APPENDIX 23
Preliminary Hazard Analysis

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MANGOOLA
OPEN CUT
GLENCORE

PRELIMINARY HAZARD ANALYSIS

Mangoola Coal Continued Operations Project

FINAL

April 2019

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Mangoola Coal Continued Operations Project

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Mangoola Coal Operations Pty Limited

Project Director:	John Merrell
Project Manager:	Daniel Sullivan
Technical Director:	Tim Procter
Technical Manager:	Chris Bonomini
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umwelt
Environmental & Social Consultants

Newcastle

75 York Street
Teralba NSW 2284

T| 1300 793 267
E| info@umwelt.com.au

www.umwelt.com.au

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Executive Summary

Mangoola Coal Mine is an open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW. Mangoola Coal Operations Pty Limited (Mangoola) has operated the Mangoola Coal Mine in accordance with Project Approval (PA) 06_0014 since mining commenced at the site in September 2010.

Following exploration within Mangoola's Assessment Lease (AL) 9, Mangoola has identified further coal resources to the north of Wybong Road. Mangoola proposes to seek approval to extract these further coal resources by continuing the existing Mangoola Coal Mine into this area which is located to the immediate north of the existing mine. The Mangoola Coal Continued Operations (MCCO) Project represents approximately eight years of additional mining and would provide access to approximately 52 Million tonnes (Mt) of additional coal resources.

As a result of the MCCO Project the storage locations for a range of hazardous materials may change. The potential impacts to off-site land users as a result of the relocation of these hazardous material storages was assessed in accordance with NSW Hazardous Industry Planning and Assessment Guidelines (NSW Department of Planning (DoP) 2011).

The risk screening and classification process, undertaken in accordance with State Environmental Planning Policy 33 – Hazardous and Offensive Development (SEPP 33), indicated the storage quantities of ammonium nitrate (AN) and ammonium nitrate emulsion (ANE) exceed the screening threshold for Class 5.1 materials. The MCCO Project is therefore considered potentially hazardous and a preliminary hazard analysis (PHA) is required.

An assessment of the MCCO Project in accordance with the process detailed in the guideline Multi-level Risk Assessment (NSW DoP 2011a), found that the risks associated with the storage of hazardous materials for the MCCO Project to the surrounding land users are tolerable with appropriate minimum buffers distances in place and therefore a Level 1 Qualitative assessment was required for the PHA. Worst case consequence scenarios were considered in this assessment process.

The two primary hazards identified by the Level 1 Qualitative assessment were an explosion involving a store of Class 1.1 explosive materials and a fire incident involving the store of AN/ANE resulting in a toxic release of nitrogen dioxide. A hazard identification process and qualitative risk assessment identified a range of technical and non-technical controls that Mangoola Coal will put in place to minimise the risk of incidents that could result in off-site impacts.

Results of the risk screening and classification process undertaken demonstrated that if the Class 1.1 explosives Magazine is located at least 500 metres from off-site land users then no off-site impacts would result from any explosion incident involving the maximum storage inventory of Class 1.1 materials. The risk screening and classification process undertaken has also shown that if the AN/ANE storage is located at least 1000 metres from off-site land users then no off-site impacts would result from any fire incident resulting in a toxic release involving the maximum storage inventory of AN/ANE.

The MCCO Project design will maintain the above mentioned separation distances between hazardous materials storages and off-site land users and therefore no off-site impacts associated with the storage and handling of hazardous materials at the MCCO Project are predicted.

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1.0 Introduction

Mangoola Coal Operations Pty Limited (Mangoola) has engaged Umwelt (Australia) Pty Limited (Umwelt) to complete a Preliminary Hazard Analysis (PHA) for the Mangoola Coal Continued Operations Project (MCCO Project). The purpose of the assessment is to form part of an Environmental Impact Statement being prepared by Umwelt to accompany an application for development consent under Division 4.1 and 4.7 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the MCCO Project.

1.1 Project Overview

Mangoola Coal Mine is an open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW (refer **Figure 1.1**). Mangoola has operated the Mangoola Coal Mine in accordance with Project Approval (PA) 06_0014 since mining commenced at the site in September 2010.

The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations. The MCCO Project will extend the life of the existing operation providing for ongoing employment opportunities for the existing Mangoola workforce. The MCCO Project Area includes the existing approved Project Area for Mangoola Coal Mine and the MCCO Additional Project Area as shown on **Figure 1.1**.

The MCCO Project generally comprises:

- open cut mining peaking at up to the same rate as that currently approved (13.5 Million tonnes per annum (Mtpa) of run of mine (ROM) coal) using truck and excavator mining methods
- continued operations within the existing Mangoola Coal Mine
- mining operations in a new mining area located north of the existing Mangoola Coal Mine, Wybong Road, south of Ridgelands Road and east of the 500 kV Electricity Transmission Line (ETL)
- construction of a haul road overpass over Big Flat Creek and Wybong Road to provide access from the existing mine to the proposed Additional Mining Area
- establishment of an out-of-pit overburden emplacement area
- distribution of overburden between the proposed Additional Mining Area and the existing mine in order to optimise the final landform design of the integrated operation
- realignment of a portion of Wybong Post Office Road
- the use of all existing or approved infrastructure and equipment for the Mangoola Coal Mine with some minor additions to the existing mobile equipment fleet
- construction of a water management system to manage sediment laden water runoff, divert clean water catchment, provide flood protection from Big Flat Creek and provide for reticulation of mine water. The water management system will be connected to that of the existing mine
- continued ability to discharge excess water in accordance with the Hunter River Salinity Trading Scheme (HRSTS)

