APPENDIX U
Preliminary Hazard Analysis

EMM
creating opportunities

Preliminary Hazardous Analysis

HVO Continuation Project

HV Operations Pty Ltd
Document No. RCE-22218_HVO_PHA_Final_30Nov22_Rev(2)
Date 30/11/2022

Preliminary Hazardous Analysis

HVO Continuation Project

HV Operations Pty Ltd

Prepared by

Riskcon Engineering Pty Ltd
37 Pogson Drive
Cherrybrook NSW 2126
www.riskcon-eng.com
ABN 74 626 753 820

HV Operations Pty Ltd
Document No. RCE-22218_HVO_PHA_Final_30Nov22_Rev(2)
Date 30/11/2022

Quality Management

Rev	Date	Remarks	Prepared By	Reviewed By
A	28^{h} October 2022	Draft issued for comment	Jason Costa	Renton Parker
B	8th November 2022	Draft revised		
0	14th November 2022	Final issued		
1	29th November 2022	Final revised		
2	30th November 2022	Final revised		

Executive Summary

Background

Hunter Valley Operations (HVO) is a multi-pit open cut mining complex approximately 24 kilometres (km) north-west of Singleton in the Hunter Valley of New South Wales (NSW) (**Figure 1-1**). HVO comprises two mine sites separated by the Hunter River, HVO North and HVO South. While the two mine sites are approved under separate development consents, they are operated as one complex with fully integrated environmental management systems.

The existing HVO North operation comprises the approved mining areas of West Pit, Mitchell Pit and Carrington Pit, as shown in **Figure 1-2**. It operates under development consent DA 450-10-2003 which allows extraction of up to 22 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal until 12 June 2025.

HVO South operates under Project Approval (PA) 06_0261 and comprises the approved mining areas of Riverview Pit and Cheshunt Pit, where mining activities currently take place, and the Riverview South East Extension and South Lemington Pits 1 and 2. PA 06_0261 allows the extraction of up to 20 Mtpa of ROM coal until 24 March 2030.

Mining across HVO is undertaken using dragline and truck and shovel methods. ROM coal from HVO North and South is currently processed at the Hunter Valley (HV) Coal Preparation Plant (CPP) and/or the Howick CPP (both at HVO North), from which product coal is predominantly transported via overland conveyor to the HV load point (HVLP) or Newdell LP and via rail to the Port of Newcastle for export. The Lemington CPP (LCPP) and associated rail loop, which is approved under PA 06_0261 and would process and rail coal from HVO South, is yet to be constructed.

HVO is owned by subsidiary companies of Yancoal and Glencore, as participants in the unincorporated HVO Joint Venture (JV). HV Operations Pty Ltd is the appointed manager of the JV.

Analysis Outcomes

A hazard identification table was developed for the Project to identify potential hazards that may be present at the site as a result of operations or storage of materials. Based on the identified hazards, scenarios were postulated that may result in an incident with the potential for offsite impacts. Postulated scenarios were discussed qualitatively and any scenarios that would not impact offsite were eliminated from further assessment. Scenarios not eliminated were then carried forward for consequence analysis.

Per the SEARs, the handling and storage of dangerous goods are assessed in this PHA. It is noted that nearby prescribed dams are assessed as required in the Blasting Impact Assessment (ESC 2022) prepared for the site. Similarly, bushfire risks (and other fire risks) are assessed in further detail in the Bushfire Management Plan.

HVO North

The consequence analysis identified that there would be no incidents originating from HVO North which would result in offsite impacts; hence, the potential for fatality or injury or environmental impacts to occur would be negligible. As the potential for offsite impacts is low to the point of negligibility, it is considered that the acceptable risk criteria published in HIPAP No. 4 (Ref.) would not be exceeded and that the development would be appropriate for the proposed land use.

HVO South

The consequence analysis identified that there would be no incidents originating from HVO South which would result in offsite impacts; hence, the potential for fatality or injury or environmental impacts to occur would be negligible. As the potential for offsite impacts is low to the point of negligibility, it is considered that the acceptable risk criteria published in HIPAP No. 4 (Ref.) would not be exceeded and that the development would be appropriate for the proposed land use.

Recommendations

Notwithstanding the conclusions following the analysis of the site, the following recommendations have been made:

- Necessary documentation associated with the storage of DGs under the Work Health and Safety Regulation 2011 shall be completed (i.e. risk assessment, register, notification, etc.).

Table of Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Description
ADG	Australian Dangerous Goods Code
AN	Ammonium Nitrate
ANE	Ammonium Nitrate Emulsion
AS	Australian Standard
CBD	Central Business District
DA	Development Application
DGs	Dangerous Goods
DPE	Department of Planning and Environment
HIPAP	Hazardous Industry Planning Advisory Paper
HSE	Health and Safety Executive
PA	Project Approval
PHA	Preliminary Hazard Analysis
SEPP	State Environmental Planning Policy
SMSS	Storage Mode Sprinkler System

1.0 Introduction

1.1 Background

Hunter Valley Operations (HVO) is a multi-pit open cut mining complex approximately 24 kilometres (km) north-west of Singleton in the Hunter Valley of New South Wales (NSW) (**Figure 1-1**). HVO comprises two mine sites separated by the Hunter River, HVO North and HVO South. While the two mine sites are approved under separate development consents, they are operated as one complex with fully integrated environmental management systems.

The existing HVO North operation comprises the approved mining areas of West Pit, Mitchell Pit and Carrington Pit, as shown in **Figure 1-2**. It operates under development consent DA 450-10-2003 which allows extraction of up to 22 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal until 12 June 2025.

HVO South operates under Project Approval (PA) 06_0261 and comprises the approved mining areas of Riverview Pit and Cheshunt Pit, where mining activities currently take place, and the Riverview South East Extension and South Lemington Pits 1 and 2. PA 06_0261 allows the extraction of up to 20 Mtpa of ROM coal until 24 March 2030.

Mining across HVO is undertaken using dragline and truck and shovel methods. ROM coal from HVO North and South is currently processed at the Hunter Valley (HV) Coal Preparation Plant (CPP) and/or the Howick CPP (both at HVO North), from which product coal is predominantly transported via overland conveyor to the HV load point (HVLP) or Newdell LP and via rail to the Port of Newcastle for export. The Lemington CPP (LCPP) and associated rail loop, which is approved under PA 06_0261 and would process and rail coal from HVO South, is yet to be constructed.

HVO is owned by subsidiary companies of Yancoal and Glencore, as participants in the unincorporated HVO Joint Venture (JV). HV Operations Pty Ltd is the appointed manager of the JV.

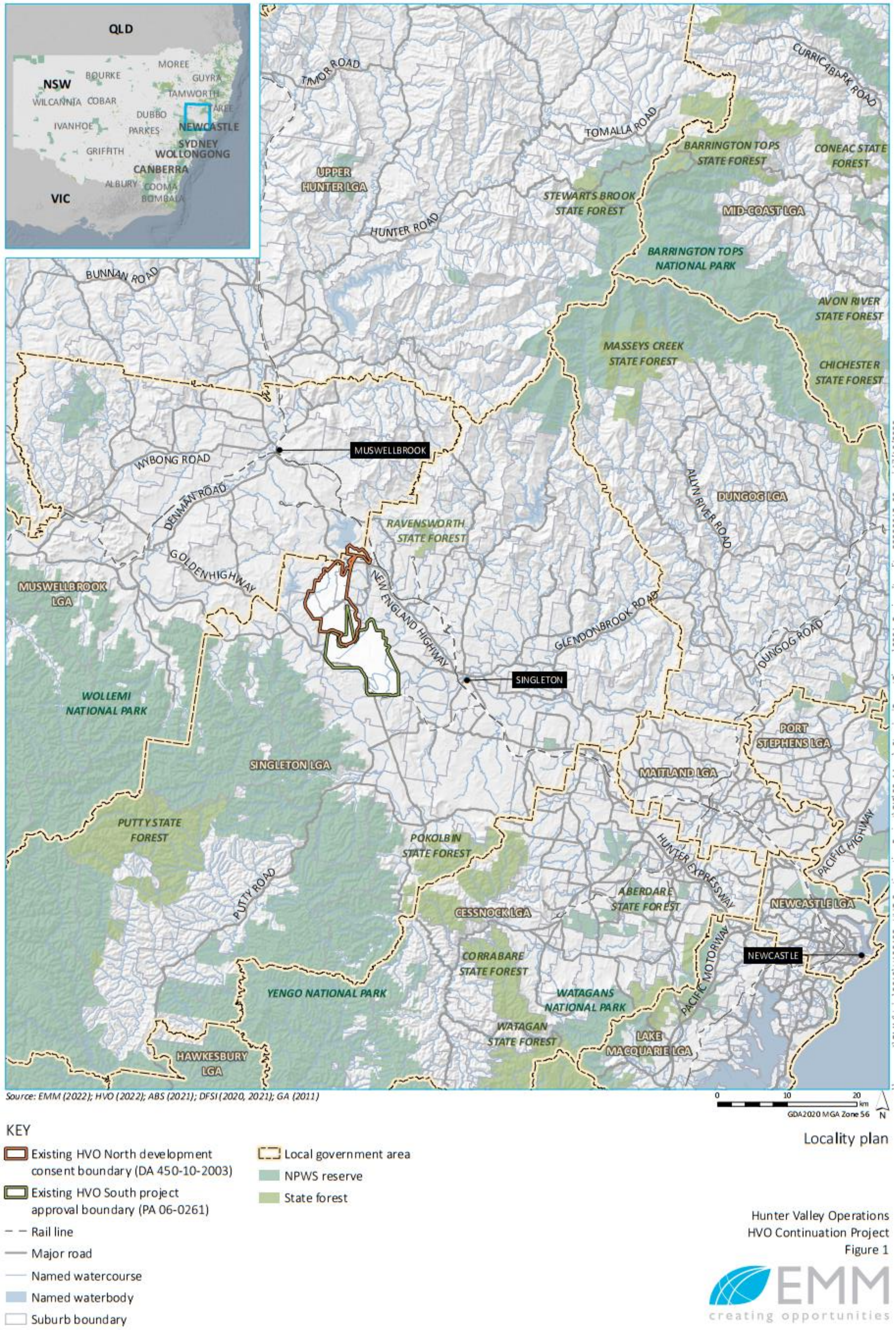


Figure 1-1: Locality Plan

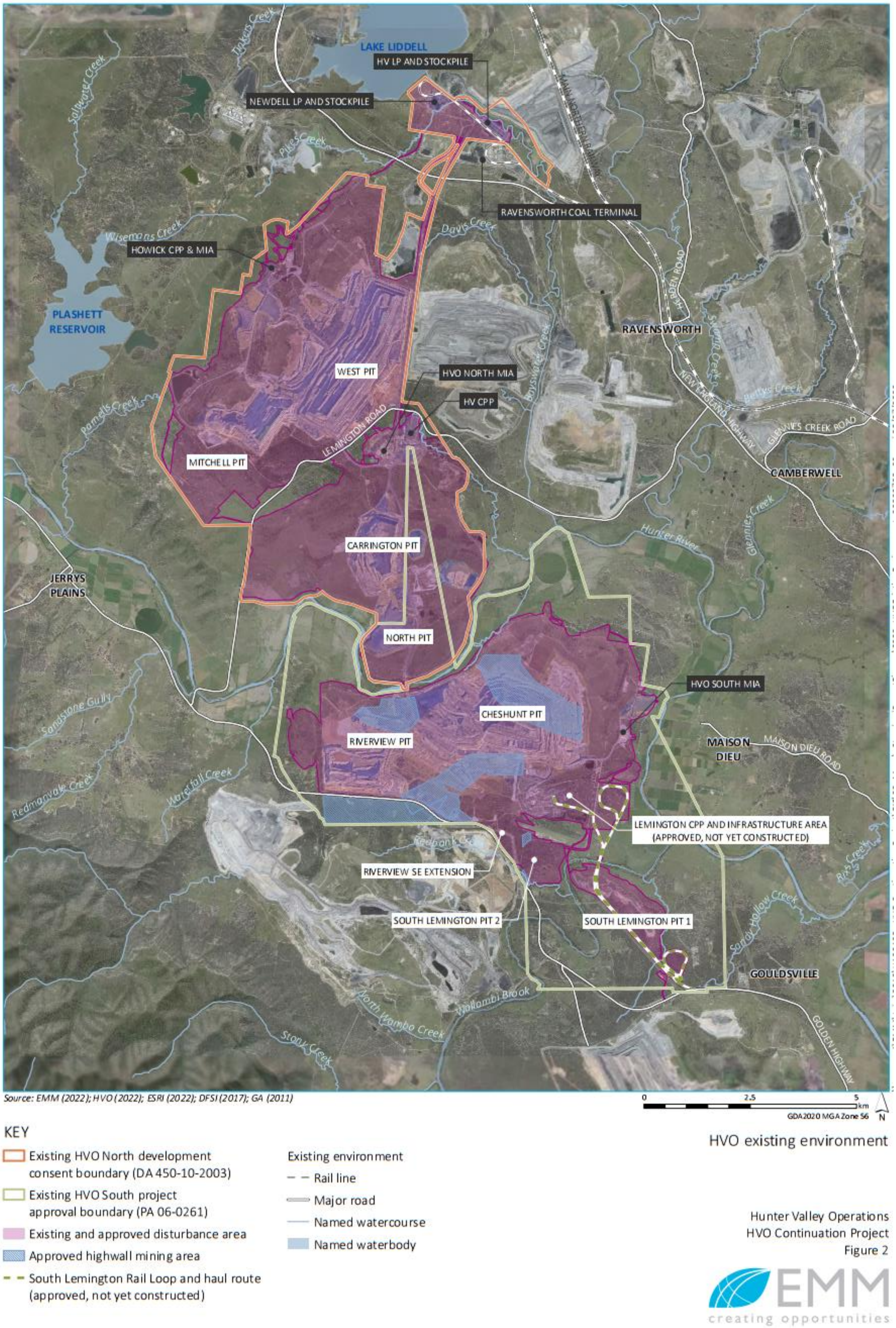


Figure 1-2: Regional Context

1.2 Project overview

The HVO Continuation Project (the Project) broadly comprises the continuation of the life of HVO North and HVO South, from the current approved mining completion dates of 2025 and 2030 respectively, to the end of 2050 at HVO North and the end of 2045 at HVO South. The continuation of mining across the HVO Complex will increase resource recovery from the existing operation, predominantly by mining through previously mined areas and to the extent of existing mining tenements and extracting coal from deeper seams at HVO North (see **Figure 1-3**).

