TO 20) LOCATED AT FOAM HOUSE OUTSIIDE HEAT FLUX FIRE ZONES)

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PROJECT DETAILS: MANILDRA GROUP, PORT KEMBLA, BULK LIQUIDS FACILIY, FORESHORE ROAD, PORT KEMBLA, NSW

DRAWING TITLE: P&ID FIREFIGHTING FOAM SYSTEM

STATUS: REVIEW ISSUE

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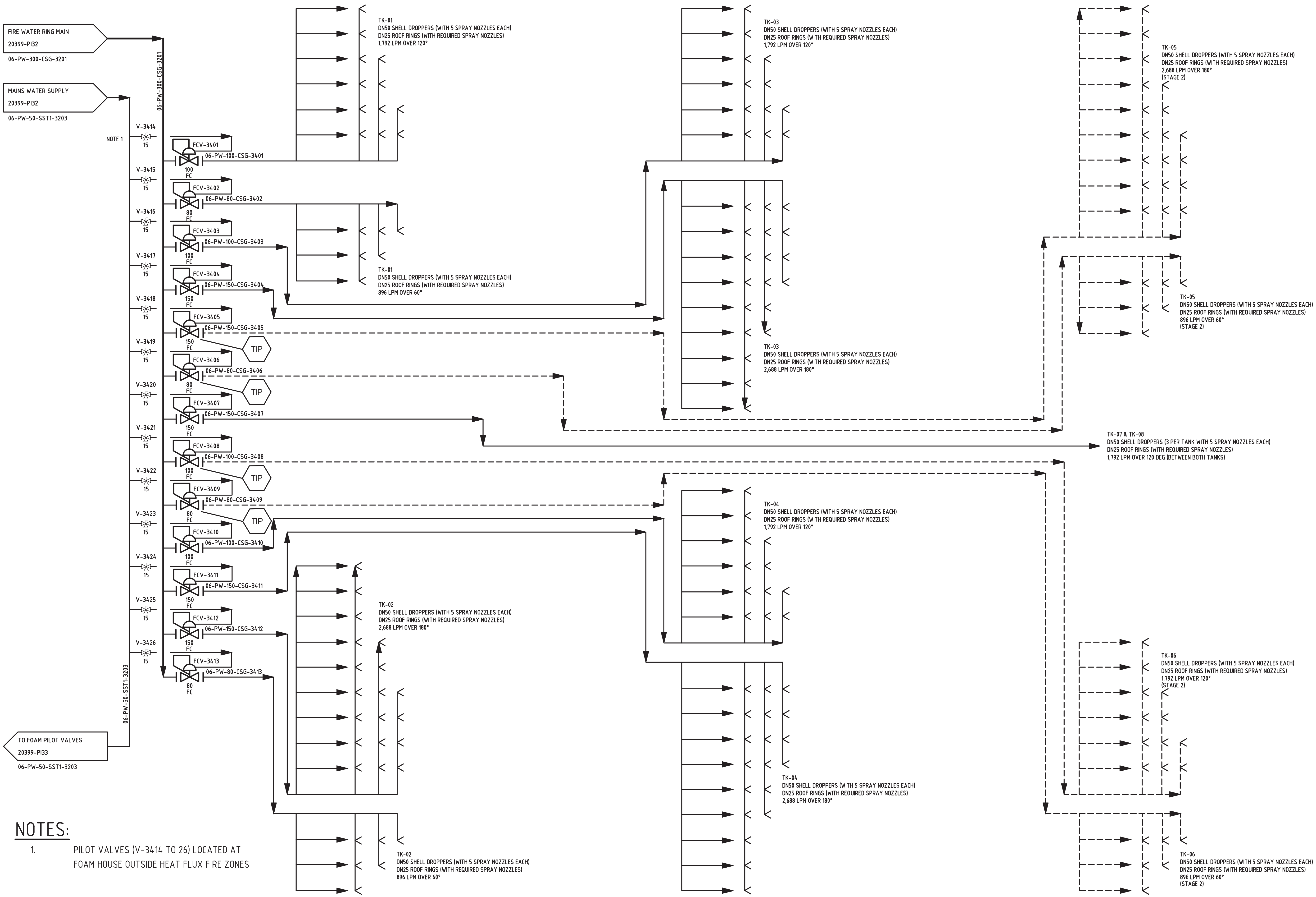

NOTES:

1. PILOT VALVES (V-3414 TO 26) LOCATED AT FOAM HOUSE OUTSIDE HEAT FLUX FIRE ZONES

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PROJECT CLIENT

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PROJECT DETAILS

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PORT KEMBLA
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FORESHORE ROAD
PORT KEMBLA, NSW