- establishment of a final landform in line with current design standards at Mangoola Coal Mine including use of natural landform design principles consistent with the existing site

- rehabilitation of the proposed Additional Mining Area using the same revegetation techniques as at the existing mine

- a likely construction workforce of approximately 145 persons. No change to the existing approved operational workforce

- continued use of the mine access for the existing operational mine and access to/from Wybong Road, Wybong Post Office Road and Ridgelands Road to the MCCO Project Area for construction, emergency services, ongoing operational environmental monitoring and property maintenance.

Figure 1.2 illustrates the key features of the MCCO Project.

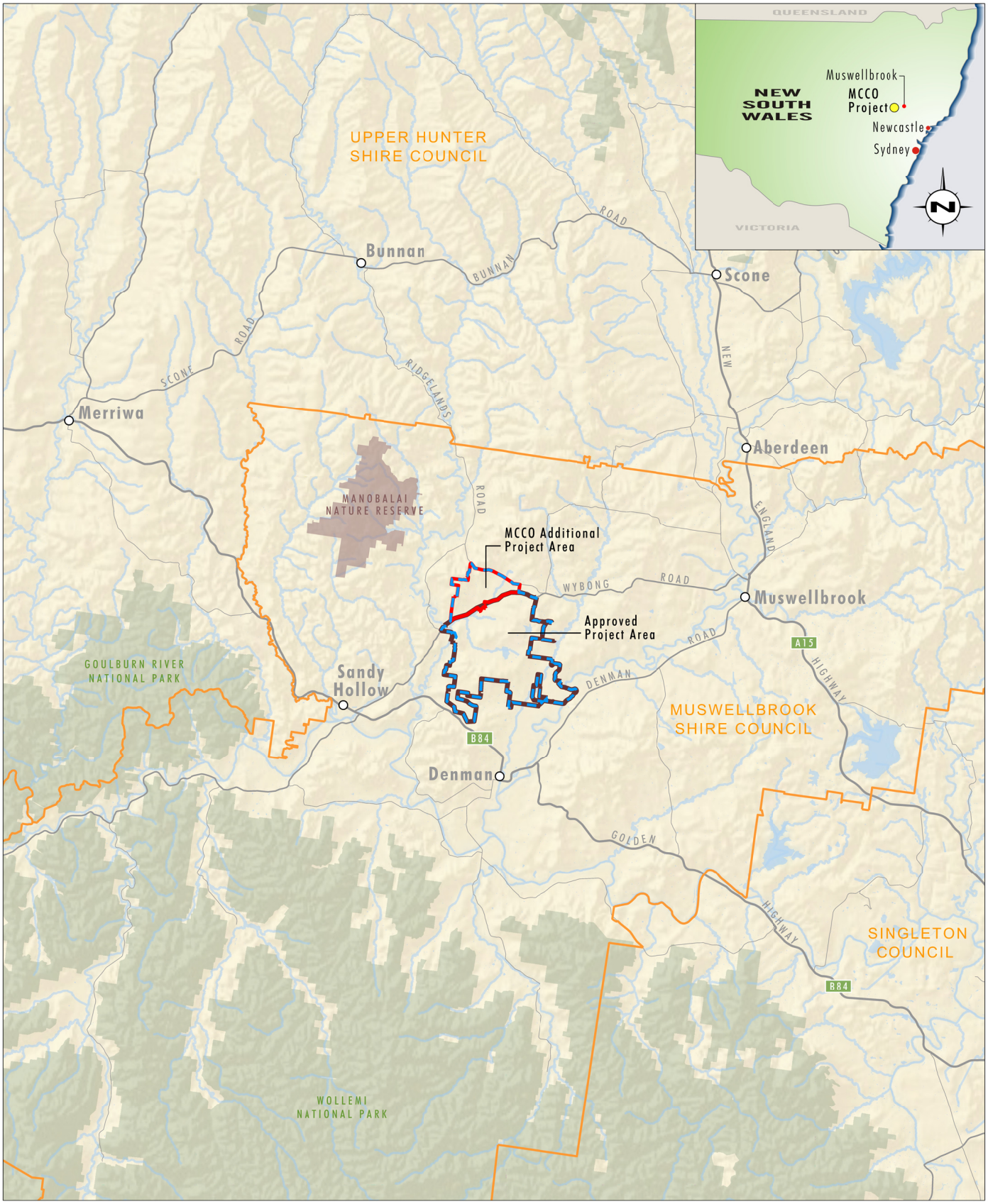
As a result of the MCCO Project the storage locations for a range of hazardous materials, including explosives and explosive pre-cursors, may change. As mining operations are dynamic, as part of the MCCO Project, Mangoola will require the flexibility to move the explosives storage facilities over the life of the operation to suit business needs and the exact storage locations have not been determined at this stage of the project design. The MCCO Project will be designed such that these storage locations are located to maintain appropriate separation distances between on-site hazardous materials storages and off-site land users to minimise as far as practicable, the risk of off-site impacts. It should be noted that the types and quantities of hazardous materials to be stored on site after MCCO Project implementation will be consistent with the types and quantities of hazardous materials currently stored on site (refer to **Section 2.0**).