At HVO South an extension to the life of the mine is proposed to facilitate improved mine sequencing outcomes and reduction in mining rate. The Project proposes a reduced mining footprint at HVO South compared to what is approved for extraction, with the previously approved coal extraction in the Riverview South East Extension area and South Lemington Pits 1 and 2 proposed to be removed from the mine plan (and future approvals) for the Project. However, some rehabilitation works will be required to be undertaken in the South Lemington Pit 1 area, as part of the mine closure process. The approved short rail loop option associated with the LCPP has also been removed from the Project.

A number of infrastructure upgrades and changes are also required to facilitate the Project (and are included as part of it), including realignment of part of Lemington Road, relocation of transmission and telecommunication lines, an upgrade of the Newdell LP including construction of a new product stockpile and train loading bin, an upgrade of the HVLP product stockpile including an extension to the existing coal stockpile, and improvements to Lake James and Parnells Dam.

To enable the Project to proceed, two new State significant development (SSD) consents are required; one for HVO North and one for HVO South, under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The Project will seek to maintain separate development consents for HVO North and South, as is currently the case. Given that the two mine sites operate as one complex, one Environmental Impact Statement (EIS) has been prepared to support the two development applications required for the Project.

This preliminary hazard analysis (PHA) forms part of the EIS and provides an assessment of the potential hazard impacts of the Project. It also assesses the potential incremental impacts of the continuation of HVO North and HVO South given separate development consents are being sought for each operation. It documents the methods and results, initiatives to avoid and minimise hazard impacts and additional mitigation and management measures proposed to address residual impacts not able to be avoided.

1.2.1 HVO North

The key changes proposed by the Project to the approved HVO North operations include:

- an extension to the life of the mine until the end of 2050;
- extraction of coal to the base of the Barrett seam across the HVO North mining area. Existing operations are approved to extract coal to the base of the Barrett seam in the West Pit and Mitchell Pit; however, are only approved to the base of the shallower Bayswater seam in Carrington Pit;
- extraction of an additional approximate 400 Million tonnes (Mt) of ROM coal through the extraction of coal from deeper seams and a small increase in the mining extent (between the existing West and Mitchell Pits and Carrington Pit);

- infrastructure upgrades, as listed below:
  - realignment of Lemington Road and construction of a new bridge over the Hunter River. While the proposed realigned corridor is partly within the HVO South development consent boundary, the realignment is required to enable the progression of mining from the Mitchell and West Pits into the Carrington area at HVO North. The works associated with the road realignment therefore form part of the HVO North Project;
  - HVO North site access road relocation off the existing Lemington Road;
  - an increase in the capacity of Parnells Dam from approximately 1 gigalitre (GL) to 4 GL;
  - realignment of transmission and telecommunication lines that are currently within the proposed mining area;
  - mine infrastructure area upgrade;
  - ancillary activities as required to facilitate operations;
  - access roads to facilitate service provider access;
  - use of demountable/temporary buildings in Project compounds as required;
  - upgrade of the existing Newdell LP train loading facility and construction of a new product stockpile; or, extension of the HVLP product coal stockpile, including the closure of a section of Liddell Station Road. While approval for both options is sought, only one will be constructed;
- coal haulage from the HVCPP to the Ravensworth ROM pad, via internal haul roads;
- revision and implementation of the tailings strategy;
- amendments to the approved final landform;
- progressive rehabilitation throughout the mine life; and
- changes to the development consent boundary to incorporate the changes listed above.

Other than as set out above, all activities that are currently approved under the existing HVO North approval are intended to continue. Key aspects and outcomes of the approved development at HVO North that will remain the same under the Project include the following:

- the maximum allowable annual coal extraction and processing rate;
- annual operational workforce numbers and associated traffic generation;
- approved heights of overburden emplacement areas;
- receipt of ROM coal from HVO South via internal haul roads for processing at all CPP facilities approved for HVO North;
- continued avoidance of the Aboriginal heritage site known as Carrington Mine - Colluvial Deposit 1 (CM-CD1); and
- the ridge between Jerrys Plains and HVO North will remain, continuing to provide an effective amenity barrier.

1.2.2 HVO South

The key changes proposed by the Project to the existing approved operations at HVO South include:

- an extension of the life of the mine until the end of 2045;
- a reduction in the approved maximum ROM coal extraction rate from 20 Mtpa to 18 Mtpa;
- changes to the approved mine sequencing (although noting that mining within the two primary open cut pits, Riverview and Cheshunt, will remain generally within the same footprint as approved);
- removal of coal extraction from the mine plan from the Riverview South East Extension, South Lemington Pit 1 and South Lemington Pit 2 mining areas;
- infrastructure upgrades and changes to that currently approved, as listed below:
  - removal of the LCPP short rail loop option;
  - removal of the approved conveyor from HVO South to the HVCPP at HVO North (the conveyor has not been constructed);
  - construction of the Cheshunt and Riverview flood protection levees;
  - realignment of transmission lines;
  - enlargement of Lake James from approximately 0.7 GL to approximately 2 GL;
  - additional tailings pipelines and pumps;
  - ancillary activities as required to facilitate operations;
  - access roads to facilitate service provider access;
  - use of demountable/temporary buildings in Project compounds as required;
- revision and implementation of the tailings strategy; and
- amendments to the final landform due to rescheduling and or infrastructure relocations. Progressive rehabilitation will be undertaken throughout the mine life.

Other than as set out above, all activities that are currently approved under the existing HVO South approval are intended to continue. Key aspects of the approved development at HVO South that will remain the same for the Project include:

- the coal seams to be extracted (ie no increase in the depth of mining);
- the extent of approved mining areas within the Riverview and Cheshunt Pits;
- approved heights of overburden emplacement areas;
- construction of the LCPP and associated rail loop (long rail loop option only);
- transfer of coal from HVO South to HVO North for processing; and
- annual operational workforce numbers and associated traffic generation.

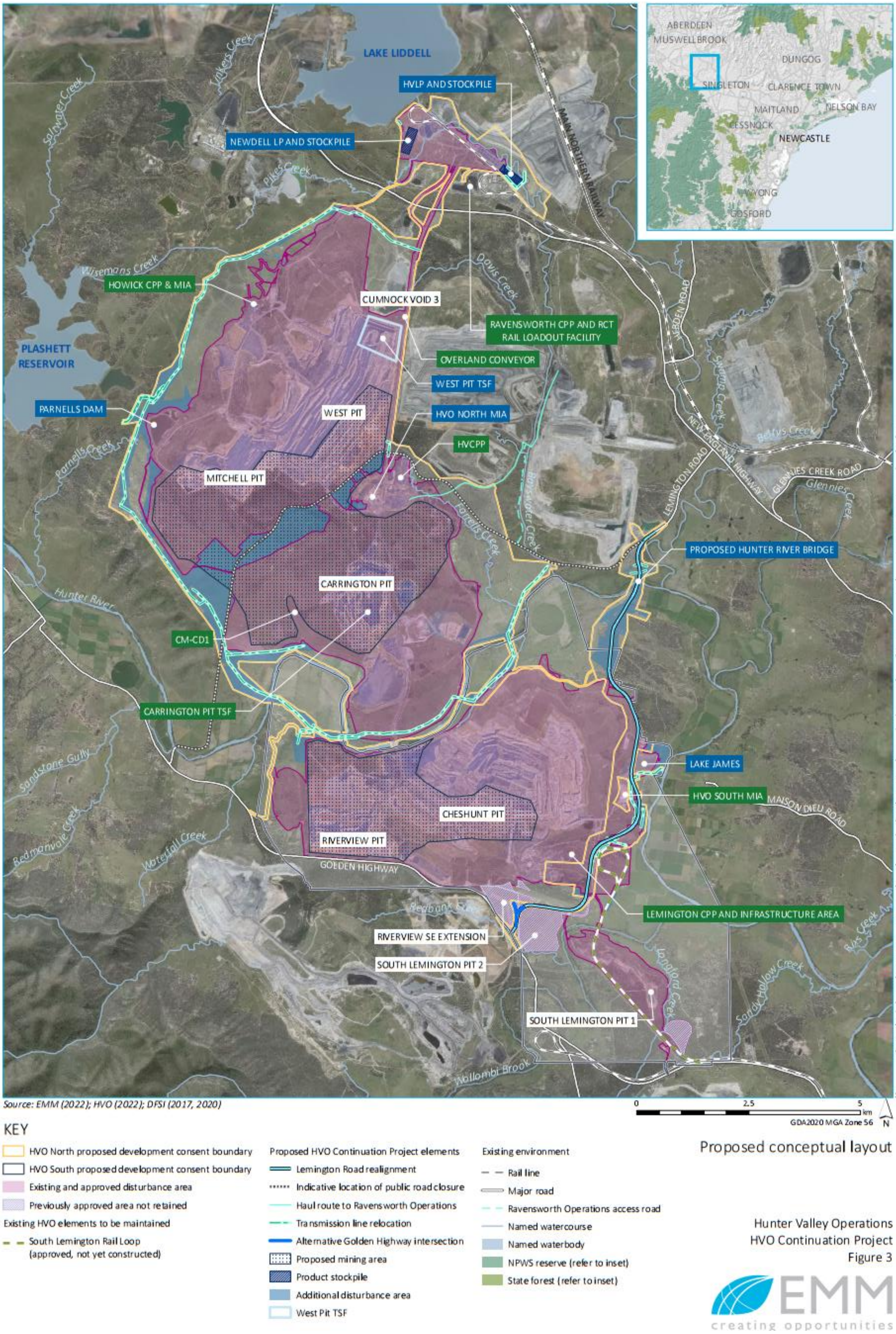


Figure 1-3: Project Overview

1.3 Project terminology

The following key terms are used throughout this assessment to describe the Project:

- **HVO Complex** – comprises both HVO North and HVO South operations.
- **The Project** – the Project in its entirety, encompassing the continuation of the life of the complex; ie, both HVO North and HVO South, within their respective proposed development consent boundaries, as illustrated in **Figure 1-2**.
- **Project area** – The area that is the subject of the two development applications, ie, the proposed development consent boundary for HVO North and the proposed development consent boundary for HVO South.
- **Existing and approved disturbance area –** Areas that are disturbed and/or approved under the NSW EP&A Act to be disturbed under the current development consents that apply to the HVO Complex.
- **Approved mining area –** The areas within the approved disturbance area that have been previously assessed and approved under the NSW EP&A Act for mining operations.
- **Additional disturbance area –** The areas that will be disturbed by the Project that are outside of both the existing and approved disturbance area for the HVO Complex and other neighbouring mines (Ravensworth Operations, United Wambo and Liddell Coal Operations (LCO)).
- **Previously approved areas not retained** – Areas that are disturbed and/or approved to be disturbed under the current development consents that apply to the HVO Complex, that will no longer be disturbed by the Project, such as the LCPP short rail loop, the Riverview South East Extension and South Lemington Pit 2 mining areas, and the approved temporary crossing across the Hunter River between HVO North and South.
- **Proposed mining area, HVO North** – Areas where coal extraction will take place for the Project at HVO North and includes:
  - areas already disturbed by mining that will be re-disturbed to facilitate coal extraction in the deeper Barrett seam;
  - areas not previously approved for mining (eg the area between the Mitchell Pit and Carrington Pit); and
  - areas approved but not yet disturbed (eg the Carrington West Wing area).
- **Proposed mining area, HVO South** – Comprises the Riverview Pit and Cheshunt Pit, where coal extraction will continue under the Project, down to the Bayswater seam. The HVO South proposed mining area does not include the previously approved South Lemington Pit 1, South Lemington Pit 2, or the Riverview South East Extension, as coal extraction is not proposed in these areas as part of the Project. However, rehabilitation activities will be required in some areas and form part of the Project.
- **Transmission line corridors** – Two categories of transmission line corridors have been defined for the purpose of quantifying the extent of disturbance for the Project:
  - realigned transmission lines (ie new transmission line easements) – the extent of disturbance will be limited to transmission line poles/towers and an access road for

maintenance along the alignment, as well as vegetation management to maintain safe powerline clearance; and

– existing transmission line easements to be decommissioned – disturbance will be confined to existing access tracks and cleared areas.