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TANK FIRE WATER

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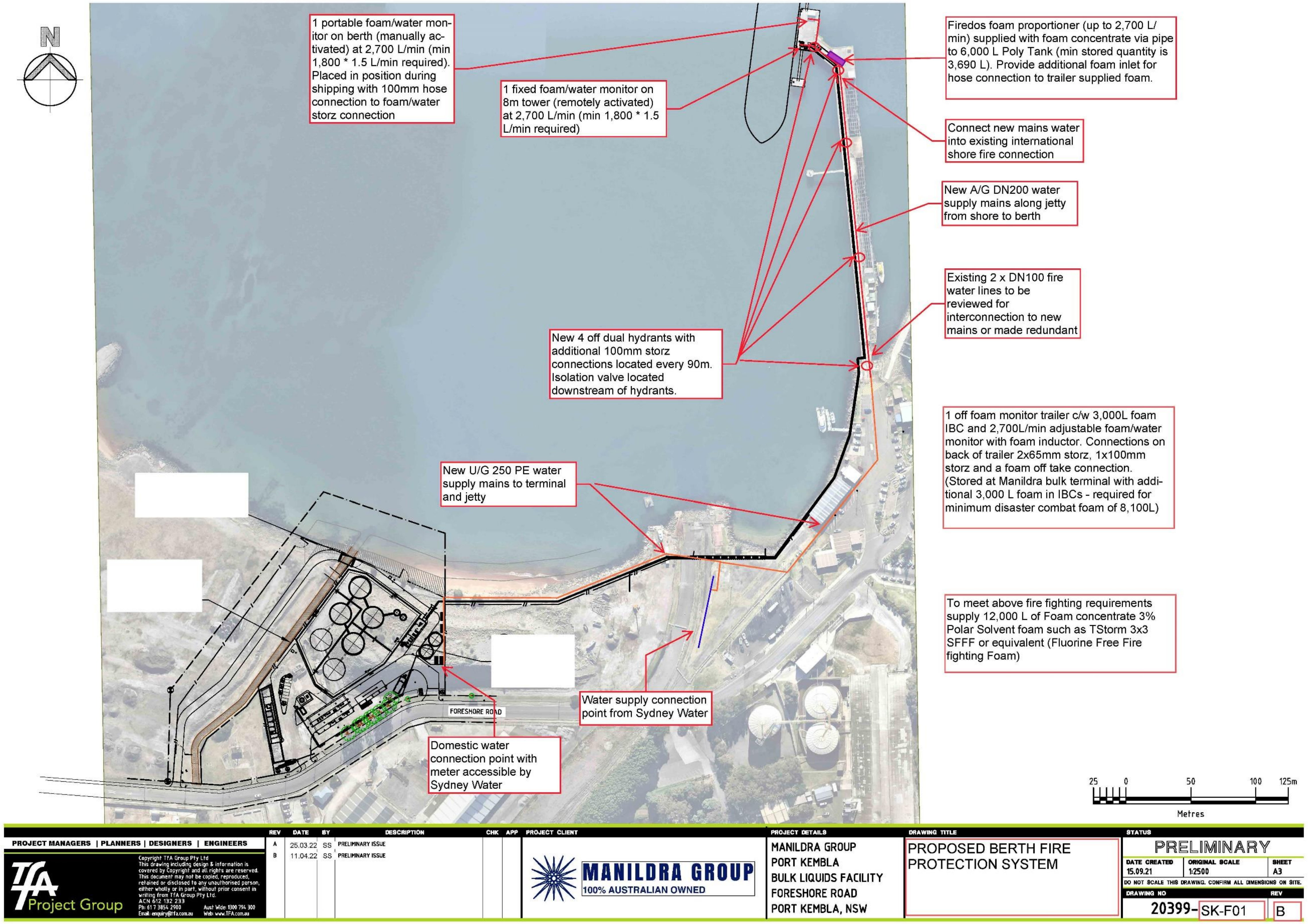
N
1 portable foam/water monitor on berth (manually activated) at 2,700 L/min (min 1,800 * 1.5 L/min required). Placed in position during shipping with 100mm hose connection to foam/water storz connection
1 fixed foam/water monitor on 8m tower (remotely activated) at 2,700 L/min (min 1,800 * 1.5 L/min required)
Firedos foam proportioner (up to 2,700 L/min) supplied with foam concentrate via pipe to 6,000 L Poly Tank (min stored quantity is 3,690 L). Provide additional foam inlet for hose connection to trailer supplied foam.
Connect new mains water into existing international shore fire connection
New A/G DN200 water supply mains along jetty from shore to berth
Existing 2 x DN100 fire water lines to be reviewed for interconnection to new mains or made redundant
New 4 off dual hydrants with additional 100mm storz connections located every 90m. Isolation valve located downstream of hydrants.
1 off foam monitor trailer c/w 3,000L foam IBC and 2,700L/min adjustable foam/water monitor with foam inductor. Connections on back of trailer 2x65mm storz, 1x100mm storz and a foam off take connection. (Stored at Manildra bulk terminal with additional 3,000 L foam in IBCs - required for minimum disaster combat foam of 8,100L)
New U/G 250 PE water supply mains to terminal and jetty
To meet above fire fighting requirements supply 12,000 L of Foam concentrate 3% Polar Solvent foam such as TStorm 3x3 SFFF or equivalent (Fluorine Free Fire fighting Foam)
FORESHORE ROAD
Water supply connection point from Sydney Water
Domestic water connection point with meter accessible by Sydney Water
25 0 50 100 125m
Metres
REV DATE BY DESCRIPTION CHK APP PROJECT CLIENT
A 25.03.22 SS PRELIMINARY ISSUE
B 11.04.22 SS PRELIMINARY ISSUE
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BULK LIQUIDS FACILITY
FORESHORE ROAD
PORT KEMBLA, NSW
DRAWING TITLE
PROPOSED BERTH FIRE PROTECTION SYSTEM
STATUS
PRELIMINARY
DATE CREATED 15.09.21
ORIGINAL SCALE 1:2500
SHEET A3
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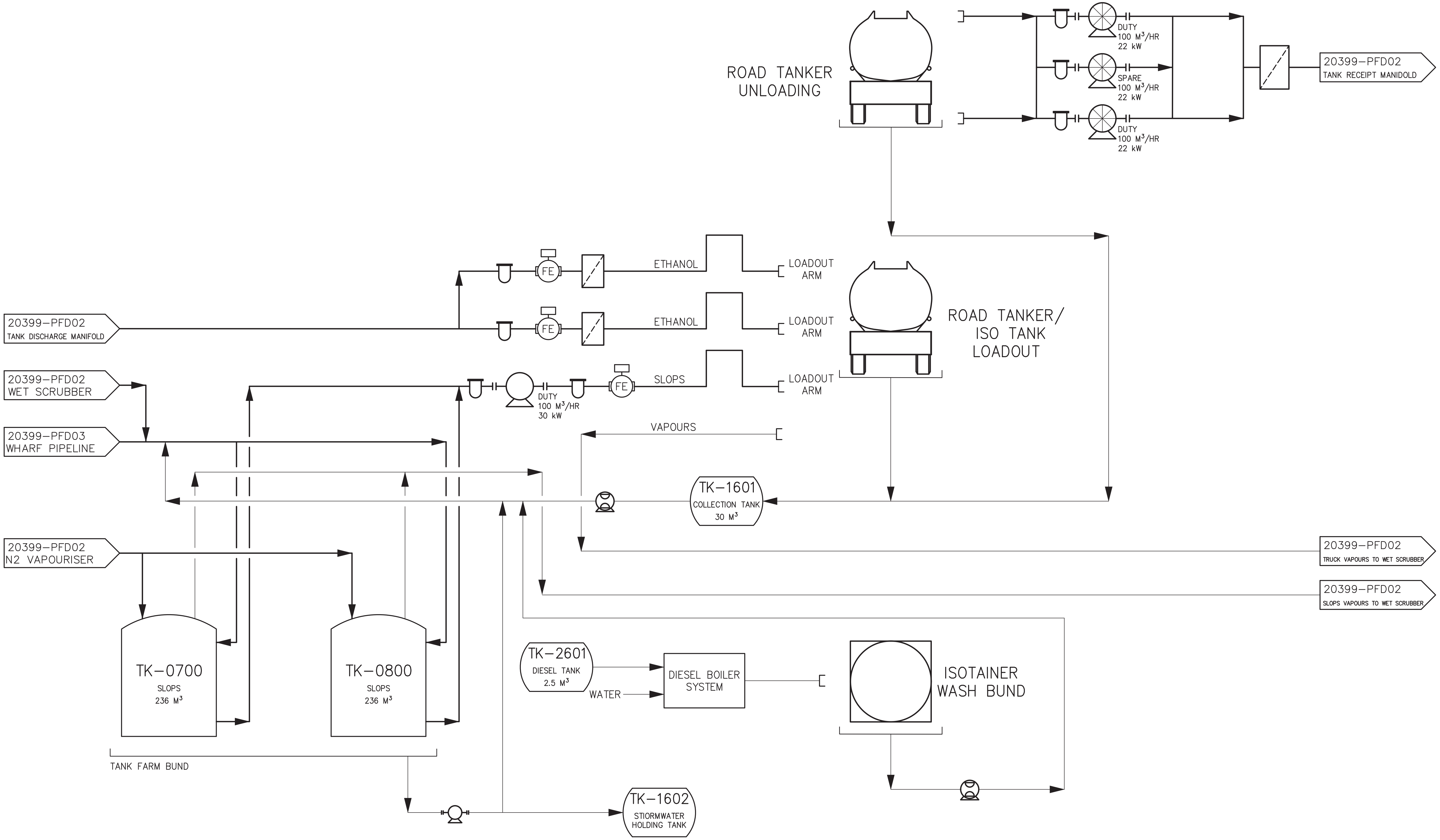
14 APPENDIX B – PROCESS FLOW DIAGRAMS



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A	26.05.21	HE	INITIAL ISSUE		
B	07.06.21	HE	GENERAL REVISION		
C	23.07.21	HE	REVISED POST HAZOP 1	BV	

PROJECT DETAILS

MANILDRA GROUP
SHOALHAVEN STARCHES
PORT KEMBLA SITE
FORESHORE ROAD
PORT KEMBLA, NSW

DRAWING TITLE

PROCESS FLOW DIAGRAM
SHEET 1

STATUS

PRELIMINARY

DATE CREATED	ORIGINAL SCALE	SHEET
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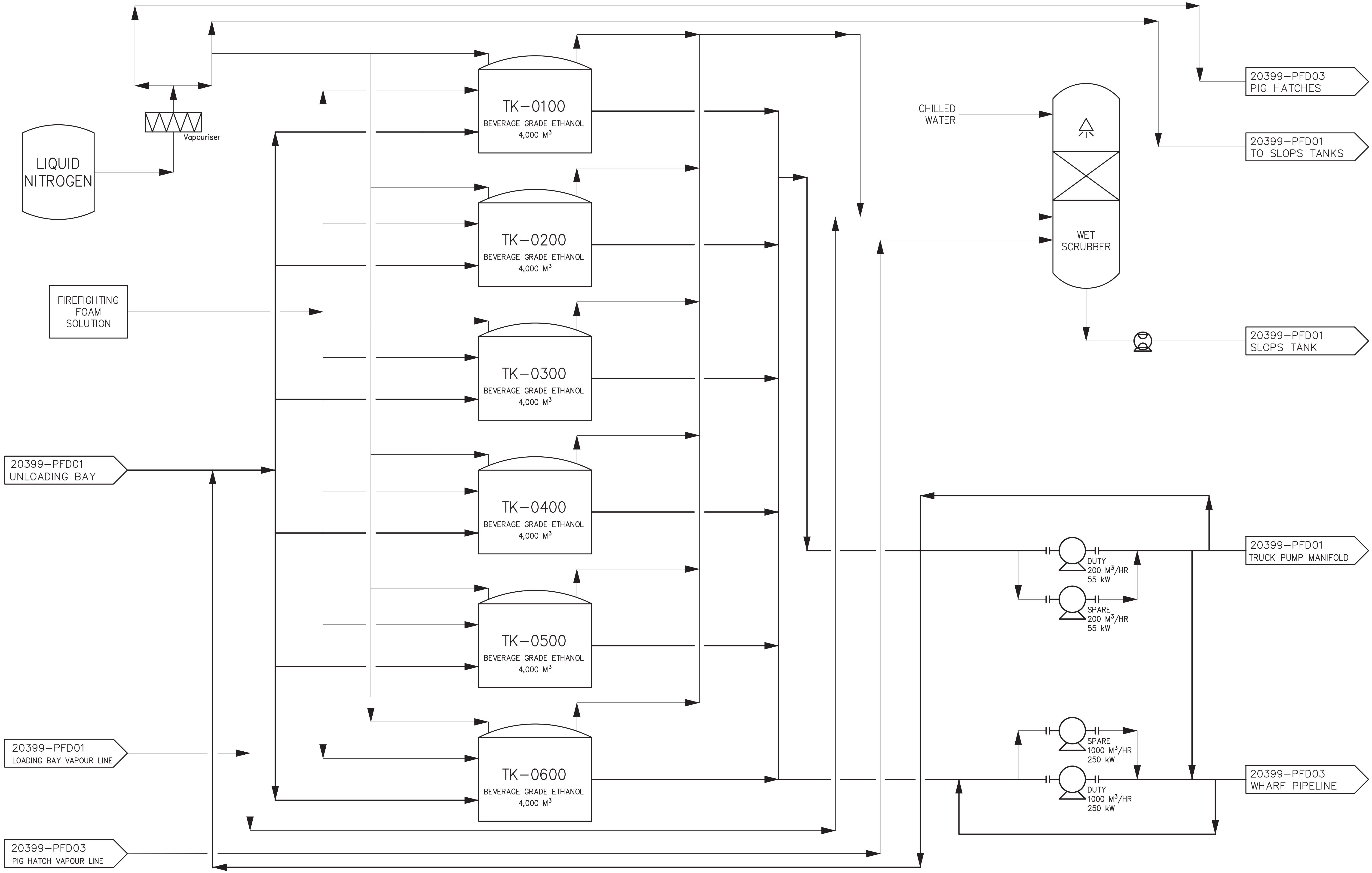