1.2 Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements (SEARs) for the MCCO Project were issued by NSW Department of Planning and Environment (DPE) on 15 February 2019 (replacing a previous version of the SEARs issued on 22 August 2017) and identify the specific requirements to be addressed by the EIS for the project. The SEARs included the following requirement with respect to hazards:

Hazards – including an assessment of the likely risks to public safety, paying particular attention to potential bushfire risks, blasting impacts and the handling and use of any dangerous goods

This Preliminary Hazard Analysis (PHA) addresses the potential risk to public safety associated with the storage and handling of hazardous materials and dangerous goods, including explosives and explosive pre-cursors, at the MCCO Project. Separate assessments have been prepared to address the likely risks to public safety associated with bushfires and blasting impacts.



Data Source: Glencore (2019), LPI (2016)

0 5 10 20km

Legend

- MCCO Project Area
- Approved Project Area
- MCCO Additional Project Area
- Local Government Area

FIGURE 1.1

Regional Locality Plan

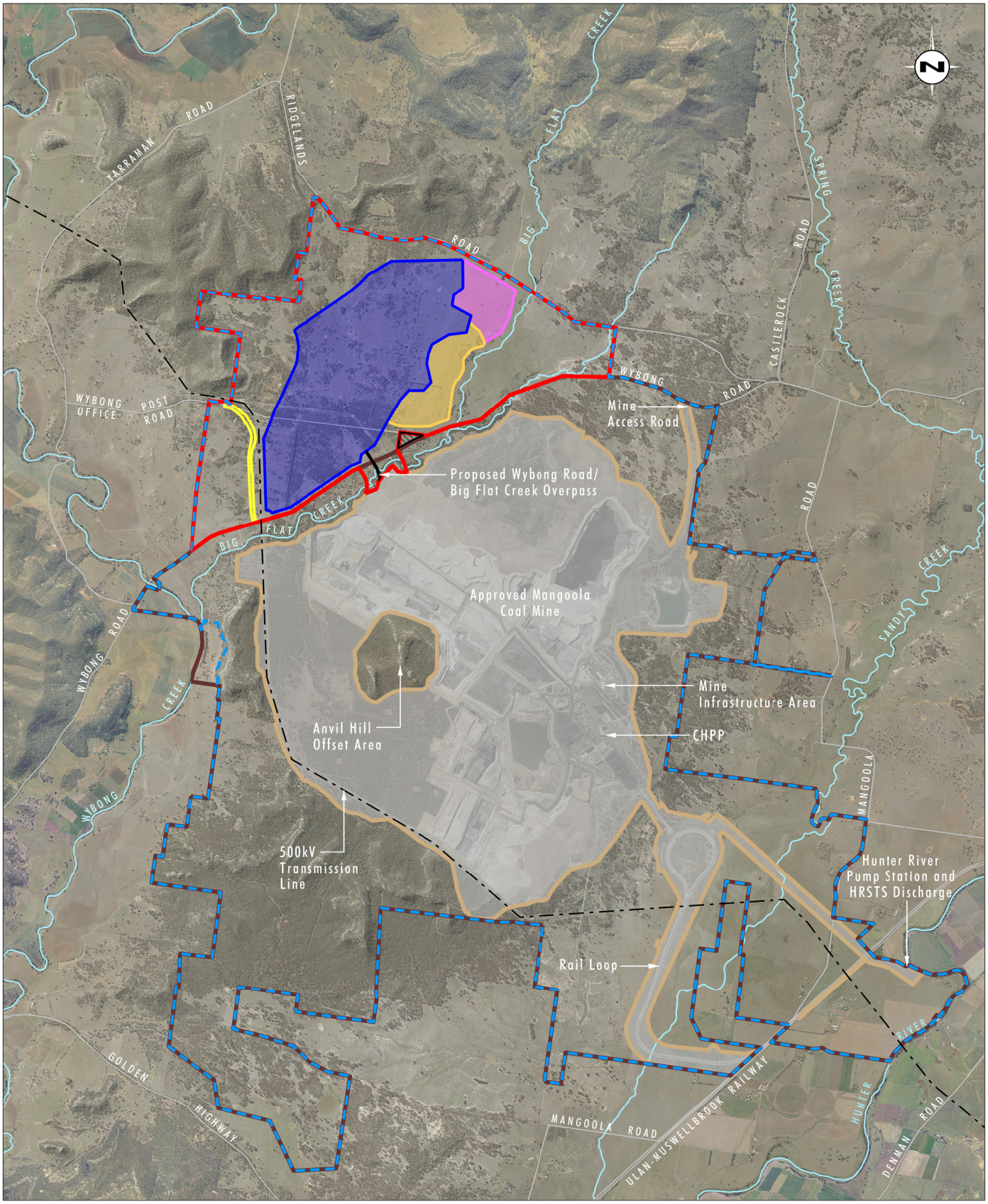


Image Source: Glencore (April 2018)
Data Source: Glencore (2019)