- **Realigned Lemington Road corridor** – The corridor extends from the Comleroi Road intersection with the Golden Highway at the southern end of the new alignment, along the Comleroi Road alignment around the south-eastern side of HVO South, and then extends in a northerly direction to join the existing Lemington Road at a point approximately 2.3 km south of the New England Highway/Lemington Road intersection. The corridor also allows for two options with respect to the connection to the Golden Highway; one assuming that the Golden Highway is realigned by United Wambo as approved under SSD 7142, and a second option that connects with the current alignment of the Golden Highway.
- **Project disturbance area** – this area is a combination of the additional disturbance area and the existing and approved disturbance area, minus the areas not being retained by the Project. If the Project is approved, this will become the 'approved disturbance area' under the new SSD consents.

1.4 Assessment requirements

This assessment has been prepared in accordance with requirements of the NSW Department of Planning and Environment (DPE). These were set out in the Secretary's Environmental Assessment Requirements (SEARs) for the Project (HVO North (SSD 11826681) and HVO South (SSD 11826621)), issued on 11 March 2021. **Table 1-1** lists individual requirements relevant to this PHA and where they are addressed in this report.

Table 1-1: PHA Related SEARs

Requirement	Section addressed
An assessment of the likely risks to public safety, paying particular attention to potential bushfire risks, interactions with nearby prescribed dams and the handling and use of any dangerous goods;	Section 4.0 and Section 5.0. Bushfire risk is directly addressed in the Bushfire Management Plan (Ref. [2]). Nearby prescribed dams are addressed as required in the Blasting Impact Assessment (Ref. [3]).
A health risk assessment that considers the adverse effects from human exposure to acute and cumulative project related environmental hazards, in accordance with Environmental Health Risk Assessment: Guidelines for assessing human health risk from environmental hazards.	Section 4.0 and Section 5.0.

1.5 Objectives

The objectives of the PHA for the Project include:

- Complete the PHA according to the Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – Hazard Analysis (Ref. [4]);
- Assess the PHA results using the criteria in HIPAP No. 4 – Risk Criteria for Land Use Planning (Ref. [1]); and

- Demonstrate compliance of the site with the relevant codes, standards and regulations (i.e. NSW Planning and Assessment Regulation 1979, WHS Regulation, 2017 Ref. [5]).

1.6 Scope of Services

EMM Consulting, on behalf of HVO, has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare a PHA for the Project. This document represents the PHA study for HVO North & HVO South in Hunter Valley, NSW.

The scope of work is to complete a PHA study for HVO North & HVO South in the Hunter Valley, NSW. The scope does not include any other assessments at the site or any other facilities.

2.0 Methodology

2.1 Multi-Level Risk Assessment

The Multi-Level Risk Assessment approach (Ref. [6]) published by the DPE, has been used as the basis for the study to determine the level of risk assessment required. The approach considered the Project in the context of its location, the quantity and type (i.e. hazardous nature) of Dangerous Goods (DGs) stored and used, and the facility's technical and safety management control. The Multi-Level Risk Assessment Guidelines are intended to assist industry, consultants and the consent authorities to carry out and evaluate risk assessments at an appropriate level for the facility being studied.

There are three levels of risk assessment set out in Multi-Level Risk Assessment which may be appropriate for a PHA, as detailed in **Table 2-1**.

Table 2-1: Level of Assessment PHA

Level	Type of Analysis	Appropriate If:
1	Qualitative	No major off-site consequences and societal risk is negligible
2	Partially Quantitative	Off-site consequences but with low frequency of occurrence
3	Quantitative	Where 1 and 2 are exceeded

The Multi-Level Risk Assessment approach is schematically presented in **Figure 2-1**.

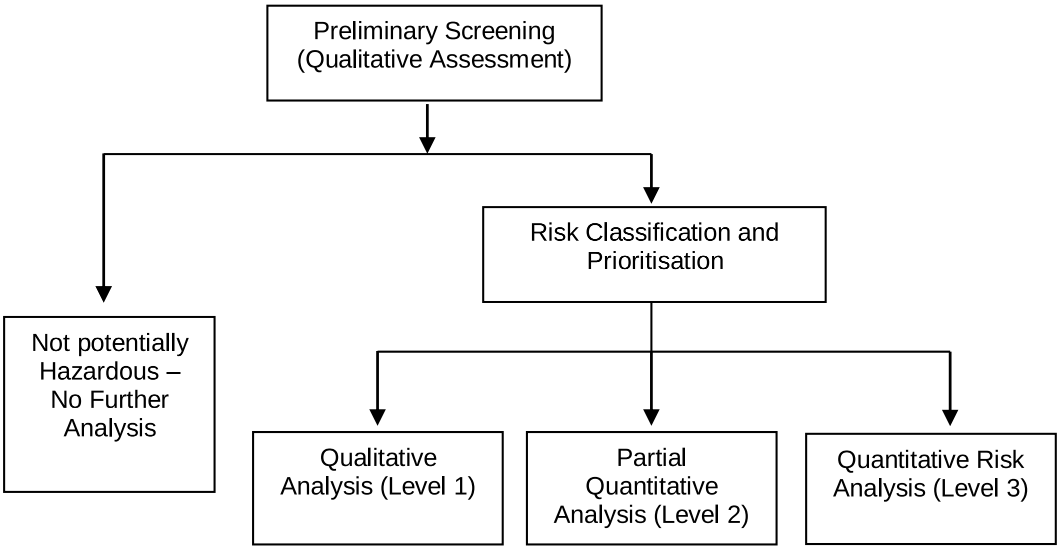


Figure 2-1: The Multi-Level Risk Assessment Approach

Based on the type of DGs to be used and handled at the proposed facility, a **Level 2 Assessment** was selected for the Project. This approach provides a qualitative assessment of those DGs of lesser quantities and hazard, and a quantitative approach for the more hazardous materials to be used on-site. This approach is commensurate with the methodologies recommended in "Applying SEPP 33" and "Multi-Level Risk Assessment" (DPE, 2011).

2.2 Risk Assessment Study Approach

The methodology used for the PHA is as follows:

Hazard Analysis – A detailed hazard identification was conducted for the site facilities and operations. Where an incident was identified to have a potential off-site impact, it was included in the recorded hazard identification word diagram (**Appendix A**). The hazard identification word diagram lists incident type, causes, consequences and safeguards. This was performed using the word diagram format recommended in HIPAP No. 6 (Ref. [4]).

Each postulated hazardous incident was assessed qualitatively in light of proposed safeguards (technical and management controls). Where a potential offsite impact was identified, the incident was carried into the main report for further analysis. Where the qualitative review in the main report determined that the safeguards were adequate to control the hazard, or that the consequence would obviously have no offsite impact, no further analysis was performed. **Section 3.0** of this report provides details of values used to assist in selecting incidents required to be carried forward for further analysis.

Consequence Analysis – For those incidents qualitatively identified in the hazard analysis to have a potential offsite impact, a detailed consequence analysis was conducted. The analysis modelled the various postulated hazardous incidents and determined impact distances from the incident source. The results were compared to the consequence criteria listed in HIPAP No. 4 (Ref. [1]). The criteria selected for screening incidents is discussed in **Section 3.0**.

Where an incident was identified to result in an offsite impact, it was carried forward for frequency analysis. Where an incident was identified to not have an offsite impact, and a simple solution was evident (i.e. move the proposed equipment further away from the boundary), the solution was recommended, and no further analysis was performed.

Frequency Analysis – In the event a simple solution for managing consequence impacts was not evident, each incident identified to have potential offsite impact was subjected to a frequency analysis. The analysis considered the initiating event and probability of failure of the safeguards (both hardware and software). The results of the frequency analysis were then carried forward to the risk assessment and reduction stage for combination with the consequence analysis results.

Risk Assessment and Reduction – Where incidents were identified to impact offsite and where a consequence and frequency analysis was conducted, the consequence and frequency analysis for each incident were combined to determine the risk and then compared to the risk criteria published in HIPAP No. 4 (Ref. [1]). Where the criteria were exceeded, a review of the major risk contributors was performed, and the risks reassessed incorporating the recommended risk reduction measures. Recommendations were then made regarding risk reduction measures.

Reporting – On completion of the study, a draft report was developed for review and comment. A final report was then developed, incorporating the comments received, for submission to the regulatory authority.

3.0 Quantities of Dangerous Goods Stored and Handled

The classes and quantities stored at the sites are summarised in **Table 3-1**. **Figure 3-1** shows the site area and indicates key hazardous material locations.

It is noted that the quantities of materials in **Table 3-1** and locations shown on **Figure 3-1** are dynamic and may change subject to the requirements of relevant AS/Code in place at the time.

Table 3-1: Maximum Classes and Quantities of Dangerous Goods Stored (Ref. [7])

UN Number	Material	Storage location	Storage type	ADG code class/division	Packing group	Storage capacity
HVO North						
00C1	Diesel	HVO North	Above ground tanks	C1	-	2,125,000 L
00C1	Combustible liquids C1	Howick w/shop waste oil/diesel tank	Above ground tank	C1	-	5,200 L
3375	Ammonium nitrate emulsion (ANE)	HVO North	Above ground tanks	5.1	II	180,000 kg
1942	Ammonium nitrate (AN)	HVO North	Above ground tank	5.1	III	94,000 kg
3099	Oxidising liquid toxic, N.O.S.	HVO North	Outdoor bunded store	5.1	III	1,000 L
NA	Detonators, non-electric for blasting, electric for blasting	HVO North	External magazines	1.1B, 1.4S	1	204,000
HVO South						
00C1	Diesel	HVO South	Above ground tank	C1	-	1,320,000 L
00C1	Combustible liquids C1	Light vehicle w/shop waste oil/diesel tank	Above ground tank	C1	-	2,000 L
00C2	Combustible liquids C2	HVO South	Above ground tank	C2	-	15,000 L
1075	Petroleum gases, liquified	South fuel farm (Lemington)	Above ground tank	2.1	-	75,000 L
3375	Ammonium nitrate emulsion	South ANE Facility - ANE Tank 1	Above ground tank	5.1	II	140,000 kg

UN Number	Material	Storage location	Storage type	ADG code class/division	Packing group	Storage capacity
2426	Ammonium nitrate, liquid (hot concentrated solution)	South ANE Facility - AN solution tanks 1-4	Above ground tank	5.1	II	80,000 L
1942	Ammonium nitrate	South ANE Facility - AN Transit Bin	Above ground tank	5.1	III	194,000 kg
1942	Ammonium nitrate (Subject of MOD 8)	South ANE Facility - AN Storage Stack	Open storage stack	5.1	III	7,250,000 kg
1500	Sodium nitrite	South ANE Facility - Gasser Shed	Indoor dry store	5.1	III	5,000 kg
3099	Oxidising liquid toxic, N.O.S.	South ANE Facility - Gasser Shed	Indoor IBC store	5.1	III	5,000 L
2811	Environmentally hazardous substance, solid, N.O.S. (Thiourea)	South ANE Facility - Thiourea Store	Dry store container	6.1	III	5,000 kg
2790	Acetic acid solution	South ANE Facility - Acetic Acid Store	Outdoor bunded store	8	II	5,000 L