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C	23.07.21	HE	REVISED POST HAZOP 1	BV	

PROJECT DETAILS

MANILDRA GROUP
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PORT KEMBLA SITE
FORESHORE ROAD
PORT KEMBLA, NSW

DRAWING TITLE

PROCESS FLOW DIAGRAM
SHEET 2

STATUS

PRELIMINARY

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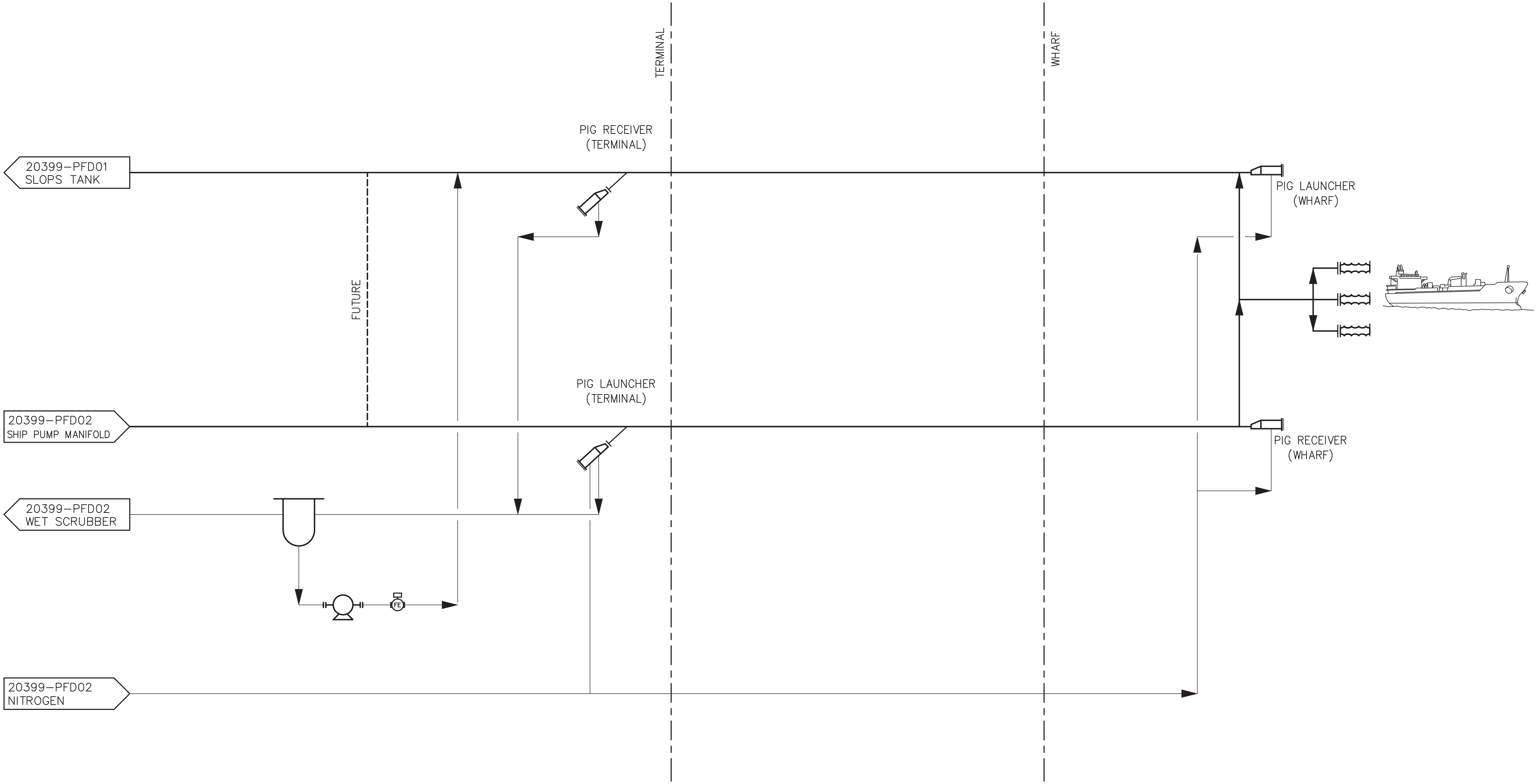

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NAME: DATE:

PROFESSIONAL QUALIFICATION:

SIGNATURE:

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REV	DATE	BY	DESCRIPTION	CHK	APP
A	26.05.21	HE	INITIAL ISSUE		
B	07.06.21	HE	GENERAL REVISION		
C	23.07.21	HE	REVISED POST HAZOP 1	BV	

PROJECT DETAILS

MANILDRA GROUP
SHOALHAVEN STARCHES
PORT KEMBLA SITE
FORESHORE ROAD
PORT KEMBLA, NSW

DRAWING TITLE

PROCESS FLOW DIAGRAM
SHEET 3

STATUS

PRELIMINARY

DATE CREATED	ORIGINAL SCALE	SHEET
21.05.21	NTS	A3

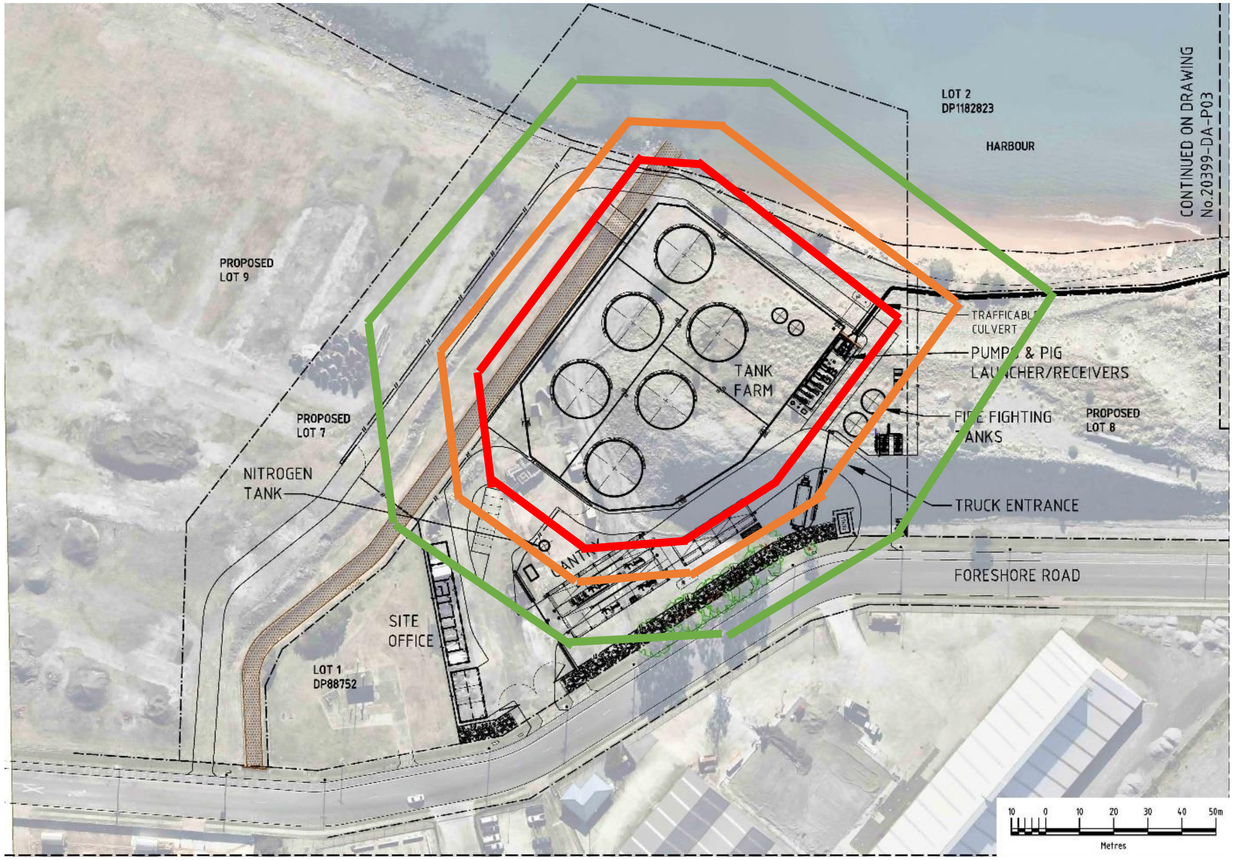
DO NOT SCALE THIS DRAWING. CONFIRM ALL DIMENSIONS ON SITE.