0 1.0 2.0 3.0 km

Legend

- MCCO Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Proposed Additional Mining Area
- Proposed Emplacement Area
- Proposed Topsoil Stockpile Area
- Wybong Post Office Road Realignment
- Crown Land (TSR) Excluded from MCCO Project Area

FIGURE 1.2

Key Features of the Mangoola Coal Continued Operations Project

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2.0 Preliminary Hazard Analysis

Under *State Environment Planning Policy 33 – Hazardous and Offensive Development* (SEPP 33), a preliminary risk screening of a proposed development is required to determine the need for a PHA. The preliminary screening involves identification and assessment of the storage of specific dangerous goods classes that have the potential for significant off-site effects. If, at the proposed location, and in the presence of controls, the risk level exceeds the acceptable criteria for impacts on the surrounding land use, the development is classified as 'hazardous' or 'offensive' industry and may not be permissible within most land use zones in NSW.

A 'hazardous industry' under SEPP 33 is one which, when all locational, technical, operational and organisational safeguards are employed continues to pose a significant risk. An 'offensive industry' is one which, even when controls are used, has emissions which result in a significant level of offence e.g. odour or noise emissions. Separate air quality and noise assessments have been completed for the MCCO Project to address potentially offensive impacts and as a result are not discussed further within this report. A proposal cannot be considered either hazardous or offensive until it is firstly identified as 'potentially hazardous' or 'potentially offensive' and subjected to the assessment requirements of SEPP 33. A PHA is required if a proposed development is 'potentially hazardous'.

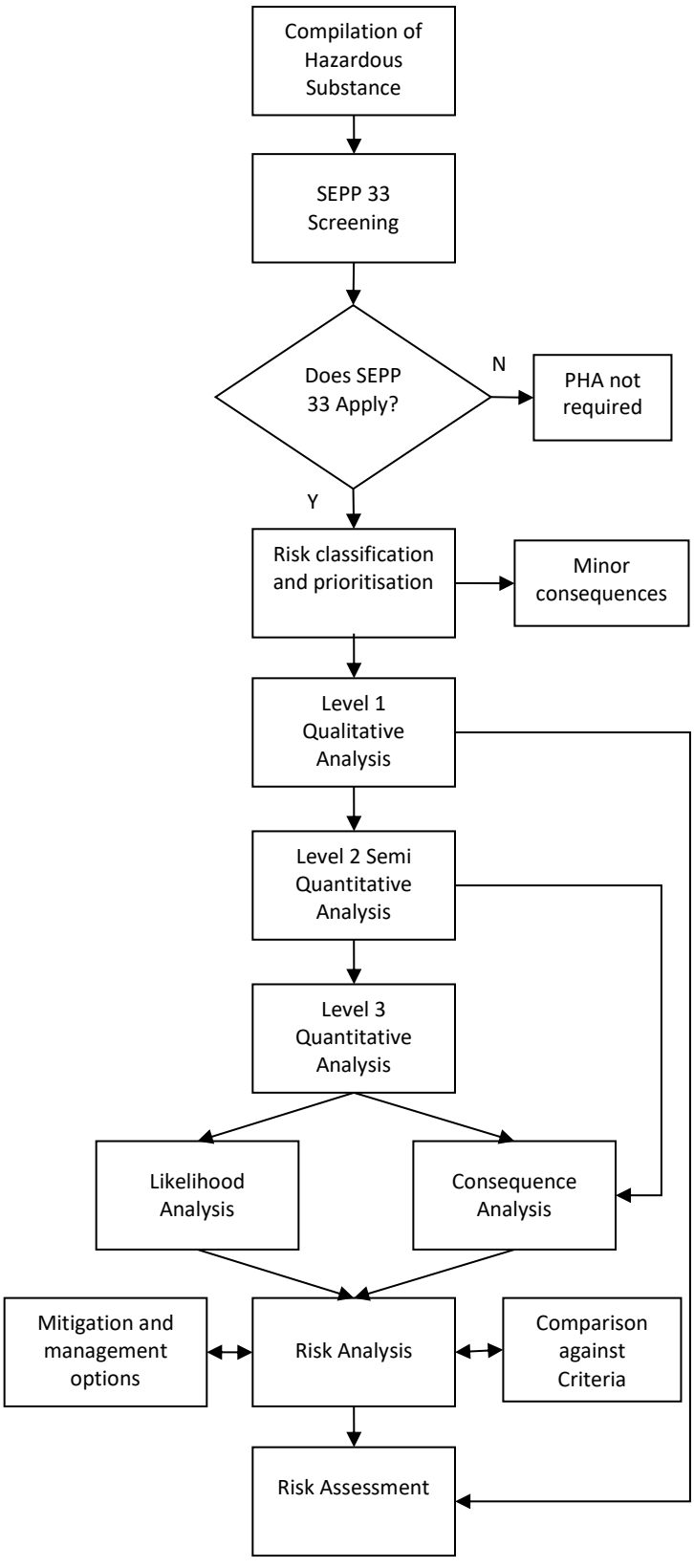
A proposed development may also be 'potentially hazardous' if the number of traffic movements for the transport of hazardous materials exceeds the annual or weekly criteria outlined in Table 2 of *Applying SEPP 33* (DoP 2011b). If these thresholds are exceeded a route evaluation study is likely to be required.