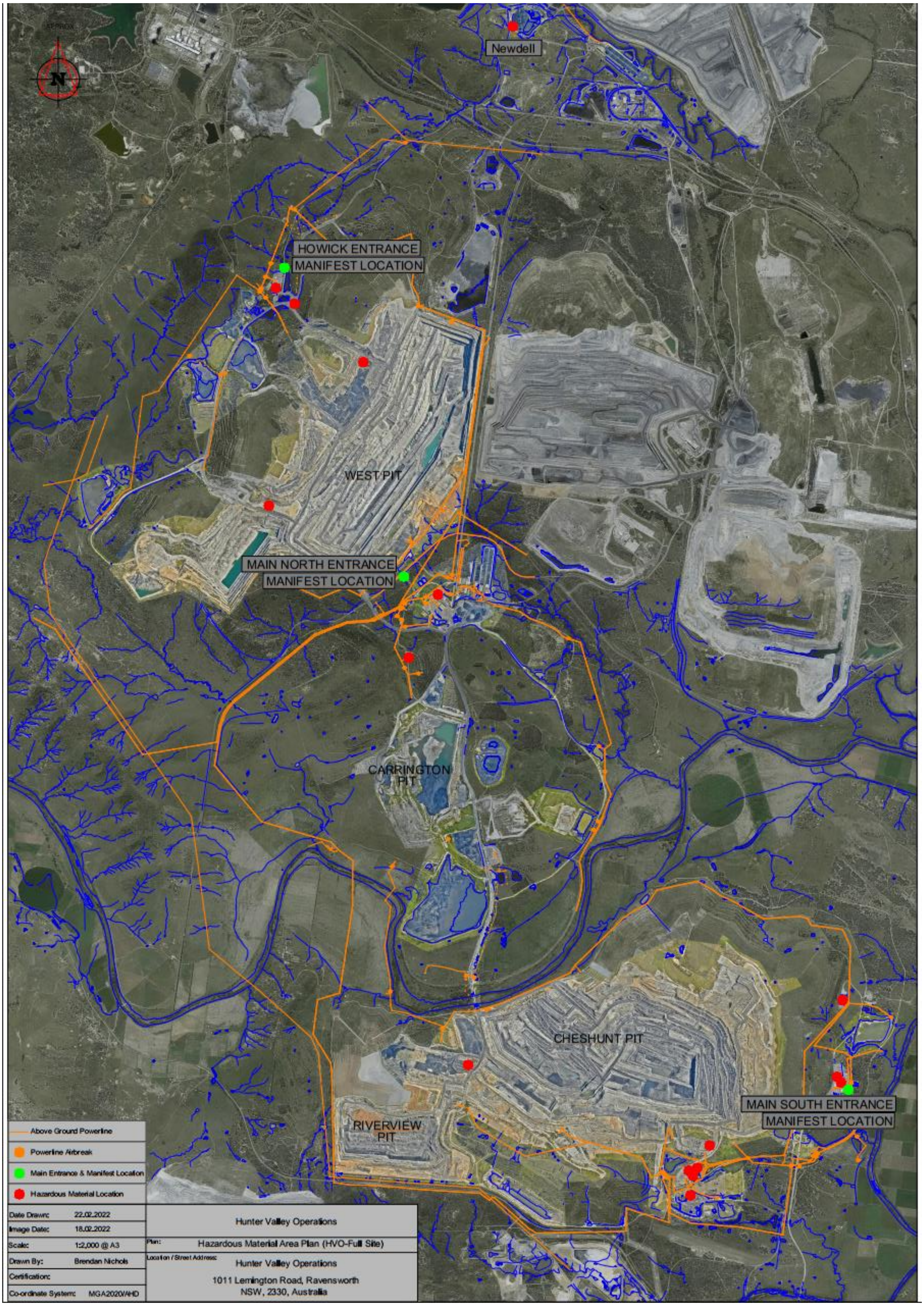


Figure 3-1: Site Area

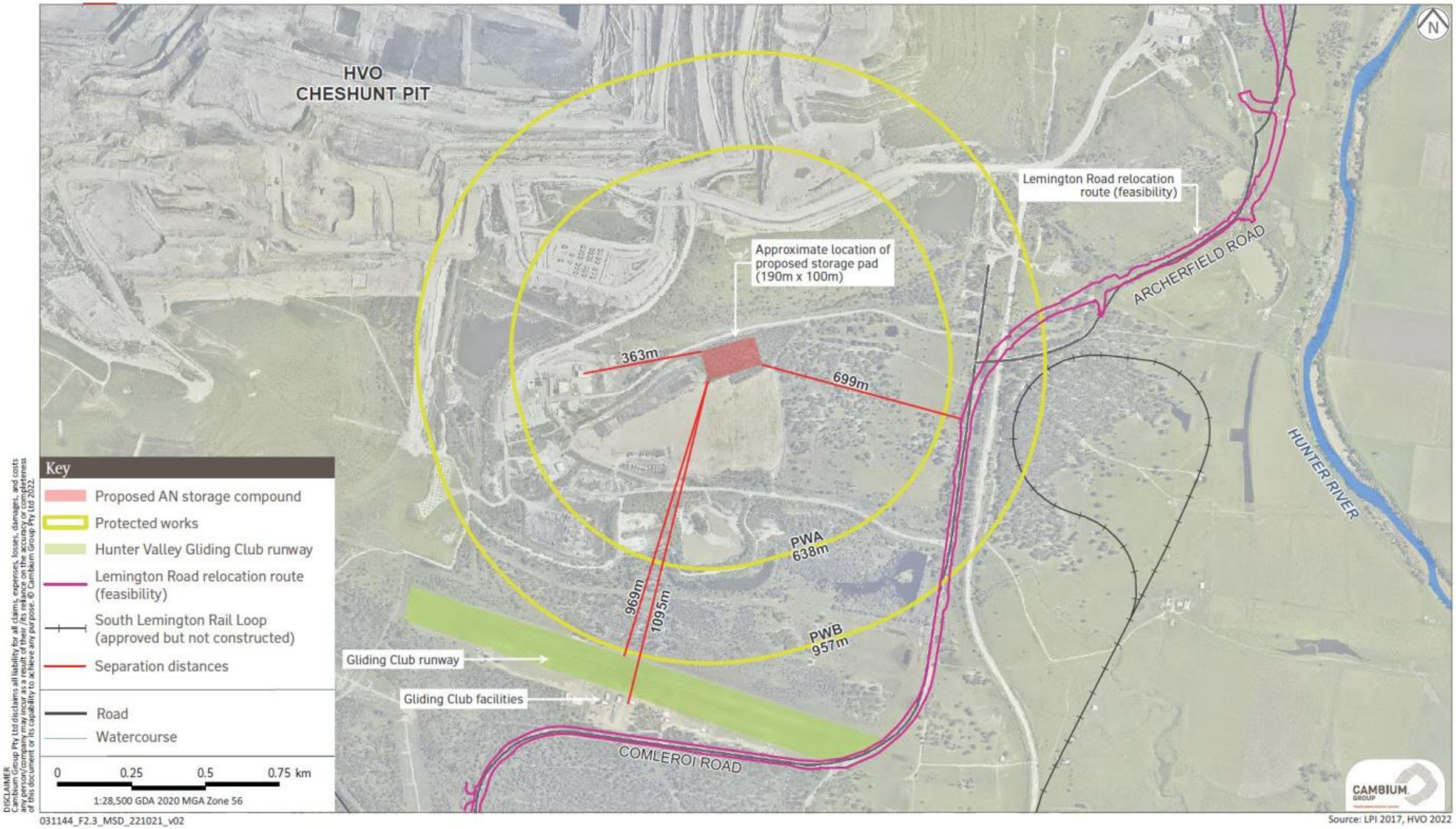


Figure 3-2: Additional 7,250 t Storage Area (Ref. [8])

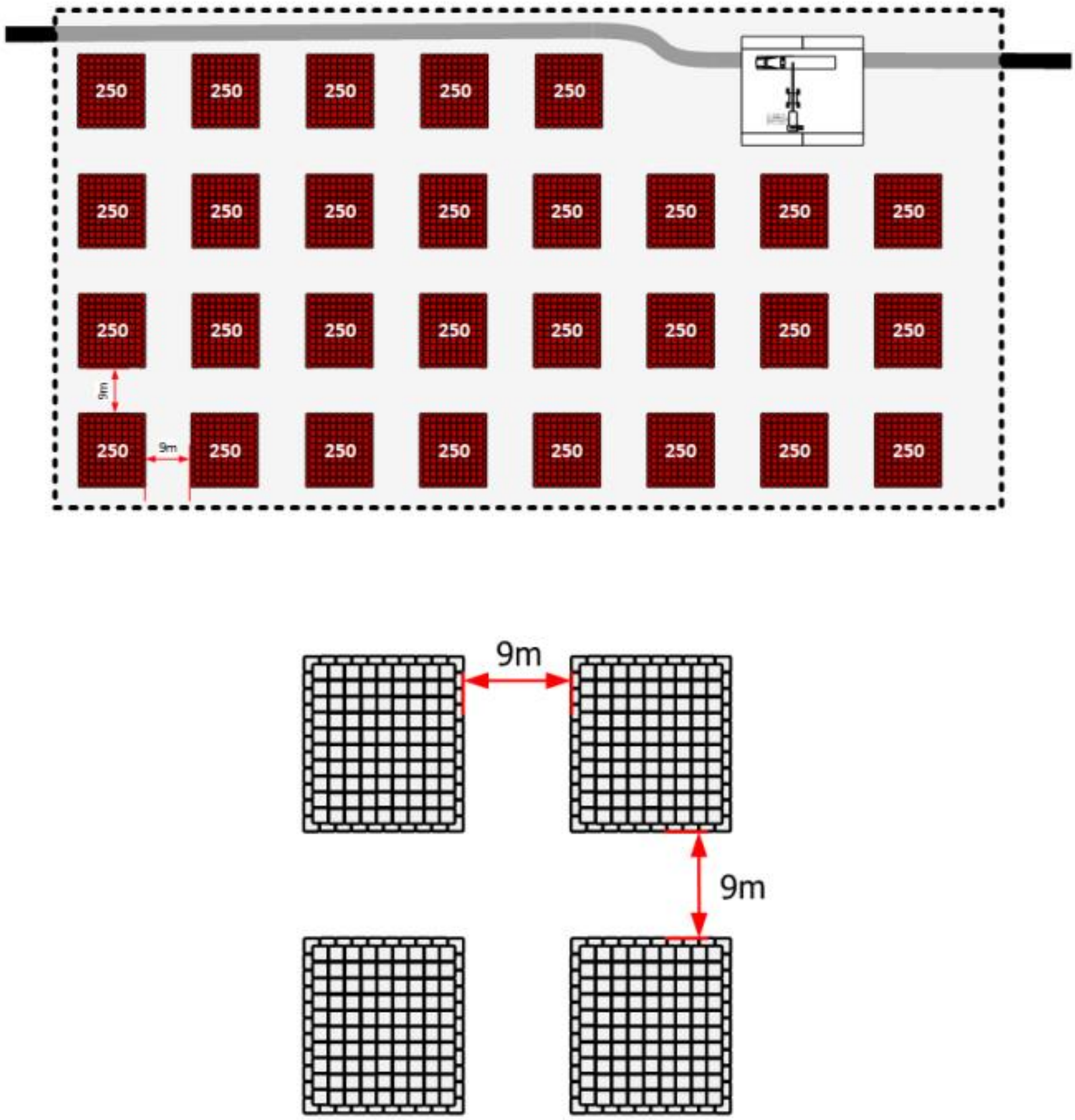


Figure 3-3: Additional AN Storage Configuration (Ref. [8])

It is also noted that a proposed modification (Modification 8) to the HVO South Project Approval (PA 06_0261) is currently under assessment by DPE which covers the following:

HV Operations seeks approval to allow up to 7,250 t of additional AN storage within an area proximate to the existing ANE Plant at HVO South. In addition, an increase in the approved storage quantity of various materials associated with AN production is sought. The proposed AN compound is within a previously disturbed area and exceeds Australian Standard AS4326.

The storage arrangement of an additional 7,250 t of AN will involve open-air storage in stacks of a maximum of 250 t, with each stack separated from adjacent stacks by a minimum of 9 m. This location and storage configuration is shown in **Figure 3-2** and **Figure 3-3** respectively. Further detail surrounding this storage can be found in the Modification Report issued to DPE on 11th October 2022.

For the purpose of this assessment, it is assumed that this development application will be approved.

4.0 Hazard Identification

4.1 Introduction

A hazard identification table has been developed and is presented at **Appendix A**. This table has been developed following the recommended approach in Hazardous Industry Planning Advisory Paper No. 6, Hazard Analysis Guidelines (Ref. [4]). The Hazard Identification Table provides a summary of the potential hazards, consequences and safeguards at the site. The table has been used to identify the hazards for further assessment in this section of the study. Each hazard is identified in detail and no hazards have been eliminated from assessment by qualitative risk assessment prior to detailed hazard assessment in this section of the study.

It is noted that diesel and LPG are stored in large quantities across the site, however for the purpose of this PHA, ammonium nitrate (AN) is identified as the product of highest risk and so this report has primarily focussed on the hazards associated with AN.

4.2 Properties of Dangerous Goods

Table 4-1 provides a description of the DGs stored and handled at the site, including the Class and the hazardous material properties of the DG Class.

Table 4-1: Properties of the Dangerous Goods and Materials Stored at the Site*

Class	Hazardous Properties
Ammonium Nitrate Solid and Emulsion	Solid AN and ANE are a Class 5.1 oxidising agent and will support combustion of other materials as AN produces oxygen as one of its decomposition products. Toxic gases such as nitrogen dioxide (NO_2) and nitrous oxide (N_2O) are also produced during decomposition of ANE. Solid AN and ANE may explode under certain conditions but does not readily explode. High temperature, confinement and contamination are the primary factors influencing the likelihood and severity of an AN or ANE explosion.
Diesel	Diesel is a combustible liquid which means that it has the potential to produce flammable vapours, which can be ignited. As a combustible liquid, diesel is not a hazardous substance unless stored in association with Class 3 flammable liquids. HVO maintains adequate separation distances in accordance with AS1940 between the HVO Mine bulk combustible liquids storages and flammable liquids storages. The Project will maintain adequate separation distances between bulk combustible liquids storages and flammable liquids storages.
LPG	LPG is stored under pressure in a liquefied state and is composed primarily of propane and butane. At ambient pressure and temperature LPG presents in the gaseous state as a flammable gas. Mixtures of LPG and air within the flammable range (LPG concentrations in air of 2.5% to 9.5%) may be ignited and explode. The resulting explosion is typically a deflagration rather than a detonation associated with high explosives. Jet fires may also result if LPG pipe or vessel fitting leaks are ignited. If the pressurised storage vessel is exposed to excessive heat a boiling liquid expanding vapour explosion (BLEVE) may result.

* The Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref. [9])

4.3 Hazard Identification

Based on the hazard identification table presented in **Appendix A**, the following hazardous scenarios have been developed:

- HVO North ANE Reload area (West Pit) AN fire and explosion.
- HVO South ANE Facility AN fire and explosion.
- Diesel tank pool fire.
- AN Decomposition and Toxic Gas Dispersion.
- LPG Release, Ignition and Jet Fire, Flash Fire, Explosion or BLEVE.
- Potentially Contaminated Water from Firefighting Activities.

Each identified scenario is discussed in further detail in the following sections.