DRAWING NO	REV
20399-PFD03	B

15 APPENDIX C – RADIANT HEAT CONTOURS

Appendix C – Radiant Heat Contours

Scenario 1: Compound Fire

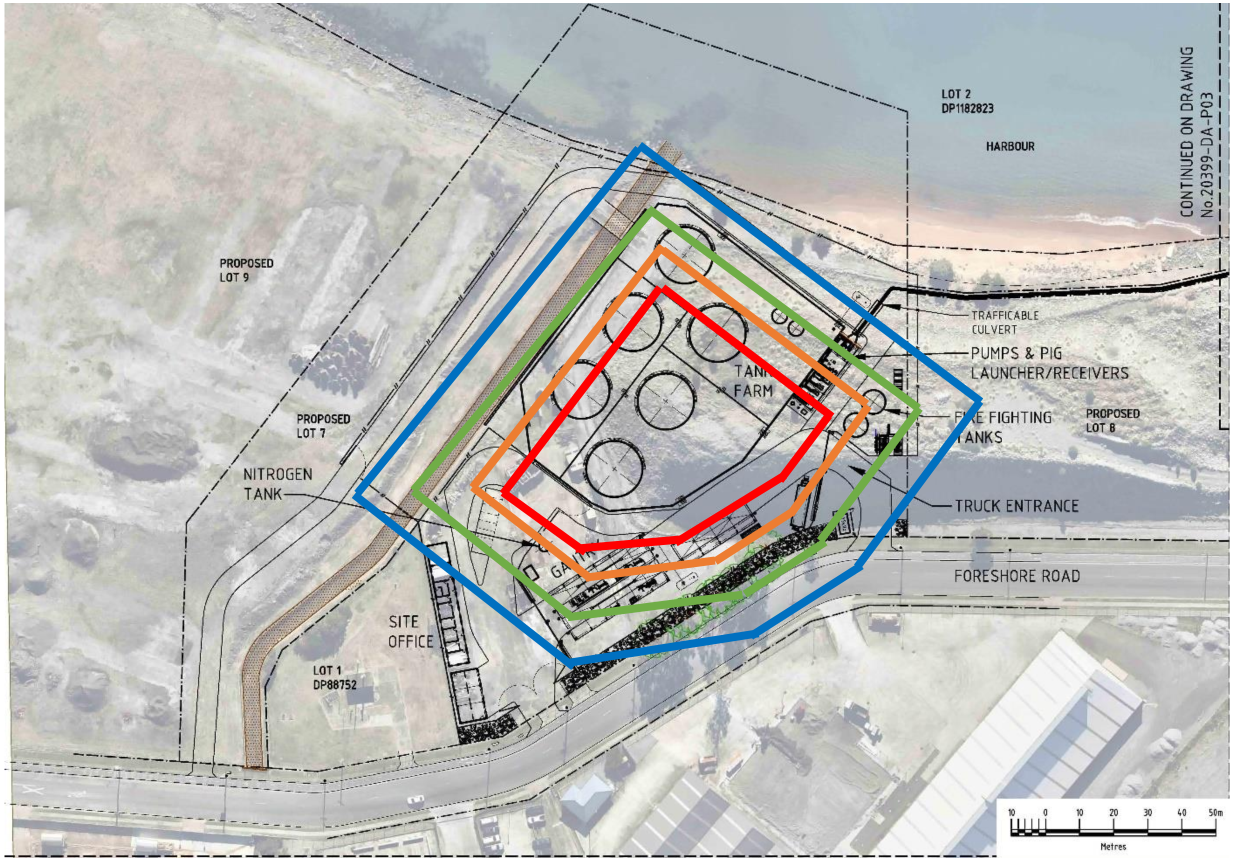


Key:

Red line	**23 kW/m²**
Orange line	**12.6 kW/m²**
Green line	**4.7 kW/m²**

Note: The radiant heat contours are approximate due to the irregular shape of the bund and the 3 kW/m² contour is not shown as the 4.7 kW/m² contour essentially covers the site.

Scenario 2: Bund Fire (representative case is the bund closest to the fire water tanks)

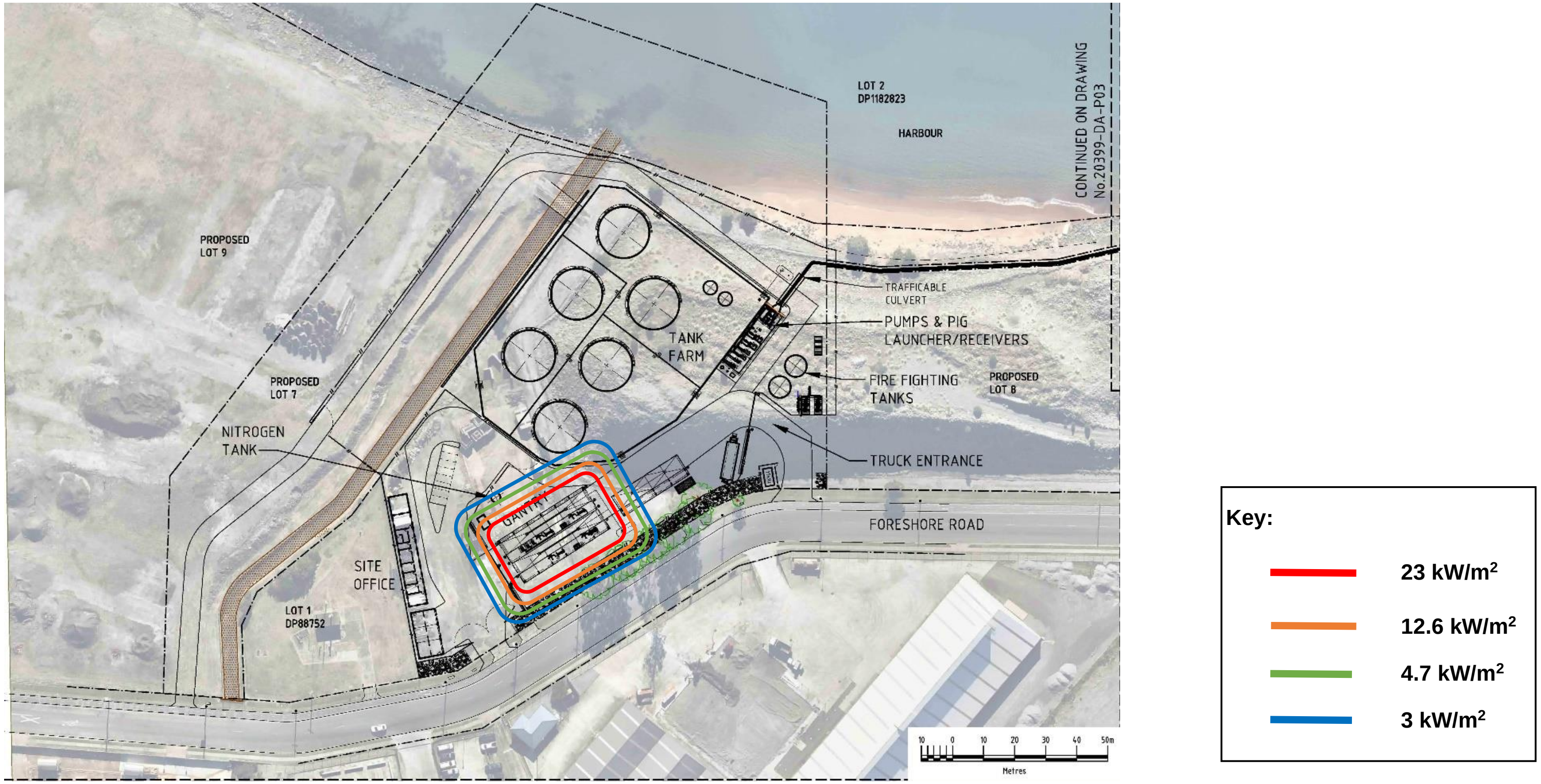


Key:

Red line	**23 kW/m²**
Orange line	**12.6 kW/m²**
Green line	**4.7 kW/m²**
Blue line	**3 kW/m²**