Hazardous Industry Planning Advisory Paper (HIPAP) *No. 6 – Guidelines for Hazard Analysis* (DoP 2011f) and *Multi-level Risk Assessment* (DoP 2011a) notes that a PHA should identify and assess all hazards that have the potential for off-site impact. The expectation is that the hazards would be analysed to determine the consequence to people, property and the environment and the potential for hazards to occur.

An assessment of potential hazards and risk associated with the MCCO Project was conducted with reference to the relevant DPE hazardous industry planning guidelines. The purpose of the assessment was to:

- establish the expected change in storage, handling and transport of dangerous goods associated with the MCCO Project
- identify potential hazard events that could lead to off-site impacts associated with the change in storage, handling and transport of dangerous goods
- determine limitations with regards to storage quantities, on-site locations and traffic movements for dangerous goods to minimise the possibility that the proposed design and subsequent operations could lead to off-site impacts exceeding DPE land use criteria.

The methodology used to identify and assess the hazards and respective failure scenarios that have the potential for off-site impact is outlined in **Figure 2.1**. The details of how this methodology is implemented are discussed in the respective sections of this report.



SEPP 33 Screening involves compiling information on the quantity of hazardous materials used, the mode of storage and location with respect to off-site land users and the number and size of annual and weekly road movements of the hazardous material.

A proposed development should be considered potentially hazardous if the storage or transport of hazardous substances exceeds the respective screening thresholds.

Risk classification and prioritisation involves ranking of the facility using techniques to make broad estimates of the consequence and likelihood of accidents. The output is expressed in terms of individual and societal risk and is compared against respective criteria.

A Level 1 analysis is a qualitative assessment based on detailed hazard identification. The objective is to demonstrate that the activity does not pose a significant risk. Where the qualitative analysis cannot satisfactorily demonstrate there will be no significant risk, further analysis is required.

A Level 2 analysis supplements the Level 1 analysis by quantifying the main risk contributors to show that their consequences are acceptable.

A Level 3 quantitative analysis is required when the screening and hazard identification process and/or risk classification and prioritisation process has identified risk contributors with consequences beyond the site boundaries. The analysis requires a comprehensive quantification of significant consequences and their likelihood.

The Risk Assessment compares the results of the risk analysis with the respective risk criteria. Where the level of risk is not acceptable, risk minimisation, mitigation and management options need to be investigated.

Figure 2.1 Overview of PHA Methodology

2.1 Preliminary Risk Screening

Preliminary risk screening is undertaken to determine the requirement for a PHA. SEPP 33 contains a number of assessment criteria for the storage quantities of hazardous material that have the potential to create off-site impacts.

2.2 Storage Quantity Screening

Table 2.1 contains an inventory of hazardous materials presently stored and used at the Mangoola Coal Mine that may be relocated as part of the MCCO Project. **Table 2.1** also contains the SEPP 33 screening criteria. It should be noted that the types and quantities of hazardous materials to be stored on site after MCCO Project implementation will be consistent with the types and quantities of hazardous materials currently stored on site; that is, the maximum hazardous materials storage inventories will not increase as a result of the MCCO Project. **Figure 2.2** shows the current hazardous materials storage locations, however, the storage locations of the majority of these hazardous materials may change as a result of the MCCO Project.

Storage quantities for the Class 2.1 flammable gases (liquefied petroleum gas and aerosols), Class 3 flammable liquids and Class 8 corrosive substances do not exceed the screening thresholds (refer to **Table 2.1**). SEPP 33 does not define screening thresholds for diesel (combustible C1). As with the present Fuel Farm arrangement, all combustible liquids will be stored in accordance with *AS1940 – 2017 The storage and handling of flammable and combustible liquids* (AS1940) with adequate separation distances from Class 3 flammable liquids. As such the diesel may be assessed as a Class C1 combustible liquid and is therefore not subject to SEPP 33 screening.

As mining operations are dynamic, as part of the MCCO Project, Mangoola will require the flexibility to move the explosives storage facilities over the life of the operation to suit business needs. Therefore, the assessment of potential hazard associated with these storage facilities, should they be relocated, has been based on maintaining suitable separation distances from off-site land users. The required separation distance to off-site land users from a quantity of Class 1.1 explosives to ensure no intolerable off-site overpressure impacts is determined using *Figure 5: Class 1.1 Explosives* (Applying SEPP 33, NSW DoP, 2011b).

While the primary classification of the AN and ANE is as an oxidising agent, this material may explode under certain conditions such as heating in confinement and high impacts. The existing stores of ammonium nitrate (AN) and ammonium nitrate emulsion (ANE) (within the Orica Compound) and the Magazine are adequately separated to prevent sympathetic initiation should one store explode when assessed against the Australian Explosives Industry and Safety Group (AEISG) code (January 2015) for storage of UN3375 (ANE).