4.4 HVO North ANE Reload Area (West Pit) AN Fire and Explosion

The HVO North ANE Reload area (West Pit) stores a maximum of 94 tonnes of solid AN in the form of prill, and 2 x 90,000 L tanks of ANE. If radiant heat from a fire (i.e. bushfire or vehicle fire) were to impinge on the AN bins or ANE tanks, there is the potential that the AN could decompose, ignite and explode. An explosion of this quantity of AN could have major impacts to the plant and personnel in the area.

To prevent any fires from impinging on the storage bins, several hundred metres of clearance to any combustible materials, including grass, trees and other DG stores has been intentionally provided. Hence, in the event of a nearby bushfire, it would be expected that the fire would burn itself out prior to contacting the AN or reaching anywhere nearby. Additionally, the bins are protected by fire extinguishers and hose reels so any fire within the area would be readily extinguished prior to contacting the AN.

The potential for sympathetic detonation of the ANE storage tanks upon detonation of the AN storage bins was considered, and vice versa. However, the separation distance between the nearest AN storage bin and ANE tank is approximately 15 m. The two ANE tanks are also separated by approximately 10 m. There is no sufficient evidence within the literature to indicate that sympathetic detonation will occur across these distances and involving non-heated products. Additionally, due to the controls discussed further below, the simultaneous, independent detonation of all of these products is not considered credible. Therefore, an explosion involving the entire storage of AN prill and ANE has not been modelled further.

Nonetheless, there is still the potential that the AN is impacted by radiant heat which may result in thermal decomposition and subsequent explosion. Hence, this scenario has been carried forward for further analysis.

4.5 HVO South ANE Facility and Reload AN Fire and Explosion

The HVO South ANE facility stores a significant amount of AN products. The storage area contains a maximum of 2 x 30,000 L liquid AN tanks, 2 x 10,000 L liquid AN tanks, 1 x 100,000 kg stack of AN and 1 x 94,000 kg solid AN storage bin in the form of prill, and 2 x 70,000 L tanks of ANE. Similar to the scenario outlined in **Section 4.4** the potential for fire impingement on the AN prill or ANE may result in a catastrophic explosion and so this scenario has been carried forward for further analysis.

4.6 Diesel Tank Pool Fire

Diesel is stored in above-ground tanks which are either integrally bunded (i.e. double-skinned) or situated within bunds. These tanks are of various volume throughout the site and the diesel is used to fuel the equipment on site and within blasting recipes. Diesel is not a flammable liquid but a combustible liquid; hence, it is difficult to ignite. However, if it is exposed to an ignition source for a prolonged period of time then it may ignite and will sustain combustion.

The potential for diesel to spill externally to the tanks is extremely low due to several tanks being double walled and other diesel tanks being located within dedicated bunds. The stores are also compliant with the requirements of AS 1940:2017 (Ref. [10]) and AS 1692:2006 (Ref. [11]). The potential for the two walls of a tank to fail simultaneously is low to the point of being negligible as the tanks are protected from physical damage; hence, the potential for a catastrophic release is not considered to be credible. Additionally, the tanks are protected from vehicular impact by bollards.

There is the potential for minor leaks and releases to occur above ground during filling from pipework connections; however, these would be minor (i.e. <100 L) and could easily be cleaned up by the operator using spill kits included on the delivery tankers. As there would always be an operator present when a minor spill occurred, even if the spill did ignite, it would result in a small fire which could be readily combatted by site personnel using first attack firefighting equipment (fire extinguishers and hose reels). Therefore, this incident does not require further analysis as it does not pose a significant risk of propagation or equipment damage.

4.7 AN Decomposition and Toxic Gas Dispersion

In the event AN is impacted by excessive radiant heat, it may begin to decompose resulting in the release of noxious products (i.e. oxides of nitrogen). Noxious products are toxic and thus they may result in downwind impacts. However, this scenario will only occur in the event of a substantial fire as excessive radiant heat exposure would be unlikely to occur under normal operation.

It will be necessary to ensure first responders are not impacted by noxious products that may be produced in the event of an incident. A noxious detection system would likely be unreliable as it would be sized for a decomposition event which may not occur under conditions which may vary substantially from those observed at the site. Therefore, it should be conservatively assumed that toxic gases are present when a fire occurs at the site.

However, the site procedures outline the response to any significant fire scenario of immediate evacuation to an acceptable distance. Based on this response, it is considered that the risks posed by toxic by-products of combustion are sufficiently managed. Hence, this incident has not been carried forward for further assessment.

4.8 LPG Release, Ignition and Jet Fire, Flash Fire, Explosion or BLEVE

LPG is stored in a 75,000 L bullet at the HVO South area. As the site LPG is depleted, it will be refilled by a delivery tanker at the site. During loading of the tank there is the potential for the hose to rupture which may be the result of a puncture of the hosing or deterioration through general wear and tear. It has been assumed the hoses are inspected monthly and pressure tested annually in accordance with the Australian Dangerous Goods Code (ADG, Ref. [12]).

Notwithstanding this, there is the potential for a hose to become damaged between inspection and test periods which may lead to sufficient deterioration resulting in a hose rupture when transferring pressurised LPG. Excess flow and non-return valves will isolate the flow of LPG; however, if these fail in addition to a hose rupture, LPG will be released resulting in an LPG vapour cloud. The operator may be able to respond and isolate the LPG transfer by activating an emergency stop button located on the tanker.

If the operator is incapacitated or unable to stop the transfer, the LPG will continue to flow developing a substantial cloud which may contact an ignition source and ignite which would result in a flash fire or explosion which would burn back to the release point and subsequent jet fire. It is noted the area is unconfined; hence, an explosion is unlikely to occur and would likely result in a flash fire.

The potential for a fatality to occur as a result of a flash fire is not considered credible as the mechanism for a fatality to occur from a flash fire is via combustion of flammable vapours at head height which results in oxygen within the lungs being consumed as the fuel burns. The impacted person will involuntarily inhale, as low oxygen is detected, resulting in inhalation of hot combustion products which burn the sensitive lining of the lungs. As LPG is a dense gas, any release will spread along at ground level and due to the open nature of the site it will not accumulate to a level where a person offsite will be fully engulfed; hence, a fatality is unlikely to occur.

Similarly, an explosion is only likely to occur if the LPG release is confined, which is not the case in this instance.

Similarly, to the scenario described above, a hose may rupture resulting in a jet fire. If this jet fire were aimed at the delivery tanker, the tanker shell would begin to heat, transferring the heat into the LPG within the tank which would begin to vaporise and increase the pressure within the tanker. At the design pressure of the tank, the pressure relief valve will begin to lift to relieve pressure within the tanker.

As the liquid level within the tanker drops, the impact zone of the jet fire may impact the vapour space in the tanker. The vapour will absorb less energy than the liquid which will result in localised heating of the tanker shell at the point of the jet fire impact. This may compromise the structural integrity of the tanker shell which may rupture resulting in a blast overpressure as the vessel fails and formation of an LPG vapour cloud which may also ignite resulting in a vapour cloud explosion known as a Boiling Liquid Expanding Vapour Explosion (BLEVE). A similar scenario may occur within the tank itself.

Despite the risks associated with the storage and potential release of LPG, the incidents described above are not expected to impact over the site boundary due to the size of the site and its purpose. LPG impacts are also not anticipated to result in propagation; hence, this incident has not been carried forward for further analysis.

4.9 Potentially Contaminated Water from Firefighting Activities

It is noted that the preferred strategy for emergency response at the site is evacuation due to the high potential for incident escalation which may result in an explosion and could have far reaching impacts. However, there may be several incidents that could occur on site that won't immediately result in an escalation event (i.e. fuel oil fire, grass land fire) and it may be prudent to combat these incidents to prevent an escalation. Should these incidents occur, it will be necessary to apply water to control and suppress the fires.

During combustion there are a range of combustion products generated with several of these being toxic (i.e. poly aromatic hydrocarbons). As water is applied, it may become contaminated by these products which will be transported by the water flow. Should the water be discharged from the site there is the potential for an environmental incident, in addition to any liquid effluent (i.e. fuel oil) being transported with the water.

The site is located in a ‘water management system’ which means that no runoff from firefighting activities or other water uses is permitted to leave the site boundaries. However, the storage areas are not located near a site boundary and so water is expected to remain entirely on site. This is addressed further in the Environmental Protection Licence (EPL) 640 (Ref. [13]), the Hazardous Substances and Dangerous Goods Procedure (Ref. [7]) and the Pollution Incident Response Management Plan (PIRMP) (Ref. [14]).

The volume of firewater which may be potentially contaminated would be assumed to be from fighting a small fire as large events require evacuation. Hydrants connected to the fire mains are available around infrastructure areas. Fire hoses are also supplied by water storage tanks. The Bushfire Management Plan (Ref. [2]) provides additional detail around bushfire response capabilities. Notwithstanding, all firewater will remain onsite. Hence, this scenario has not been carried forward for further analysis.

5.0 Consequence Analysis

5.1 Incidents Carried Forward for Consequence Analysis

The following incidents were identified to have the potential to propagate an incident or significantly damage equipment:

- HVO North ANE Reload area (West Pit) AN fire and explosion.
- HVO South ANE Facility AN fire and explosion.

Each identified scenario is discussed in further detail in the following sections.

5.2 HVO North ANE Reload Area (West Pit) AN Fire and Explosion

In the event the AN storage bins or ANE tanks at the HVO North ANE Reload Area are impacted by a fire (such as a bushfire or vehicle fire) to the point that the AN decomposes, the bins/tanks may explode resulting in substantial overpressure impacts.

The Australasian Explosives Industry Safety Group (AESIG) developed Edition 5 of a detailed Code of Practice in 2018 titled “Storage and Handling of UN3375” (Ref. [15]). This document (the ANE Code) outlines a methodology for determining separation distances required for ANE (UN 3375) storage.

It is noted that a recently published a Code of Practice (the Code) titled “Storage and Handling of Solid Ammonium Nitrate” (Ref. [16]) is also considered applicable to the site, however Riskcon have been advised to utilise the ANE Code for consistency with previous Development Applications.

Section 9 of AS 4326:2008 (Ref. [17]) has also been consulted in this assessment, however the AESIG Codes are considered more applicable for assessment relating to separation distances per Clause 9.3.1 of AS 4326:2008 which specifies that applicable separation distances should be found within relevant State or Territory regulations. The AESIG Codes are deemed adequate in meeting this requirement. Additionally, Clause 1.2.2 (e) of AS 4326:2008 directly excludes “emulsions and slurries based on ammonium nitrate and fuels” such as UN 3375 ANE and therefore the Codes of Practice are considered directly applicable.

AS 2187.1:1998 (Ref. [18]) has also been reviewed. AN is referred to in AS 2187.1:1998 in reference to separation from Class 1 explosives, i.e. magazine storage. Ammonium Nitrate and derivatives (i.e. ANE) however are Class 5.1 oxidising agents and therefore not directly applicable to AS 2187.1:1998. Notwithstanding, this Standard has been consulted in this assessment.

Table 5-1 shows the AN and derivatives to be stored within the area.

Table 5-1: AN & ANE Storage at HVO North (West Pit)

UN Number	Material	Storage location	Storage type	ADG code class/division	Packing group	Storage capacity
3375	Ammonium nitrate emulsion (ANE)	Western Reload - ANE Tank 1	Above ground tank	5.1	II	90,000 kg
3375	Ammonium nitrate emulsion	Western Reload - ANE Tank 2	Above ground tank	5.1	II	90,000 kg

UN Number	Material	Storage location	Storage type	ADG code class/division	Packing group	Storage capacity
1942	Ammonium nitrate (AN)	Western Reload - AN Transit Bin	Above ground tank	5.1	III	94,000 kg

Based on the methodology provided in the Process and Risk Report prepared by HVO Coal Assets Pty Ltd (Ref. [19]) which is modelled from the methodology provided in the SAFEX Good Practice Guide (Ref. [20]), the following information has been used to calculate the Net Explosive Quantity (NEQ) at the storage area:

Table 5-2: HVO North NEQ

Store	Quantity (kg)	TNT Equivalence	NEQ (kg)
ANE Tank 1	90,000	0.8	72,000
ANE Tank 2	90,000	0.8	72,000
AN Transit Bin	94,000	0.32	30,080
		Total	174,080

For conservatism, an explosion has been modelled based upon the contribution of the entire contents of the store. In reality, this is extremely unlikely due to separation between the vessels and the unlikelihood of the vessels to be full simultaneously and at the time of explosion.

The separation distance required by Appendix B of the ANE Code, which is the same as Table 3.2.3.2 of AS 2187.1:1998 for an explosion of 174 tonnes from “Public Works Class A” (i.e. public roads) is 825 m. However, this distance can be reduced based on the provision of a warning and ability to evacuate. All AN related explosions come with warning given that the material is required to be heated for an extended period of time. Based on this, 50% of the Public Works Class B distance can be used. In this case, this is 50% of 1,240 = **620 m**.

The storage area is located at a distance greater than 620 m from the Protected Works Class A (i.e. sensitive receptors such as public streets) and so will not result in an “offsite” fatality. It is noted that these locations may be within the site development consent due to the significant size of the site, however they are treated as the closest receptors for the purpose of this assessment. Therefore, this scenario has not been carried forward for further analysis.