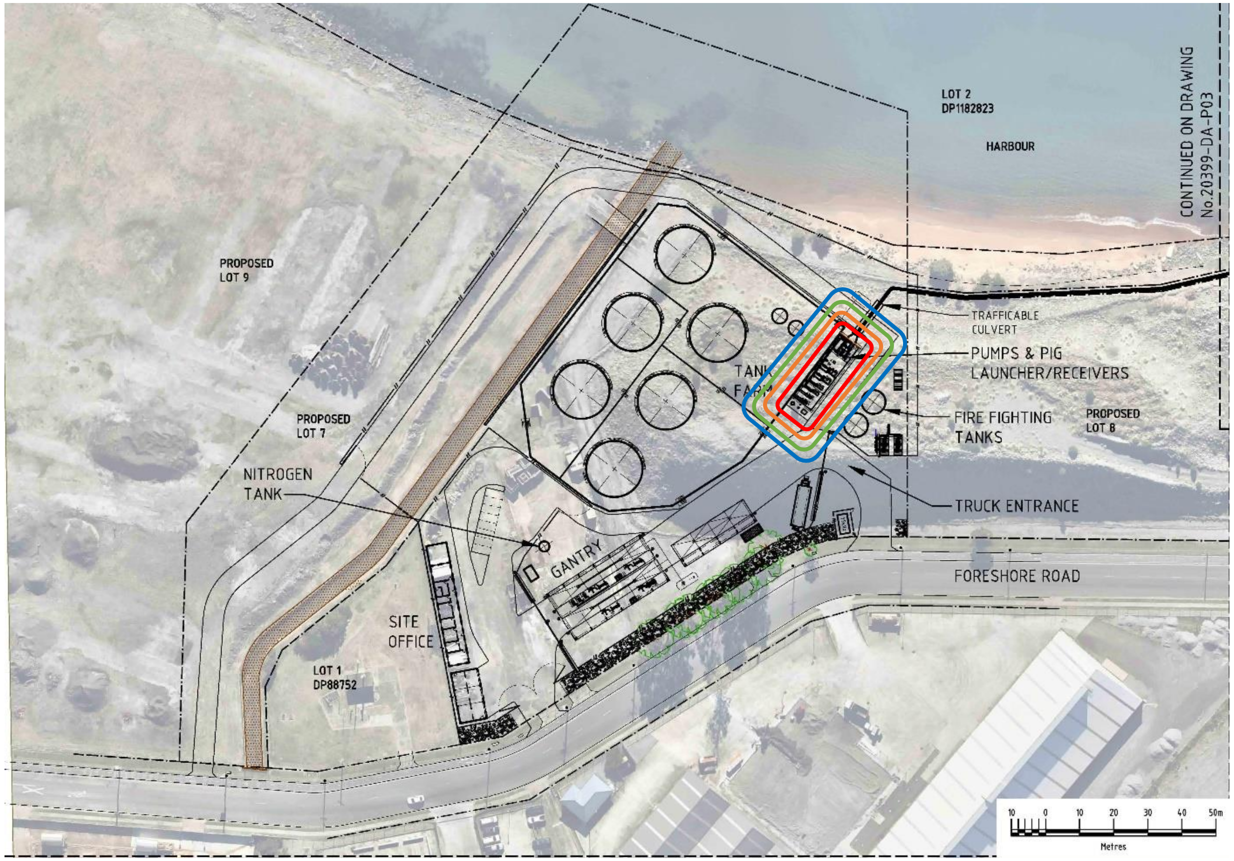
Note: The radiant heat contours are approximate due to the irregular shape of the bund.

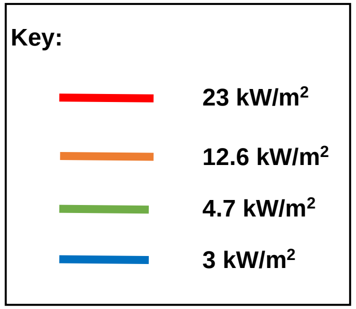
Scenario 3: Road Tanker Transfer Bay Fire



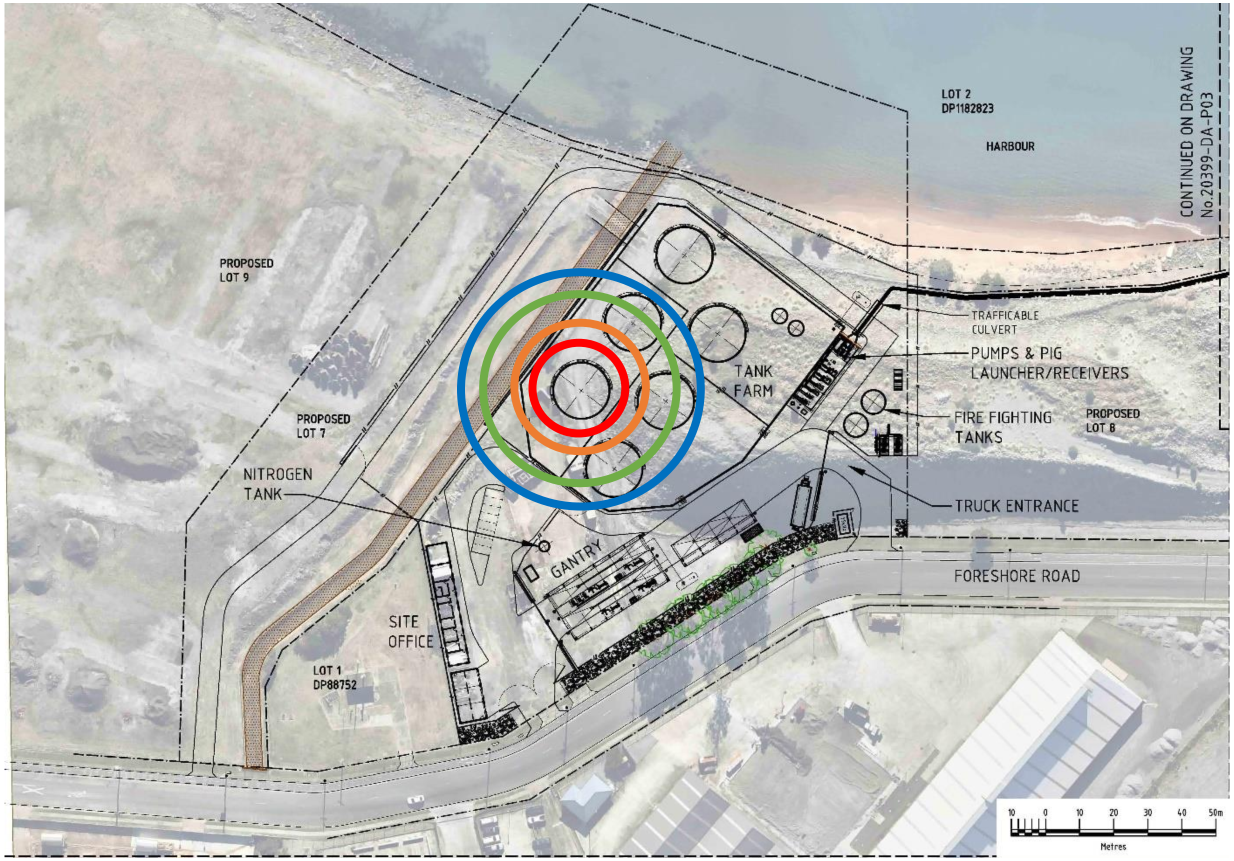
Note: The radiant heat contours are shown for a fire in either transfer bay.