Should the magazine be relocated it will be adequately separated from the AN/ANE store and therefore the net explosive quantity (NEQ) to be considered for screening purposes is 41 tonnes. For 41 tonnes of Class 1.1 explosive (refer to **Table 2.1**) the separation distance to all off site receptors required to ensure screening thresholds are not triggered is 500 metres.

Conservatively assuming a 100% trinitrotoluene (TNT) equivalence for ANE and 32% TNT equivalence for AN (SAFEX International, *Good Practise Guide: Storage of Solid Technical Grade Ammonium Nitrate*, 2011) the NEQ to be considered for screening purposes of AN/ANE as a Class 1.1 explosive is 100 tonnes. The separation distance for a 100 tonne Class 1.1 store to off-site land users required to ensure screening thresholds are not triggered is 650 metres.

Mangoola has committed to store all materials in accordance with appropriate buffer distances, as discussed in further detail in **Section 4.0**.

If the storages were to be located closer to off-site land users than indicated above, further analysis would need to be conducted to determine whether the level of risk to off-site receptors is tolerable, however, this is not proposed.

Notwithstanding the above, the storage quantity of ANE exceeds the screening threshold for Class 5.1 materials and the MCCO Project is therefore considered potentially hazardous and a PHA is required to accompany the Development Application.

2.3 Transport Screening

As the MCCO Project is not increasing above the currently approved ROM coal production levels of up to 13.5 Mtpa the transport frequencies and quantities of hazardous materials to the Mangoola Coal site for the MCCO Project will remain at the same levels associated with the present mining operations. Therefore, no changes are proposed, and no further assessment is required.

Table 2.1 MCCO Hazardous Materials Inventory

Material	Storage Location	Storage Type	ADG Code[1] Class/Division (PG)	Existing and MCCO Project Storage Capacity	SEPP 33 Screening Threshold	Trigger SEPP 33
Ammonium Nitrate Emulsion	Orica Compound	Above ground tank	5.1	80 T	5 T	Yes
Ammonium Nitrate	Orica Compound	Bulk	5.1	60 T	5 T	Yes
Diesel	Orica Compound	Above ground tank	C1	60,000 L	-[2]	NA
Detonators, boosters, lead line	Magazine	Mounded magazine	1.1B	41 T	Dependent on distance to site boundary.	
Diesel additive	Fuel Farm	Drums	8 (II)	450 L	25, 000 kg	No
Diesel	Fuel Farm	Above ground tanks	C1	712kL	-[2]	No
LPG	Contractor Yard	Cylinders	2.1	100 L	16,000 L	No
Paints, insect repellent etc.	Contractor Yard	Aerosols	2.1	<100 kg	100 kg	No
Paints, solvents etc.	Contractor Yard	Packages	3 (II)	<500 kg	5 T	No
Adhesives and hardeners	Contractor Yard	Packages	8 (III)	<100 kg	50,000 kg	No
General Purpose Cleaner	Maintenance	Drums	8 (II)	450 L	25, 000 kg	No
Adhesives and hardeners	Maintenance	Packages	8 (III)	<100 kg	50,000 kg	No
Paints, insect repellent etc.	CHPP	Aerosols	2.1	<100 kg	100 kg	No
Paints, solvents etc.	CHPP	Packages	3 (II)	<500 kg	5 T	No
LPG	Main Store	Cylinders	2.1	600 L	16,000 L	No
Paints, insect repellent etc.	Main Store	Aerosols	2.1	<100 kg	100 kg	No
Paints, solvents etc.	Main Store	Packages	3 (II)	<500 kg	5 T	No
LPG	Main Building	Above ground tank	2.1	7,500 L	16,000 L	No
Paints, insect repellent etc.	Main Building	Aerosols	2.1	<100 kg	100 kg	No
Paints, solvents etc.	Main Building	Packages	3 (II)	<500 kg	5 T	No