It is noted that there is potential for the storage location to be relocated in the future based on mining progress at the site. In the event that the storage location of AN and ANE is changed, relevant assessment will be completed per the requirements of the Australian Standards, Regulations and Codes of Practice in order to ensure that separation distances and all other requirements are met.

The Effects consequence modelling software developed by Gexcon was used to validate the results and separation distances presented in the above Sections. **Figure 5-1** and the resulting data provided in Appendix B indicates that adequate separation distances are provided, and the methodology used based on the AESIG Code of Practice is accurate and more conservative than the required separation distances. The aqua coloured contours shown on **Figure 5-1** represent an overpressure value of 7 kPa.

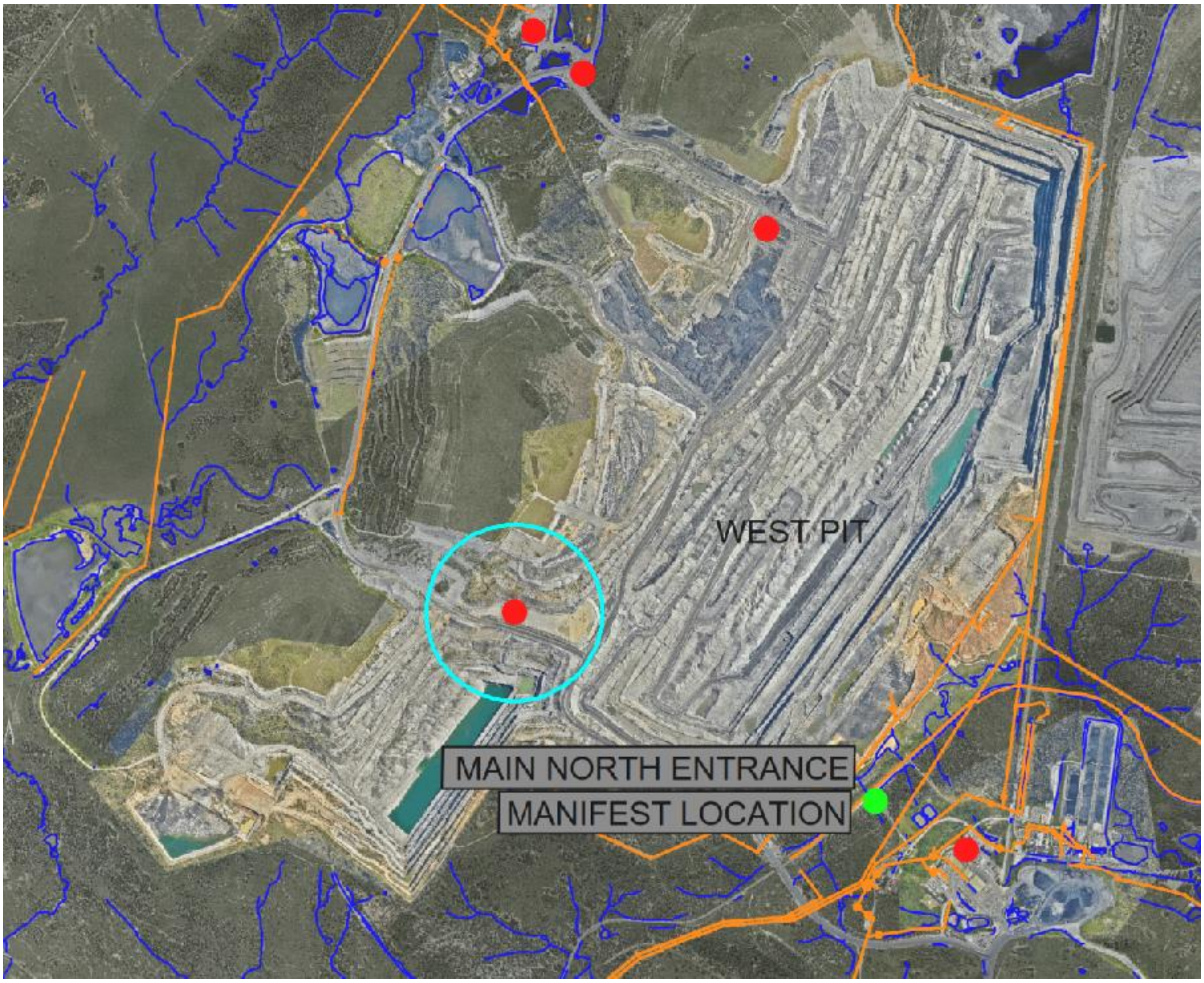


Figure 5-1: HVO North AN Explosion 7 kPa Overpressure Contours

5.3 HVO South ANE and Reload Facility AN Fire and Explosion

In the event the AN storage bins or ANE tanks at the HVO South ANE facility are impacted by a fire (such as a bushfire or vehicle fire) to the point that the AN decomposes, the bins/tanks may explode resulting in substantial overpressure impacts.

Table 5-3 shows the AN and derivatives to be stored within the area. For the purposes of this assessment, liquid solution of AN is being treated as ANE.

Table 5-3: AN & ANE Storage at HVO South Reload Facility

UN Number	Material	Storage location	Storage type	ADG code class/division	Packing group	Storage capacity
3375	Ammonium nitrate emulsion	South ANE Facility - ANE Tank 1	Above ground tank	5.1	II	70,000 kg
3375	Ammonium nitrate emulsion	South ANE Facility - ANE Tank 2	Above ground tank	5.1	II	70,000 kg
2426	Ammonium nitrate, liquid (hot	South ANE Facility - AN solution tanks 1-4	Above ground tank	5.1	II	80,000 L

UN Number	Material	Storage location	Storage type	ADG code class/division	Packing group	Storage capacity
	concentrated solution)					
1942	Ammonium nitrate	South ANE Facility - AN Transit Bin	Above ground tank	5.1	III	94,000 kg
1942 / 2067	Ammonium nitrate	South ANE Facility - AN Storage Stack	Open storage stack	5.1	III	100,000 kg
1942	Ammonium nitrate (Subject of MOD 8)	South ANE Facility - AN Storage Stack	Open storage stack	5.1	III	7,250,000 kg

The same methodology utilised in **Section 5.2** is again implemented here.

Table 5-4: HVO South NEQ

Store	Quantity (kg)	TNT Equivalence	NEQ (kg)
ANE Tank 1	70,000	0.8	56,000
ANE Tank 2	70,000	0.8	56,000
AN Liquid Tanks	80,000	0.8	64,000
AN Transit Bin	94,000	0.32	30,080
AN Storage Stack	100,000	0.32	32,000
29 x 250 t AN Storage Stacks	7,250,000	0.32	Single stack = 80,000

It is noted that the open stack storage of AN represents the largest quantity at the area, however this quantity (7,250 tonnes) will be distributed across 29 stacks, each will a maximum quantity of 250 tonnes, as shown in **Figure 3-3**. Detonation of a single stack will not result in sympathetic detonation of nearby stacks due to the separation distances provided per the requirements of the SAFEX Good Practice Guide (Ref. [20]).

Similarly, it is not anticipated that explosion of any single store will propagate to other areas. Therefore, the largest quantity expected to contribute to an explosion is 250 tonnes.

The separation distance required by Appendix B of the ANE Code, which is the same as Table 3.2.3.2 of AS 2187.1:1998 for an explosion of 250 tonnes from "Public Works Class A" (i.e. public roads) is 940 m. However, this distance can be reduced based on the provision of a warning and ability to evacuate. All AN related explosions come with warning given that the material is required to be heated for an extended period of time. Based on this, 50% of the Public Works Class B distance can be used. In this case, this is 50% of 1,400 = **700 m**.

The storage area is located at a distance greater than 700 m from the Protected Works Class A (i.e. sensitive receptors such as public streets) and so will not result in an "offsite" fatality. It is noted that these locations (Lemington Road & Gliding Club Air Strip) are within the site development consent due to the significant size of the site, however they are treated as the closest receptors for the purpose of this assessment. Therefore, this scenario has not been carried forward for further analysis.

It is noted that there is potential for the storage location to be relocated in the future based on mining progress at the site. In the event that the storage location of AN and ANE is changed, relevant assessment will be completed per the requirements of the Australian Standards, Regulations and Codes of Practice in order to ensure that separation distances and all other requirements are met.

The Effects consequence modelling software developed by Gexcon was used to validate the results and separation distances presented in the above Sections. **Figure 5-2** and the resulting data provided in Appendix B indicates that adequate separation distances are provided, and the methodology used based on the AESIG Code of Practice is accurate and more conservative than the required separation distances. The aqua coloured contours shown on **Figure 5-2** represent an overpressure value of 7 kPa.

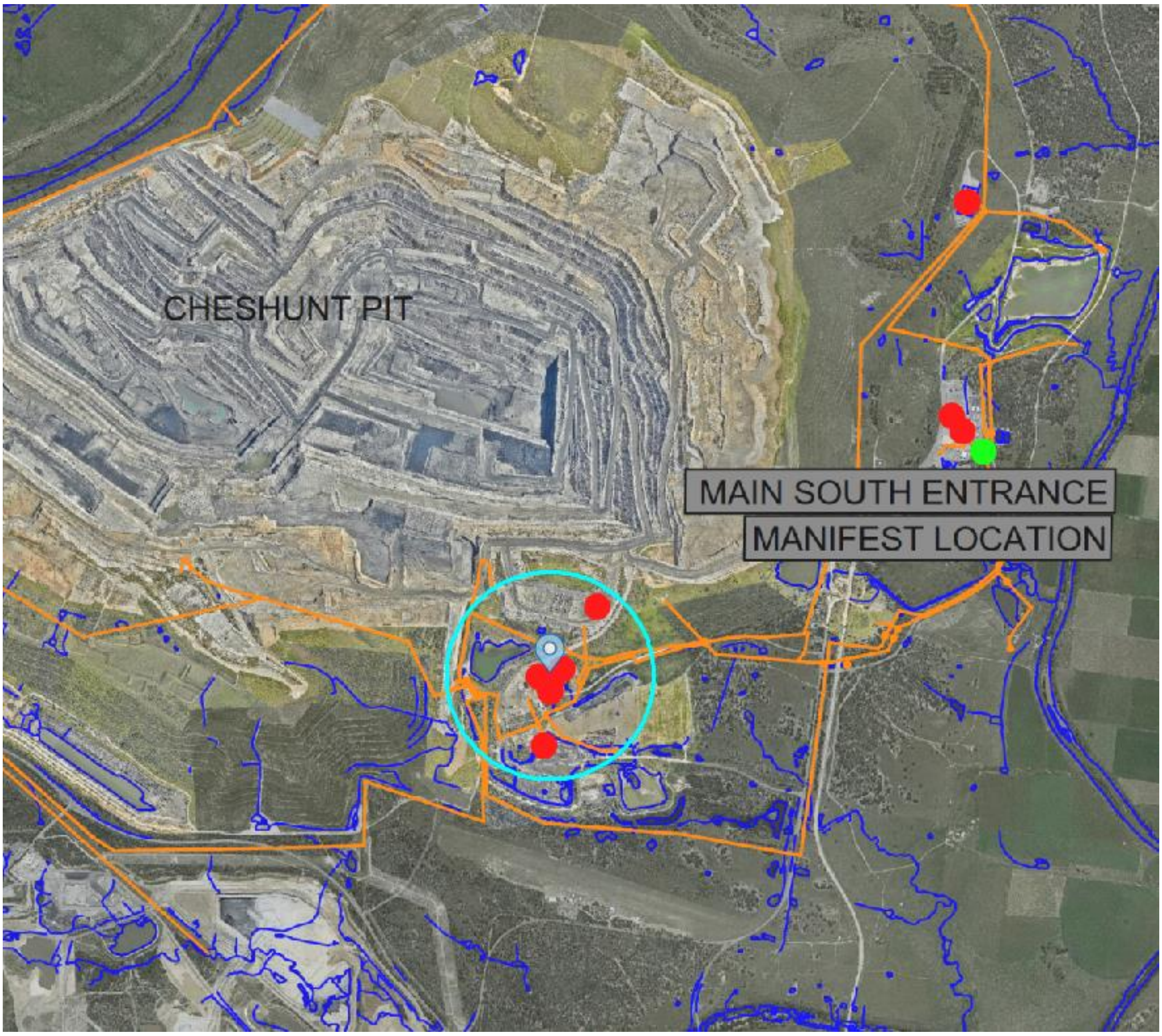


Figure 5-2: HVO South AN Explosion 7 kPa Overpressure Contours

6.0 Conclusion and Recommendations

6.1 Conclusions

A hazard identification table was developed for the Project to identify potential hazards that may be present at the site as a result of operations or storage of materials. Based on the identified hazards, scenarios were postulated that may result in an incident with the potential for offsite impacts. Postulated scenarios were discussed qualitatively and any scenarios that would not impact offsite were eliminated from further assessment. Scenarios not eliminated were then carried forward for consequence analysis.

Per the SEARs, the handling and storage of dangerous goods are assessed in this PHA. It is noted that nearby prescribed dams are assessed as required in the Blasting Impact Assessment (ESC 2022) prepared for the site. Similarly, bushfire risks (and other fire risks) are assessed in further detail in the Bushfire Management Plan.