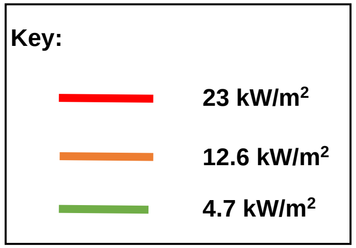
Scenario 4: Pump Bund Fire





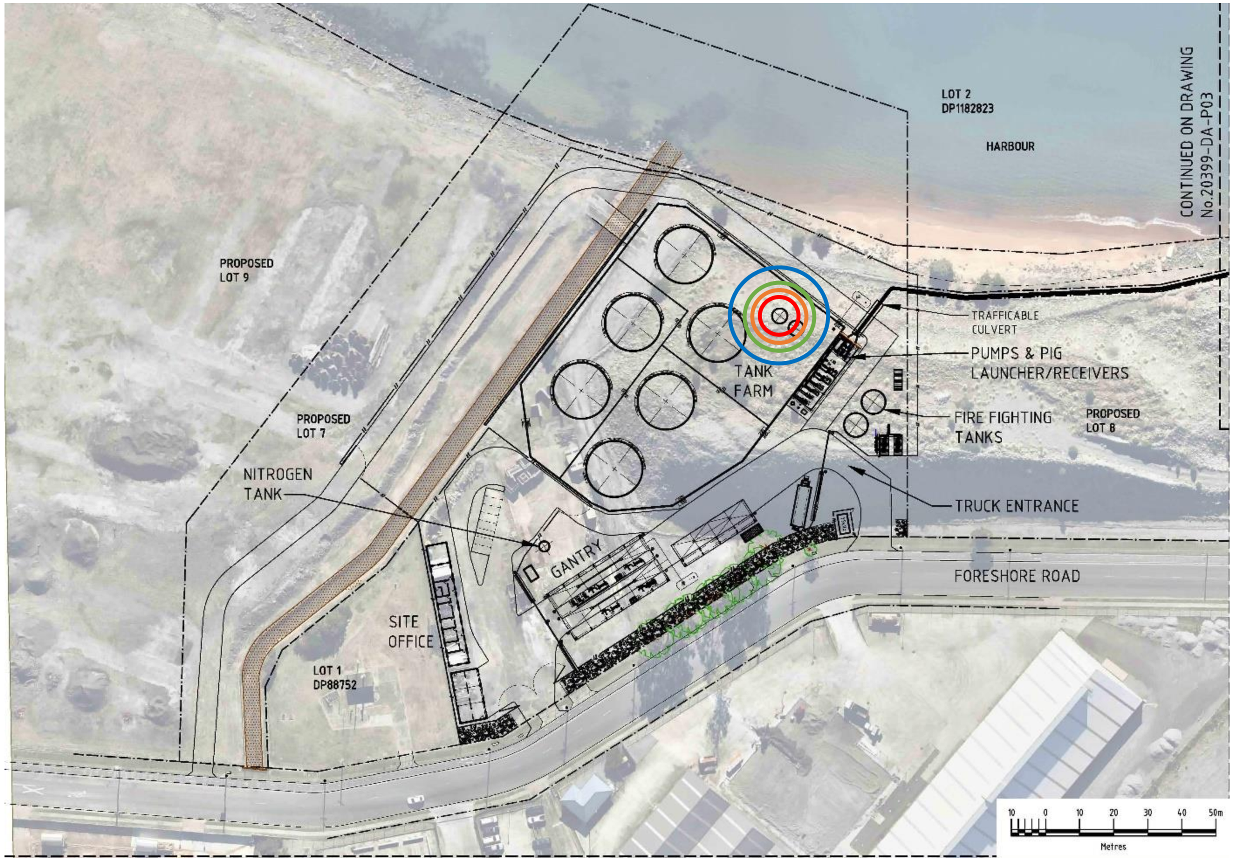
Scenario 5: Tank Top Fire





Note: The radiant heat contours are at tank-top height.

Scenario 6: Slops Tank Top Fire



Key:

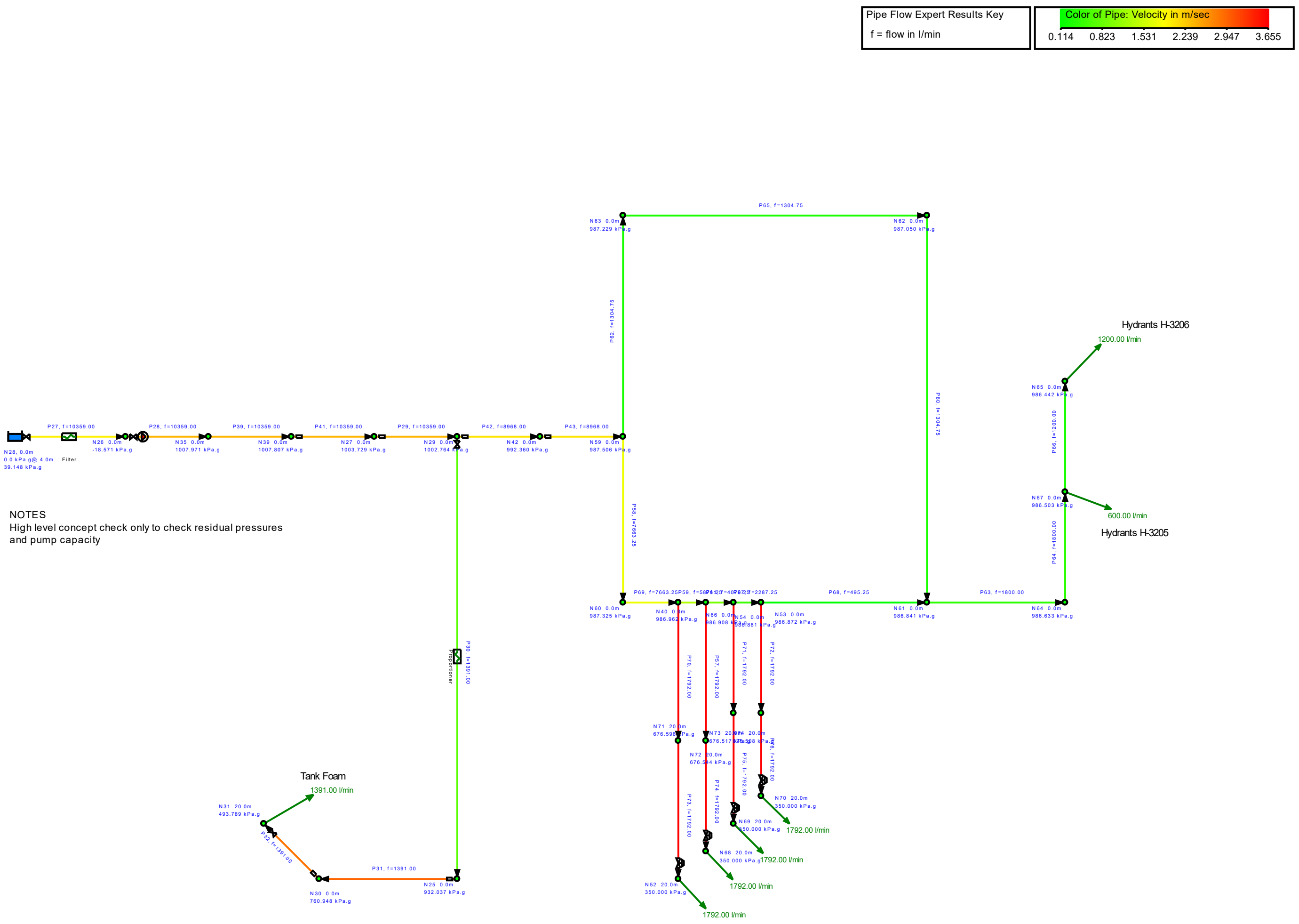
Red	**23 kW/m^2**
Orange	**12.6 kW/m^2**
Green	**4.7 kW/m^2**

Note: The radiant heat contours are at tank-top height.

16 APPENDIX D – HYDRAULIC MODELLING

Fire Water Hydraulic Calculations

(Worst Case Scenario)


Pipe Flow Expert Results Key
f = flow in l/min
Color of Pipe: Velocity in m/sec
0.114 0.823 1.531 2.239 2.947 3.655
Hydrants H-3206
1200.00 l/min
600.00 l/min
Hydrants H-3205
NOTES
High level concept check only to check residual pressures
and pump capacity
Tank Foam
1391.00 l/min
1792.00 l/min
1792.00 l/min
1792.00 l/min
1792.00 l/min

Fluid Data

Zone	Fluid Name	Chemical Formula	Temperature °C	Pressure kPa.g	Density kg/m³	Centistokes	Centipoise	Vapour Pressure kPa.a	State
1	Water	H2O	20.000	0.000	998.000000	1.000000	1.002000	2.400000	Liquid

Pump Data

Pipe Id	Pipe Name	Pump Name	Speed rpm	Pref. Op From l/min	Pref. Op To l/min	Flow In/Out l/min	Velocity m/sec	Suction Pressure kPa.g	Discharge Pressure kPa.g	Pump Head (+) kPa.g	Pump NPSHr m.hd (absolute)	Pump NPSHa m.hd (absolute)	Pump Efficiency Percentage	Pump Power Kilowatts
28	P28	Pump	7900	0.00	0.00	10359.00	2.395	-22.577	1008.135	1030.712	0.000	7.801	75.00	237.2699

Pump Data

Name:	Pump
Catalog:	
Manufacturer:	
Type:	
Size:	
Stages:	0
Speed:	7900 Rpm
Impeller Diam:	438.000 mm
Min Speed:	Not Specified
Max Speed:	Not Specified
Min Diam:	Not Specified
Max Diam:	Not Specified

Fluid Data

Fluid:	Water
Density:	998.000000 kg/m³
Viscosity:	1.0020 cP
Temperature:	20.000 °C
Vapor Pressure:	2.400 kPa.a
Atm Pressure:	101.325 kPa.a