1. ADG Code – Australian Dangerous Goods Code
2. No SEPP 33 quantity screening thresholds for these materials

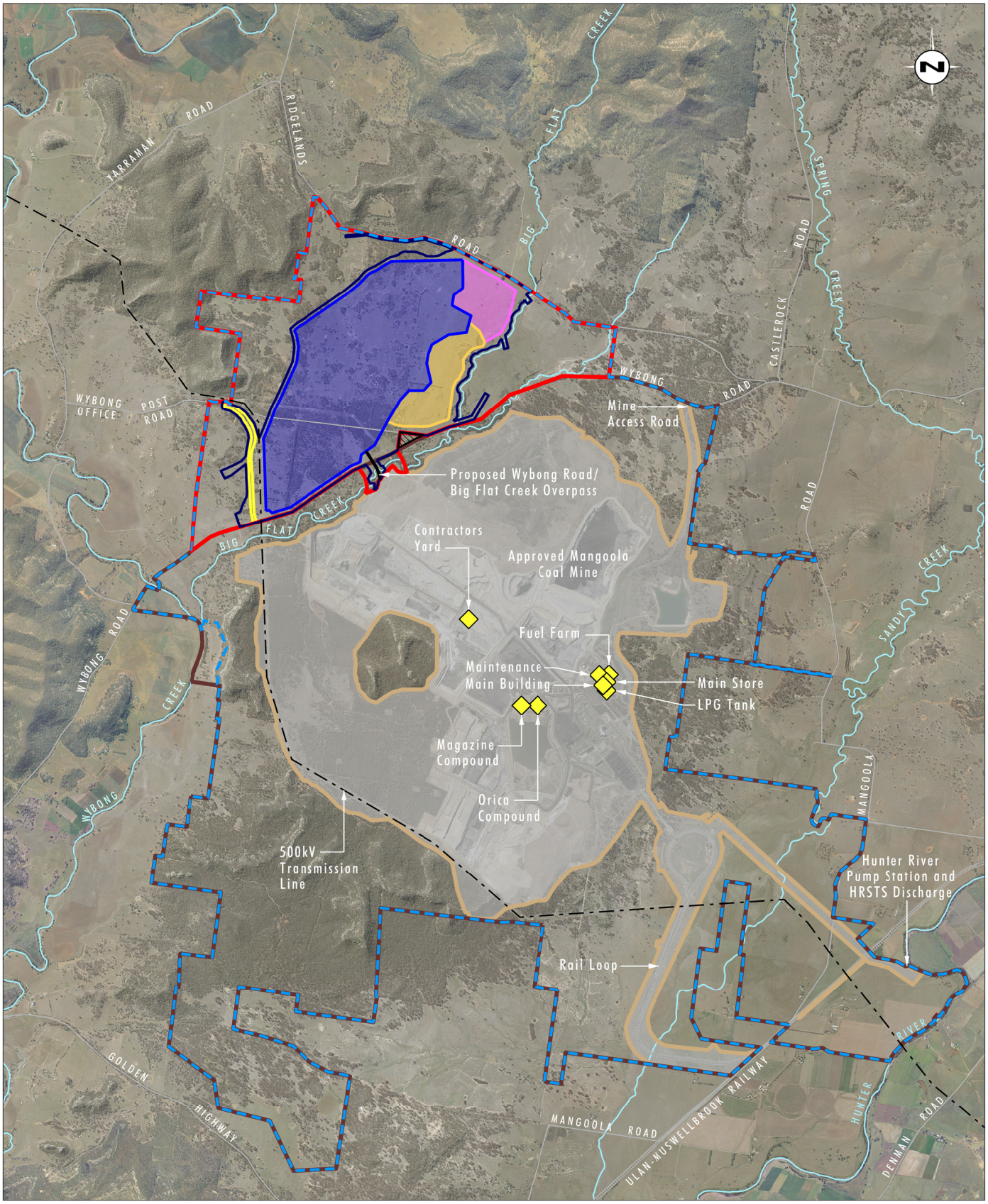


Image Source: Glencore (April 2018)
Data Source: Glencore (2019)

0 1.0 2.0 3.0 km

Legend

- MCCO Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Footprint
- Proposed Additional Mining Area
- Proposed Emplacement Area
- Proposed Topsoil Stockpile Area
- Wybong Post Office Road Realignment
- Crown Land (TSR) Excluded from MCCO Project Area
- Hazardous Materials Storage Location

FIGURE 2.2

Existing Hazardous Materials Storage Locations

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3.0 Risk Classification and Prioritisation

Multi-level Risk Assessment (MLRA) (DoP 2011a) suggests the use of a preliminary analysis of the risks related to a proposed development to enable the selection of the most appropriate level of risk analysis in the PHA. This preliminary analysis includes risk classification and prioritisation using a technique adapted from the *Manual for Classification of Risk due to Major Accidents in Process and Related Industries (Manual for Classification of Risk)* (International Atomic Energy Agency – IAEA – 1993). A complete description of the technique is presented in the MLRA (DoP 2011a). The technique is based on a general assessment of the consequences and likelihoods of accidents and their risks to individuals and society, and the comparison of these risks to relevant criteria to determine the level of assessment required, be it qualitative or quantitative.

3.1 Methodology

The objective of the risk classification and prioritisation process is to identify whether the risks identified as part of the SEPP 33 preliminary screening process pose acceptable risks or whether further assessment is required. The assessment involves the following steps:

- classification of the type of activities and materials inventories
- estimation of consequences
- estimation of probabilities of major accidents for fixed installations
- estimation of societal risk
- estimation of individual risk
- evaluation of alternatives
- assessment using criteria to determine required level of risk assessment.

For each potentially hazardous activity information is required regarding the location, type, production and storage condition of the activity, as well as name, physical state and amount of hazardous substances involved. Table II of the *Manual for Classification of Risk* (IAEA 1993) provides a guideline of required information.

If a facility has effective physical isolation and separation between the storage vessels with the same dangerous goods classification, then the content of the largest storage vessel would typically be used to estimate the effect of an incident.

When selecting the activities likely to have the potential to cause risk/damage, the following should be considered:

- if more than one substance in the same activity can cause damage independently from the other substances, analyse them separately
- if a group of substances may act together, consider them as a single (equivalent) substance

- if a flammable substance is also toxic, both effects have to be accounted for. After following the methodology within MLRA (DoP 2011a) it will be clear whether flammable properties are important or not, compared with toxic properties.

3.2 Estimation of Consequences

Consequences of an accident depend on the type of substance, activity and the quantity involved, as well as the population exposed to its effect.