HVO North

The consequence analysis identified that there would be no incidents originating from HVO North which would result in offsite impacts; hence, the potential for fatality or injury or environmental impacts to occur would be negligible. As the potential for offsite impacts is low to the point of negligibility, it is considered that the acceptable risk criteria published in HIPAP No. 4 (Ref. [1]) would not be exceeded and that the development would be appropriate for the proposed land use.

HVO South

The consequence analysis identified that there would be no incidents originating from HVO South which would result in offsite impacts; hence, the potential for fatality or injury or environmental impacts to occur would be negligible. As the potential for offsite impacts is low to the point of negligibility, it is considered that the acceptable risk criteria published in HIPAP No. 4 (Ref. [1]) would not be exceeded and that the development would be appropriate for the proposed land use.

6.2 Recommendations

Notwithstanding the conclusions following the analysis of the site, the following recommendations have been made:

- Necessary documentation associated with the storage of DGs under the Work Health and Safety Regulation 2011 shall be completed (i.e. risk assessment, register, notification, etc.).

7.0 References

[1] Department of Planning, "Hazardous Industry Planning Advisory Paper No. 4 - Risk Criteria for Land Use Safety Planning," Department of Planning, Sydney, 2011.

[2] Hunter Valley Operations, "Bushfire Management Plan," Hunter Valley Operations, Hunter Valley Region, 2020.

[3] Enviro Strata Consulting, "HVO Blasting Impact Assessment," EMM Pty Ltd, Hunter Valley Region, 2022.

[4] Department of Planning, "Hazardous Industry Planning Advisory Paper No. 6 - Guidelines for Hazard Analysis," Department of Planning, Sydney, 2011.

[5] SafeWork NSW, "Work Health and Safety Regulation," SafeWork NSW, Lisarow, 2017.

[6] Department of Planning, Multi-Level Risk Assessment, Sydney: Department of Planning, 2011.

[7] Hunter Valley Operations, "HVO Hazardous Substances and Dangerous Goods Procedure," Hunter Valley Operations, Hunter Valley Region, 2021.

[8] Umwelt, "HVO Mod 8 Report," Umwelt, Hunter Valley Region, 2022.

[9] National Transport Commission (NTC), "Australian Code for the Transport of Dangerous Goods by Road & Rail, 7th Edition," 2011.

[10] Standards Australia, AS 1940:2017 - Storage and Handling of Flammable and Combustible Liquids, Sydney: Standards Australia, 2017.

[11] Standards Australia, "AS 1692-2006 - Steel tanks for flammable and combustible liquids," Standards Australia, Sydney, 2006.

[12] Road Safety Council, The Australian Code for the Transport of Dangerous Goods by Road and Rail Edition 7.4, Canberra: Road Safety Council, 2016.

[13] NSW EPA, "HVO EPL 640," NSW EPA, Hunter Valley Region, 2022.

[14] Hunter Valley Operations, "HVO Pollution Incident Response Management Plan," Hunter Valley Operations, Hunter Valley Region, 2022.

[15] Australian Explosives Industry And Safety Group Inc., "Code of Practice: Storage and Handling of UN3375," Australian Explosives Industry And Safety Group Inc., Sydney, 2018.

[16] Australasian Explosives Industry Safety Group Inc., "Code of Practice: Storage and Handling of Solid Ammonium Nitrate," Australasian Explosives Industry Safety Group Inc., Sydney, 2022.

[17] Standards Australia, "AS 4326-2008 - Storage and Handling of Oxidising Agents," Standards Australia, Sydney, 2008.

[18] Standards Australia, "AS 2187.1-1998 Explosives - Storage," Standards Australia, Sydney, 1998.

[19] HVO Coal Assets Pty Ltd, "Process and Risk Report: Proposed Modular Ammonium Nitrate Emulsion (ANE) Manufacturing Facility," Hunter Valley Operations, Hunter Valley Region, 2021.

[20] SAFEX International Industry Working Group on Ammonium Nitrate, "SAFEX Good Practice Guide GPG 02: Storage of Solid Technical Grade Ammonium Nitrate," SAFEX International, Blonay, Switzerland, 2014.

[21] I. Cameron and R. Raman, Process Systems Risk Management, San Diego: Elsevier, 2005.

[22] F. P. Lees, Loss Prevention in the Process Industries, London: Butterworth-Heinemann, 2005.

Appendix A

Hazard Identification Table

A1. Hazard Identification Table

Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
AN Storage Bins	• Fire impinging on AN bin	• Ignition of AN and fire propagation • Decomposition of AN and explosion	• Organic matter (trees, grass, etc) separated from bin by several hundred metres to reduce potential for bushfires impacting storage • Trucks inspected prior to entering the bin area to avoid potential of hot brakes causing a fire • Bins separated from all other DGs and adjacent bins • First attack firefighting equipment present (fire extinguishers / water tanks) to combat any fire which may occur • No confinement of the bins to reduce explosion impacts
Diesel Tanks	• Tank failure • Hosing or hosing coupling failure during delivery • Flange, valve, or pump seal failures	• Release of combustible liquid and potential ignition and pool fire	• Regular maintenance and inspections prevent unidentified deterioration of equipment • Self-bunded tanks reduce potential for release to occur • Storage designed per the requirements of AS 1940-2017 (Ref. [10]) • Trained drivers delivering diesel / refilling vehicles • Hoses inspected regularly as part of ADG requirements for delivery of DG and combustible liquids • Combustible liquids have high flash points and are difficult to ignite • First attack firefighting equipment present (fire extinguishers / water tanks) to combat any fire which may occur
ANE Tanks	• Fire in adjacent storage areas	• Potential for heat exposure to result in ANE to heat to a point of explosion	• First attack firefighting equipment present (fire extinguishers / water tanks) to combat any fire which may occur • Separation provided between tanks
Delivery Truck Area	• Hot tanker elements (brakes or bearings)	• Potential for small truck fire, escalating into full truck fire directly impinging on AN prill	• Trucks inspected for signs of hot elements prior to entering the site (i.e. smoke, glowing elements, etc.)

Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
		contained within tanker and explosion • Ignition of flammable or combustible materials and fire near delivery area	• First attack firefighting equipment present (fire extinguishers / water tanks) to combat any fire which may occur • Trained operators (both truck drivers and plant operators)

Appendix B

Consequence Analysis

B1. Incidents Assessed in Detailed Consequence Analysis

The following incidents are assessed for consequence impacts.

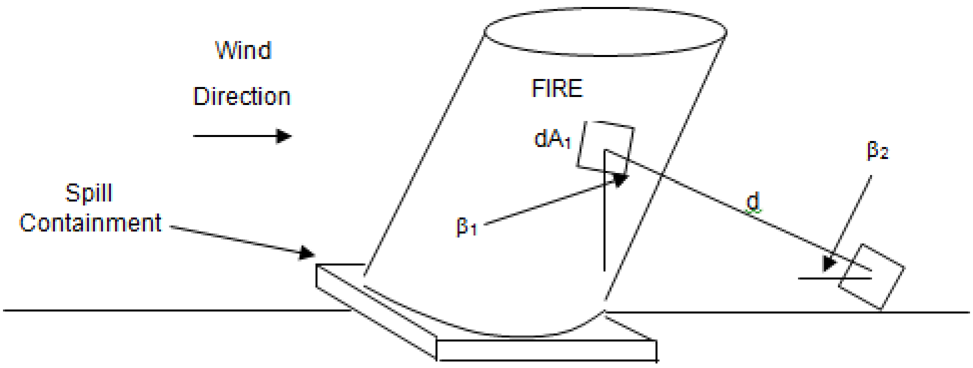
- HVO North ANE Reload area AN fire and explosion.
- HVO South AN fire and explosion.
- HVO South ANE Facility AN fire and explosion.

Each incident has been assessed in the sections below.

B2. Spreadsheet Calculator (SSC)

The SSC is designed on the basis of finite elements. The liquid flame area is calculated as if it is a circle to find the radius for input into the SSC model.

The SSC is designed on the basis of finite elements. The liquid flame area is calculated as if it is a circle to find the radius for input into the SSC model. **Appendix Figure B-1** shows a typical pool fire, indicating the target and fire impact details.



Appendix Figure B-1: Heat Radiation on a Target from a Cylindrical Flame

A fire in a bund or at a tank roof will act as a cylinder with the heat from the cylindrical flame radiating to the surrounding area. A number of mathematical models may be used for estimating the heat radiation impacts at various distances from the fire. The point source method is adequate for assessing impacts in the far field; however, a more effective approach is the view factor method, which uses the flame shape to determine the fraction of heat radiated from the flame to a target. The radiated heat is also reduced by the presence of water vapour and the amount of carbon dioxide in air. The formula for estimating the heat radiation impact at a set distance is shown in **Equation B-1** (Ref. [21]).

$$Q = EF\tau \quad \text{Equation B-1}$$

Where:

- Q = incident heat flux at the receiver (kW/m^2)
- E = surface emissive power of the flame (kW/m^2)
- F = view factor between the flame and the receiver
- τ = atmospheric transmissivity

The calculation of the view factor (F) in **Equation B-1** depends upon the shape of the flame and the location of the flame to the receiver. F is calculated using an integral over the surface of the flame, S (Ref. [21]). The formula can be shown as:

$$F = \int\int s \frac{\cos\beta_1 \cos\beta_2}{\pi d^2}$$ **Equation B-2**

Equation B-2 may be solved using the double integral **or** using a numerical integration method in spread sheet form. This is explained below.

For the assessment of pool fires, a Spread Sheet Calculator (SCC) has been developed, which is designed on the basis of finite elements. The liquid flame area is calculated as if the fire is a vertical cylinder, for which the flame diameter is estimated based on the fire characteristics (e.g. contained within a bund). Once the flame cylindrical diameter is estimated, it is input into the SSC model. The model then estimates the flame height, based on diameter, and develops a flame geometric shape (cylinder) on which is performed the finite element analysis to estimate the view factor of the flame. **Appendix Figure B-1** shows a typical pool fire, indicating the target and fire impact details.

The SSC integrates the element dA_1 by varying the angle theta θ (the angle from the centre of the circle to the element) from zero to 90^o in intervals of 2.5 degrees. Zero degrees represents the straight line joining the centre of the cylinder to the target (x0, x1, x2) while 90^o is the point at the extreme left-hand side of the fire base. In this way the fire surface is divided up into elements of the same angular displacement. Note the tangent to the circle in plan. This tangent lies at an angle, gamma, with the line joining the target to where the tangent touches the circle (x4). This angle varies from 90^o at the closest distance between the liquid flame (circle) and the target (x0) and gets progressively smaller as θ increases. As θ increases, the line x4 subtends an angle phi Φ with x0. By similar triangles we see that the angle gamma γ is equal to 90- θ - Φ . This angle is important because the sine of the angle give us the proportion of the projected area of the plane. When γ is 90^o, sin(γ) is 1.0, meaning that the projected area is 100% of the actual area.

Before the value of θ reaches 90^o the line x4 becomes tangential to the circle. The fire cannot be seen from the rear and negative values appear in the view factors to reflect this. The SSC filters out all negative contributions.

For the simple case, where the fire is of unit height, the view factor of an element is simply given by the expression in **Equation B-3** (Derived from **Equation B-2**):

$$VF = \Delta A \frac{\sin\gamma}{\pi \times X4 \times X4}$$ **Equation B-3**

Where ΔA is the area of an individual element at ground level.

Note: the denominator (π. x4. x4) is a term that describes the inverse square law for radiation assumed to be distributed evenly over the surface of a sphere.

Applying the above approach, we see the value of x4 increase as θ increase, and the value of sin(γ) decreases as θ increase. This means that the contribution of the radiation from the edge of the circular fire drops off quite suddenly compared to a view normal to the fire. Note that the SSC adds up the separate contributions of **Equation B-3** for values of θ between zero until x4 makes a tangent to the circle.

It is now necessary to do two things: (i) to regard the actual fire as occurring on top of a fire wall (store) and (ii) to calculate and sum all of the view factors over the surface of the fire from its base to its top. The overall height of the flame is divided into 10 equal segments. The same geometric technique is used. The value of x4 is used as the base of the triangle and the height of the flame, as the height. The hypotenuse is the distance from target to the face of the flame (called X4'). The angle of elevation to the element of the fire (alpha α) is the arctangent of the height over the ground distance. From the cos(α) we get the projected area for radiation. Thus there is a new combined distance and an overall equation becomes in **Equation B-4 ((**Derived from **Equation B-3**):

$$VF = \Delta A \frac{\sin\gamma \times \cos\alpha}{\pi \times X4 \times X4} \quad \textbf{Equation B-4}$$

The SCC now turns three dimensional. The vertical axis represents the variation in θ from 0 to 90^{o} representing half a projected circle. The horizontal axis represents increasing values of flame height in increments of 10%. The average of the extremes is used (e.g. if the fire were 10 m high then the first point would be the average of 0 and 1 i.e. 0.5 m), the next point would be 1.5 m and so on).

Thus, the surface of the flame is divided into 360 equal area increments per half cylinder making 720 increments for the whole cylinder. Some of these go negative as described above and are not counted because they are not visible. Negative values are removed automatically.

The sum is taken of the View Factors in **Equation B-3**. Actually, the sum is taken without the ∆A term. This sum is then multiplied by ∆A which is constant. The value is then multiplied by 2 to give both sides of the cylinder. This is now the integral of the incremental view factors. It is dimensionless so when we multiply by the emissivity at the "face" of the flame (or surface emissive power, SEP), which occurs at the same diameter as the fire base (pool), we get the radiation flux at the target.