Operating Notes

Pref. Op. Region: 0% - 0% of BEP

Pref. Flow Range:0.00 - 0.00 l/min

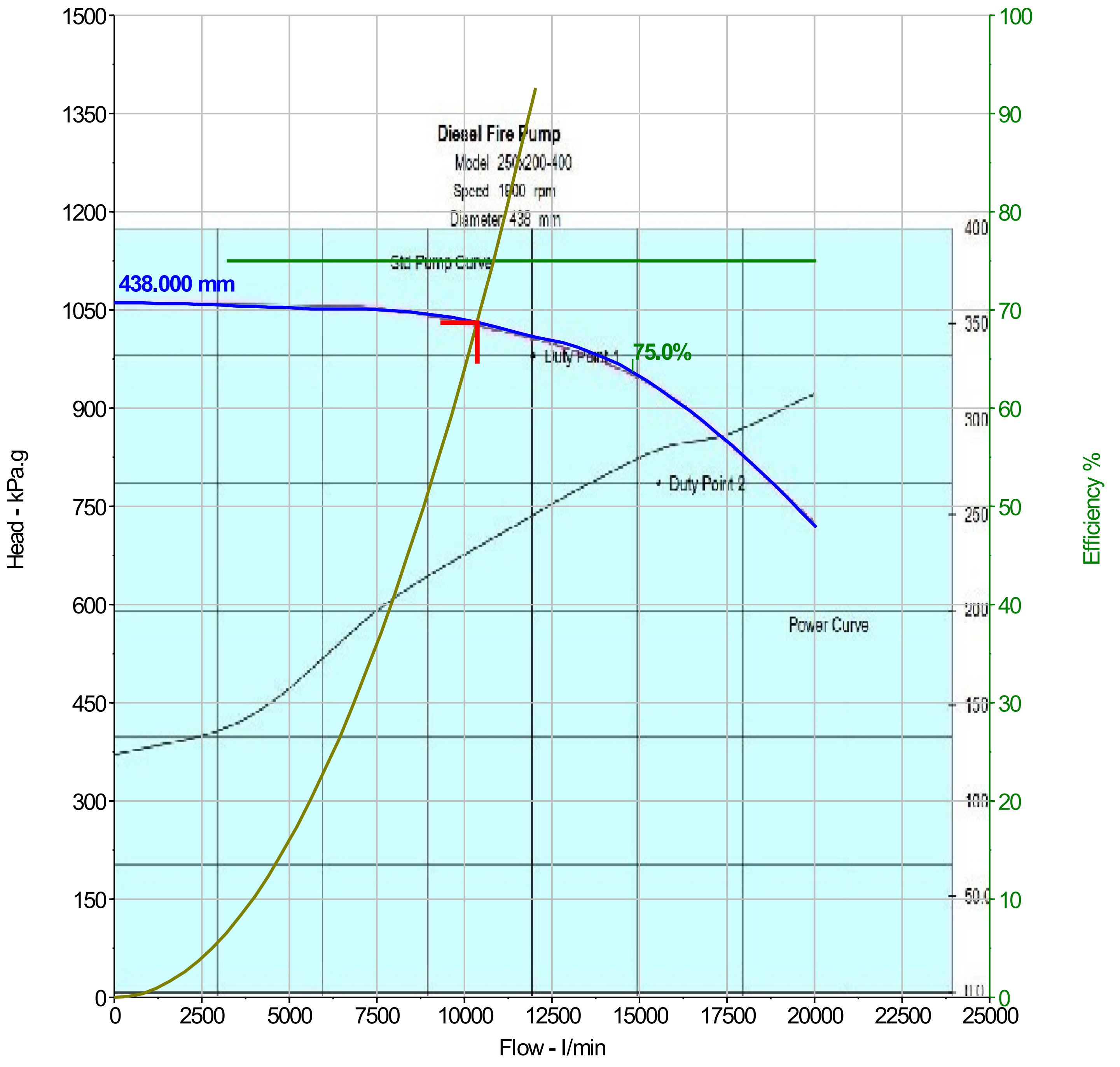
Notes:

Design Curve

Shutoff Head:	1061.120 kPa.g
Shutoff dP:	1061.120 kPa.g
BEP:	75.0% @ 14800.32 l/min
Power at BEP:	314.30 kW
NPSHr at BEP:	0.000 kPa.g
Max Flow Power:	319.66 kW @ 20042.35 l/min

Data Point

Flow:	10359.00 l/min
Head:	1030.712 kPa.g
Efficiency:	75.00%
Power:	237.27 kW
NPSHr:	0.000 kPa.g



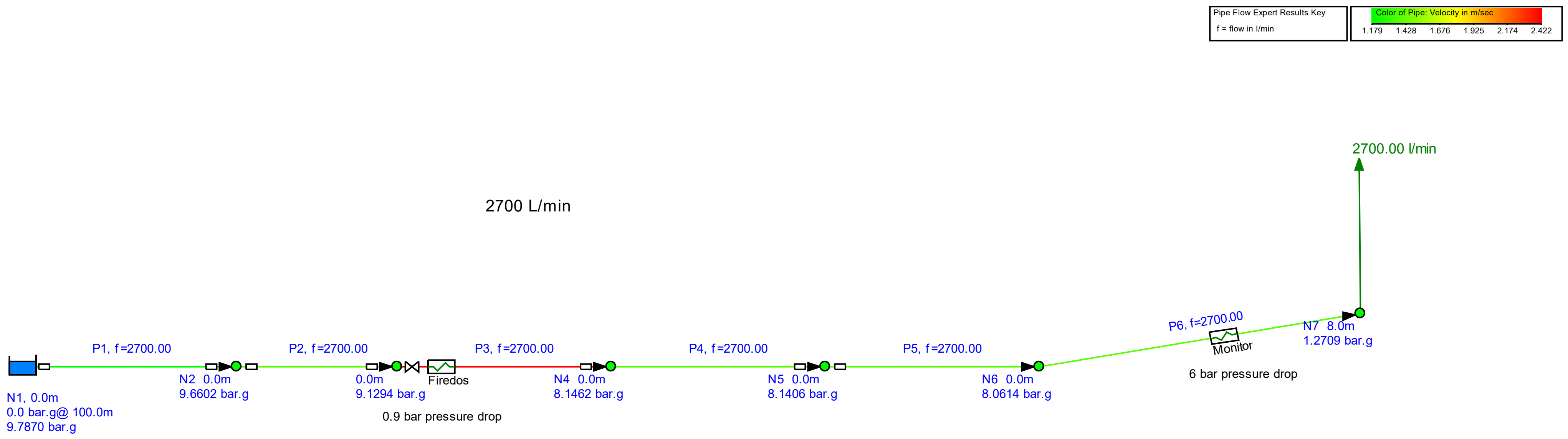
Pipe Data

Pipe Name and Notes	Inner Diameter mm	Length m	Vol Flow l/min	Velocity m/sec	Friction Loss kPa	dP Total Loss kPa
P27	333.350	40.000	10359.00	1.978	4.009	57.719
P28	302.971	1.000	10359.00	2.395	0.164	-1026.542
P29	302.971	1.000	10359.00	2.395	0.164	0.965
P30	202.463	1.000	1391.00	0.720	0.026	70.727
P31	100.000	166.000	1391.00	2.952	162.089	171.089
P32	101.500	70.000	1391.00	2.865	63.267	267.159
P39	302.971	1.000	10359.00	2.395	0.164	0.164
P41	302.971	20.000	10359.00	2.395	3.276	4.078
P42	302.971	45.000	8968.00	2.073	5.557	10.404
P43	302.971	0.050	8968.00	2.073	0.006	4.854
P57	102.006	79.000	1792.00	3.655	114.623	310.364
P58	302.971	2.000	7663.25	1.772	0.182	0.182
P59	302.971	1.000	5871.25	1.357	0.054	0.054
P60	302.971	68.000	1304.75	0.302	0.210	0.210
P61	302.971	1.000	4079.25	0.943	0.027	0.027
P62	302.971	90.000	1304.75	0.302	0.277	0.277
P63	302.971	37.000	1800.00	0.416	0.208	0.208
P64	302.971	23.000	1800.00	0.416	0.129	0.129
P65	302.971	58.000	1304.75	0.302	0.179	0.179
P66	302.971	23.000	1200.00	0.277	0.061	0.061
P67	302.971	1.000	2287.25	0.529	0.009	0.009
P68	302.971	60.000	495.25	0.114	0.031	0.031
P69	302.971	4.000	7663.25	1.772	0.363	0.363
P70	102.006	79.000	1792.00	3.655	114.623	310.364
P71	102.006	79.000	1792.00	3.655	114.623	310.364
P72	102.006	79.000	1792.00	3.655	114.623	310.364
P73	102.006	1.000	1792.00	3.655	1.451	326.598
P74	102.006	1.000	1792.00	3.655	1.451	326.544
P75	102.006	1.000	1792.00	3.655	1.451	326.517
P76	102.006	1.000	1792.00	3.655	1.451	326.508