The SEP is calculated using the work by Mudan & Croche (Ref. [22] & Ref. [21]) which uses a weighted value based on the luminous and non-luminous parts of the flame. The weighting is based on the diameter and uses the flame optical thickness ratio where the flame has a propensity to extinguish the radiation within the flame itself. The formula is shown in **Equation B-5**.

$$SEP = E_{max}e^{-sD} + E_s(1 - e^{-sD}) \quad \textbf{Equation B-5}$$

Where;

E_{max} = 140

S = 0.12

E_s = 20

D = pool diameter

The only input that is required is the diameter of the pool fire and then estimation for the SEP is produced for input into the SSC.

The flame height is estimated using the Thomas Correlation (Ref. [21]) which is shown in **Equation B-6**.

$$H = 42d_p\left[\frac{\dot{m}}{\rho_a\sqrt{gd_p}}\right]^{0.61}$$ **Equation B-6**

Where;

d_p = pool diameter (m)

ρ_a = density of air (1.2 kg/m^3 at 20^{o}C)

$\dot{m}$ = burning rate (kg/m^2.s)

g = 9.81 m/s^2

The transmissivity is estimated using **Equation B-7** (Ref. [21]).

$$\tau = 1.006 - 0.01171(\log_{10} X(H_2O) - 0.02368(\log_{10}X(H_2O))^2 - 0.03188(\log_{10} X(CO_2) + 0.001164(\log_{10}X(CO_2))^2$$ **Equation B-7**

Where:

- τ = Transmissivity (%)
- X(H_2O) = $\frac{R_H \times L \times S_{mm} \times 2.88651 \times 10^2}{T}$
- X(CO_2) = $\frac{L \times 273}{T}$

and

- R_H = Relative humidity (% expressed as a decimal)
- L = Distance to target (m)
- S_{mm} = saturated water vapour pressure in mm of mercury at temperature (at 25^{o}C S_{mm} = 23.756)
- T = Atmospheric temperature (K)

B3. Radiant Heat Physical Impacts

Appendix Table B-1 provides noteworthy heat radiation values and the corresponding physical effects of an observer exposed to these values (Ref. [1]).

Appendix Table B-1: Heat Radiation and Associated Physical Impacts

Heat Radiation (kW/m^2)	Impact
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of a fatality for people exposed instantaneously
23	• Likely fatality for extended exposure and chance of a fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved or failure would occur
12.6	• Significant chance of a fatality for extended exposure. High chance of injury

Heat Radiation (kW/m²)	Impact
	• Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
4.7	• Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second-degree burns will occur)
2.1	• Minimum to cause pain after 1 minute

B4. Overpressure

Appendix Table B-1 provides noteworthy overpressure values and the corresponding physical effects of an observer exposed to these values (Ref. [1]).

Appendix Table B-2: Overpressure and Associated Physical Impacts

Overpressure (kPa)	Impact
70	• Threshold of lung damage • 100% chance of fatality for a person in a building or in the open • Complete demolition of houses
35	• House uninhabitable • Wagons and plant items overturned • Threshold of eardrum damage • 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open
21	• Reinforced structures distort • Storage tanks fail • 20% chance of fatality to a person in a building
14	• House uninhabitable and badly cracked
7	• Damage to internal partitions and joinery but can be repaired • Probability of injury is 10%. No fatality
3.5	• 90% glass breakage • No fatality and very low probability of injury

To estimate the explosion overpressure, the TNT equivalent method is used by Gexcon Effects. This method equates the quantity of AN involved in the explosion to an equivalent quantity of TNT using **Equation B-8**.

$$W_{TNT} = \alpha W \quad \textbf{Equation B-8}$$

The other parameters required in this equation are:

- W_{TNT} Equivalent weight of TNT (kg)
- W Mass of fuel (kg)
- α Explosion efficiency

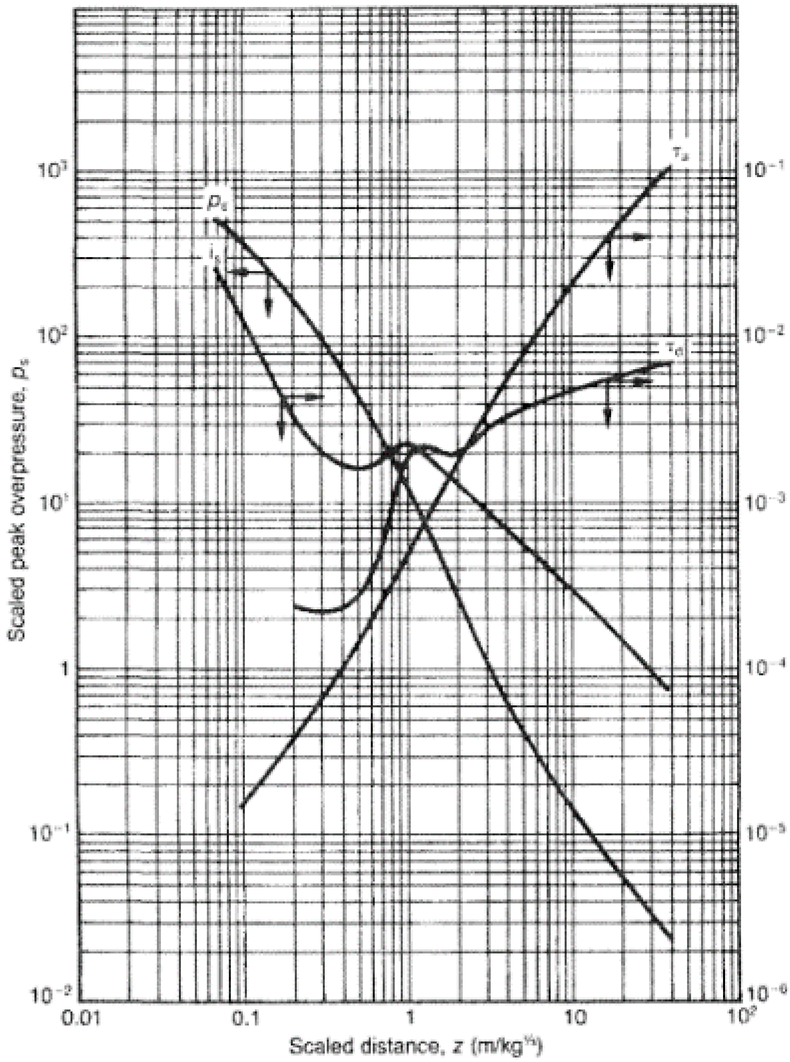
Overpressure is now calculated using a scaled distance curve, based on actual distance from the blast and the TNT equivalent, this is given in **Equation B-9**.

$$Z = \frac{R}{(W_{TNT})^{\frac{1}{3}}}$$ **Equation B-9**

Where:

- Z Scaled distance (unitless)
- R Distance from the blast (m)
- W_{TNT} Equivalent weight of TNT (kg)

Appendix Figure B-2 shows the scaled distances and pressures which is used to determine the impact distance at a specific overpressure.



Appendix Figure B-2: Scaled Parameter plots for TNT Explosions (Ref. [21])

B5. HVO North ANE Reload Area (West Pit) AN Fire and Explosion

If the HVO North ANE Reload Area (West Pit) is impacted by an external heat source such as an equipment or tyre fire it may result in sufficient heating to decompose the AN resulting in an explosion. To estimate the overpressure impacts from an AN explosion it is necessary to first estimate the equivalent weight of TNT. Gexcon Effects has been utilised to conduct this assessment and analysis and reported values are shown below.

Model: TNT Equivalency Model

version: v2022.11.274fa32 (8/11/2022)
Reference: Yellow Book 3rd edition (1997) Chapter 5, figure 5.6, (TNT blast correlation model). Kingery and Bulmash, Airblast parameters from TNT spherical air burst and hemisperical surface burst, ARBRL-TR-0255, 1984

Parameters
Inputs
Calculation Method

Type of TNT model	Based upon mass
TNT equivalency factor (-)	0.1
Source Definition	
TNT mass (kg)	2.74E05
Offset between release and explosion centre (m)	0
Meteo Definition	
Predefined wind direction	W
Vulnerability	
Pressure lethality based on	Treshold pressure level
Peak pressure total destruction (Indoors+Outdoors) (mbar)	300
Lethality total destruction (Indoors+Outdoors) (-)	1
Peak pressure indoors (glass) lethality (mbar)	100
Lethality indoors (glass) (-)	0.025
Reporting	
Distance from release centre (m)	250

Results
Explosion Results

Peak overpressure at Xd (mbar)	193.76
Pressure impulse at Xd (Pa*s)	1117.7
Positive phase duration at Xd (ms)	135.58
Equivalent TNT mass (kg)	27400
Maximum peak overpressure (bar)	6.6712
Confined mass in flammable range (kg)	2.74E05
Dist. centre mass of confined expl. cloud to study point (m)	250
Damage (general description) at Xd	Moderate damage (Zone C: 17 - 35 kPa).
Damage to brick houses at Xd	Not habitable without major repair works. Partial roof failures, 25% of all brick walls have failed, serious damage to the remaining carrying elements. Damage to windowframes and doors (7-15 kPa).
Damage to typical American-style houses at Xd	Moderate to minor damage. Deformed walls and doors; failure of joints. Doors and window frames have failed. Wall covering has fallen down (15 kPa).
Damage to structures (empirical) at Xd	Walls made of concrete blocks have collapsed (15-20). Minor damage to steel frames (8-10 kPa). Connections between steel or aluminium ondulated plates have failed 7-14 kPa). The roof of a storage tank has collapsed (7 kPa).
Damage to windows (houses before 1975) at Xd (%)	100
Damage to windows (houses after 1975) at Xd (%)	99.966

Appendix Figure B-3: HVO North ANE Reload Area Explosion Effects Results

Provided in **Appendix Table B-3** is a summary of the impact distance for each of the overpressures of interest.

Appendix Table B-3: Overpressure from a HVO North ANE Reload Area Explosion

Overpressure (kPa)	Distance (m)
70	116
35	171
21	237
14	315

Overpressure (kPa)	Distance (m)
7	540

B6. HVO South ANE Facility AN Fire and Explosion

If the HVO South ANE Facility is impacted by an external heat source such as a grass fire it may result in sufficient heating to decompose the AN resulting in an explosion. To estimate the overpressure impacts from an AN explosion it is necessary to first estimate the equivalent weight of TNT. Gexcon Effects has been utilised to conduct this assessment and analysis and reported values are shown below.

Model: TNT Equivalency Model

Model: TNT Equivalency Model

version: v2022.11.274fa32 (8/11/2022)
Reference: Yellow Book 3rd edition (1997) Chapter 5, figure 5.6, (TNT blast correlation model). Kingery and Bulmash, Airblast parameters from TNT spherical air burst and hemisperical surface burst, ARBRL-TR-0255, 1984

Parameters
Inputs

Calculation Method	
Type of TNT model	Based upon mass
TNT equivalency factor (-)	0.1
Source Definition	
TNT mass (kg)	3.44E05
Offset between release and explosion centre (m)	0
Meteo Definition	
Predefined wind direction	W
Vulnerability	
Pressure lethality based on	Treshold pressure level
Peak pressure total destruction (Indoors+Outdoors) (mbar)	300
Lethality total destruction (Indoors+Outdoors) (-)	1
Peak pressure indoors (glass) lethality (mbar)	100
Lethality indoors (glass) (-)	0.025
Reporting	
Distance from release centre (m)	250

Results

Explosion Results	
Peak overpressure at Xd (mbar)	216.56
Pressure impulse at Xd (Pa*s)	1295.2
Positive phase duration at Xd (ms)	142.73
Equivalent TNT mass (kg)	34400
Maximum peak overpressure (bar)	6.6712
Confined mass in flammable range (kg)	3.44E05
Dist. centre mass of confined expl. cloud to study point (m)	250
Damage (general description) at Xd	Moderate damage (Zone C: 17 - 35 kPa).
Damage to brick houses at Xd	Not habitable without major repair works. Partial roof failures, 25% of all brick walls have failed, serious damage to the remaining carrying elements. Damage to windowframes and doors (7-15 kPa).
Damage to typical American-style houses at Xd	Moderate to minor damage. Deformed walls and doors; failure of joints. Doors and window frames have failed. Wall covering has fallen down (15 kPa).
Damage to structures (empirical) at Xd	Collapse of steel frames and displacement of foundation (20 kPa). Industrial steel self-framing structure collapsed (20-30 kPa). Cracking in empty oil-storage tanks (20-30 kPa). Slight deformation of a pipe-bridge (20-30 kPa). Large trees have fallen down (20-40 kPa). Walls made of concrete blocks have collapsed (15-20). Minor damage to steel frames (8-10 kPa). Connections between steel or aluminium ondulated plates have failed 7-14 kPa). The roof of a storage tank has collapsed (7 kPa).
Damage to windows (houses before 1975) at Xd (%)	100
Damage to windows (houses after 1975) at Xd (%)	100

Appendix Figure B-4: HVO South ANE Facility Explosion Effects Results

Provided in **Appendix Table B-7** is a summary of the impact distance for each of the overpressures of interest.

Appendix Table B-7: Overpressure from HVO South ANE Facility Explosion

Overpressure (kPa)	Distance (m)
70	125
35	184
21	255
14	340
7	583