Pipe Materials

Pipe Id	Pipe Name	Nominal Size	Material	Schedule Class	Roughness mm	Inner Diameter mm	Wall Thickness mm	Outer Diameter mm	Length m	Weight kgs (full length)	Internal Volume m³
27	P27	350 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	333.350	11.125	355.600	40.000	3780.520	3.491
28	P28	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	1.000	80.690	0.072
29	P29	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	1.000	80.690	0.072
30	P30	200 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	202.463	8.306	219.075	1.000	43.173	0.032
31	P31	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	100.000	11.400	124.300	166.000	688.900	1.304
32	P32	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	101.500	11.400	124.300	70.000	290.500	0.566
39	P39	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	1.000	80.690	0.072
41	P41	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	20.000	1613.800	1.442
42	P42	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	45.000	3631.050	3.244
43	P43	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	0.050	4.035	0.004
57	P57	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	102.006	6.147	114.300	79.000	1295.205	0.646
58	P58	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	2.000	161.380	0.144
59	P59	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	1.000	80.690	0.072
60	P60	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	68.000	5486.920	4.902
61	P61	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	1.000	80.690	0.072
62	P62	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	90.000	7262.100	6.488
63	P63	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	37.000	2985.530	2.667
64	P64	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	23.000	1855.870	1.658
65	P65	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	58.000	4680.020	4.181
66	P66	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	23.000	1855.870	1.658
67	P67	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	1.000	80.690	0.072
68	P68	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	60.000	4841.400	4.326
69	P69	300 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	302.971	10.439	323.850	4.000	322.760	0.288
70	P70	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	102.006	6.147	114.300	79.000	1295.205	0.646
71	P71	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	102.006	6.147	114.300	79.000	1295.205	0.646
72	P72	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	102.006	6.147	114.300	79.000	1295.205	0.646
73	P73	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	102.006	6.147	114.300	1.000	16.395	0.008
74	P74	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	102.006	6.147	114.300	1.000	16.395	0.008

Pipe Id	Pipe Name	Nominal Size	Material	Schedule Class	Roughness mm	Inner Diameter mm	Wall Thickness mm	Outer Diameter mm	Length m	Weight kgs (full length)	Internal Volume m³
75	P75	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	102.006	6.147	114.300	1.000	16.395	0.008
76	P76	100 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	102.006	6.147	114.300	1.000	16.395	0.008


Pipe Flow Expert Results Key
f = flow in l/min
Color of Pipe: Velocity in m/sec
1.179 1.428 1.676 1.925 2.174 2.422
2700.00 l/min
2700 L/min
P1, f=2700.00
P2, f=2700.00
P3, f=2700.00
P4, f=2700.00
P5, f=2700.00
P6, f=2700.00
N1, 0.0m
0.0 bar.g@ 100.0m
9.7870 bar.g
N2 0.0m
9.6602 bar.g
0.0m
9.1294 bar.g
Firedos
0.9 bar pressure drop
N4 0.0m
8.1462 bar.g
N5 0.0m
8.1406 bar.g
N6 0.0m
8.0614 bar.g
Monitor
6 bar pressure drop
N7 8.0m
1.2709 bar.g

Fluid Data

Zone	Fluid Name	Chemical Formula	Temperature °C	Pressure bar.g	Density kg/m³	Centistokes	Centipoise	Vapour Pressure bar.a	State
1	Water	H2O	20.000	0.0000	998.000000	1.000000	1.002000	0.024000	Liquid

Pipe Data

Pipe Id	Pipe Name and Notes	Inner Diameter mm	Length m	Mass Flow kg/sec	Vol Flow l/min	Velocity m/sec	dP Total Loss bar	Entry Pressure bar.g	Exit Pressure bar.g
1	P1	220.421	250.000	44.9100	2700.00	1.179	0.1268	9.7870	9.6602
2	P2	202.463	250.000	44.9100	2700.00	1.398	0.5309	9.6602	9.1294
3	P3	153.797	5.000	44.9100	2700.00	2.422	0.9832	9.1294	8.1462
4	P4	202.463	3.048	44.9100	2700.00	1.398	0.0056	8.1462	8.1406
5	P5	202.463	80.000	44.9100	2700.00	1.398	0.0793	8.1406	8.0614
6	P6	202.463	8.000	44.9100	2700.00	1.398	6.7905	8.0614	1.2709

Pipe Factors

Pipe Id	Pipe Name	Inner Roughness mm	Inner Diameter mm	Length m	Reynolds Number	Flow Type	Friction Factor	Entry Fittings Total K Factor	Exit Fittings Total K Factor	Component Cv	Component Kv	Sprinkler Imperial K	Sprinkler Metric K
1	P1	0.001500	220.421	250.000	258900	Turbulent	0.014947	0.4800	0.8400	none	none	none	none
2	P2	0.150000	202.463	250.000	281864	Turbulent	0.019512	30.1800	0.1800	none	none	none	none
3	P3	0.150000	153.797	5.000	371054	Turbulent	0.020309	1.6200	0.5600	none	none	none	none
4	P4	0.150000	202.463	3.048	281864	Turbulent	0.019512	0.0000	0.2800	none	none	none	none
5	P5	0.150000	202.463	80.000	281864	Turbulent	0.019512	0.4200	0.0000	none	none	none	none
6	P6	0.150000	202.463	8.000	281864	Turbulent	0.019512	none	none	none	none	none	none

Pipe Materials

Pipe Id	Pipe Name	Nominal Size	Material	Schedule Class	Roughness mm	Inner Diameter mm	Wall Thickness mm	Outer Diameter mm	Length m	Weight kgs (full length)	Internal Volume m³
1	P1	250 mm	HDPE	SDR 11	0.001500	220.421	26.314	273.050	250.000	4870.000	9.540
2	P2	200 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	202.463	8.306	219.075	250.000	10793.250	8.049
3	P3	150 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	153.797	7.239	168.275	5.000	143.750	0.093
4	P4	200 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	202.463	8.306	219.075	3.048	131.591	0.098
5	P5	200 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	202.463	8.306	219.075	80.000	3453.840	2.576
6	P6	200 mm	Steel (ANSI) Galvanised	Sch. 40	0.150000	202.463	8.306	219.075	8.000	345.384	0.258

Pipe Fittings

Pipe Id	Pipe	Fitting Position	Description	Imperial Size	Metric Size	Database Ref	K Value	Quantity	K Total	Entry K Total	Exit K Total
1	P1	Start of Pipe	Pipe Bend	10"	250 mm	PB	0.1600	3	0.4800		
1	P1	End of Pipe	Branch Tee	10"	250 mm	BT	0.8400	1	0.8400		
										0.4800	0.8400
2	P2	Start of Pipe	Elbow 45 deg.	8"	200 mm	E45	0.2200	1	0.2200		
2	P2	Start of Pipe	Branch Tee	8"	200 mm	BT	0.8400	1	0.8400		
2	P2	Start of Pipe	Long Bend RE29	8"	200 mm	LB	27.8000	1	27.8000		
2	P2	Start of Pipe	Long Bend	8"	200 mm	LB	0.2200	6	1.3200		
2	P2	End of Pipe	Gradual contraction 200x150 RE78	8"	200 mm	GrCon	0.1800	1	0.1800		
										30.1800	0.1800
3	P3	Start of Pipe	Long Bend	6"	150 mm	LB	0.2400	2	0.4800		
3	P3	Start of Pipe	Gate Valve	6"	150 mm	Gate	0.1200	2	0.2400		
3	P3	Start of Pipe	Branch Tee	6"	150 mm	BT	0.9000	1	0.9000		
3	P3	End of Pipe	Gradual enlargement 150x200	6"	150 mm	GrEn	0.5600	1	0.5600		
										1.6200	0.5600
4	P4	End of Pipe	Through Tee	8"	200 mm	TT	0.2800	1	0.2800		
										0.0000	0.2800
5	P5	Start of Pipe	Standard Bend	8"	200 mm	SB	0.4200	1	0.4200		
										0.4200	0.0000
6	P6	No Fittings									

Components

Pipe Id	Pipe Name	Inner Diameter mm	Comp. Name	Comp. Type	Comp. Value	Flow l/min	Mass Flow kg/sec	Comp. Loss m.hd
3	P3	153.797	Firedos	Fixed Loss bar	0.9000	2700.00	44.9100	9.1958
6	P6	202.463	Monitor	Fixed Loss bar	6.0000	2700.00	44.9100	61.3056

17 REFERENCES

1 Department of Planning (NSW) *Hazardous Industry Planning Advisory Paper No 2 – Fire Safety Study Guidelines*

2 Planning NSW, *Best Practice Guidelines for Contaminated Water Retention and Treatment Systems*

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4 Oil and Gas Producers, *Risk Assessment Data Directory*, March 2010

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6 TNO, *Methods for the Calculation of Physical Effects (The Yellow Book)*, 1997

7 Lees F.P., *Loss Prevention in the Process Industries*, 3rd Edition

8 HSE, *Measurements of Burning Rate and Radiative Heat Transfer for Pools of Ethanol and Cask-Strength Whisky*, 2019

9 Technical Research Institute of Sweden, *ETANKFIRE – Experimental Results of Large Ethanol Fuel Pool Fires*, 2015

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12 BP Process Safety Series, *Fire Safety Booklet, Liquid Hydrocarbon Tank Fires: Prevention and Response*, 2005

13 Thomas, *Historical Fire Incident Data Use & Sources*, June 2003

14 Planning NSW, *Best Practice Guidelines for Contaminated Water Retention and Treatment Systems*, July 1994

15 LASTFIRE Project, 2003

16 Thomas, *Historical Fire Incident Data Use and Sources*, June 2003