The external consequences ($C_{a,s}$) of major accidents to humans are calculated using equation (1) of IAEA (1993):

$$C_{a,s} = A \times d \times f_a \times f_m$$

where:

- $C_{a,s}$ = external consequences (fatalities per accident) where the subscript 'a' represents an activity and subscript 's' represents a hazardous substance
- A = affected area (hectares; 1 ha = 10^4 m^2)
- d = population density in defined populated areas (persons/ha)
- f_a = correction factor for populated area
- f_m = correction factor for mitigation effects.

Alternatively, if the population (N) within the affected area is known, the consequence can be estimated as follows:

$$C_{a,s} = N \times f_m$$

In accordance with the *Manual for Classification of Risk* (IAEA 1993) this calculation was undertaken for all relevant hazardous substances and activities.

The only items triggering SEPP 33 thresholds (refer **Table 2.1**) was the storage of Class 5.1 AN and ANE. The two primary hazards associated with AN and ANE are explosion and nitrogen dioxide (NO_2) generation. While AN and ANE's primary classification is not as an explosive, under certain conditions it may detonate. However, the consequence contours associated with an explosion of AN and ANE are much smaller than those associated with a toxic release resulting from external heating of AN and ANE. As such the separation distance from off-site land users associated with the storage of AN and ANE will be governed by the toxic release scenario rather than the explosion hazard scenario.

Upon exposure to excessive heat AN and ANE can generate toxic NO_2 gas. It should also be noted that Mangoola has a range of controls in place to minimise the possibility that the AN and ANE is exposed to excessive heating. For the purpose of this assessment, a toxic gas inventory of 20 tonnes of NO_2 has been used to assess the potential impacts associated with a NO_2 generation from excessive heating of the ANE. Although the maximum inventory of AN and ANE is 140 tonnes, the mass yield of NO_2 from AN/ANE is estimated to be approximately 11% (refer to **Appendix 1** for calculations). This yield has been calculated based on experimental mass loss rates and gas generation rates when AN has been exposed to external heating (UK Health and Safety Executive, *Ammonium Nitrate: Toxic Fume Risk From Fires in Storage*, Atkinson, G. and Adams, W.D., 2002).

3.3 Estimation of Probabilities of Major Accidents for Fixed Installations

The probability number ($N_{i,s}$) of major accidents to humans is calculated using equation (2) of *Manual for Classification of Risk* (IAEA 1993):

$$N_{i,s} = N^*_{i,s} + n, + n_f + n_0 + n_p$$

where:
- $N^*_{i,s}$ = the average probability number for the installation and the substance;
- n, = probability number correction parameter for the frequency of loading/unloading operations;
- n_f = probability number correction parameter for the safety systems associated with flammable substances;
- n_0 = probability number correction parameter for the organisational and management safety;
- n_p = probability number correction parameter for wind direction towards the populated area.

In accordance with the *Manual for Classification of Risk* (IAEA 1993) this calculation was undertaken for all relevant hazardous substances and activities, the results of these calculations are provided in **Section 3.5**.

This probability number was then converted into a probability $P_{i,s}$ by means of Table XIV of *Manual for Classification of Risk* (IAEA 1993) or directly, using the relationship between N and P which is defined as:

$$N = \log10 (P)$$

$P_{i,s}$ defines the frequency (number of accidents per year) of accidents involving a hazardous substance (subscript 's') for each hazardous fixed installation (subscript 'i'), which causes the consequences that have been estimated previously.

The probabilities of major accidents at the facility during an explosion or toxic release event are summarised in **Appendix 1**.

The correction parameter n_0 accounts for factors including the development's safety management, age of the plant, maintenance, documentation and procedures, safety culture, training and emergency planning. For assessment purposes, this factor was given a value of zero to represent average industry practice to provide a conservative estimate of the impact of the site's safety and management procedures on any major accidents. This is a conservative assessment approach and is in no way intended to reflect on safety performance at the site.

3.4 Criteria for Multi Level Risk Assessment

The method of determining the assessment criteria recommended by DPE is outlined in Figure A1.3 of the MLRA (DoP 2011a). This figure shows the three criteria regions. Below the lower criterion line the risk would be considered negligible. Above the upper criterion line the risk would be considered intolerable. The region between the two criteria lines is considered to be tolerable depending on the results of an evaluation of other risk criteria.

These criteria are used to determine the level of assessment required by the PHA as follows:

- Level 1 assessment – can be justified if the analysis of the facility demonstrates the societal risk is negligible and there are no potential accidents with significant off-site consequences.
- Level 2 assessment – can be justified if the societal risk estimates fall within the middle region i.e. between the upper and lower criteria lines and the frequency of risk contributors having off-site consequences is relatively low. The assessment must demonstrate that the facility will comply, at least in principle, with the DPE risk criteria, based on broad quantification of the risk.

- Level 3 assessment – is required if the societal risk estimates are in the intolerable zone, or where there are significant off-site risk contributors and a level 2 assessment fails to demonstrate that risk criteria will be met.

According to Section 3.1 of MLRA (DoP 2011a), quantification of the risk must be undertaken on any component identified in the risk classification and prioritisation process which has off-site consequences of greater than or equal to 1 at a frequency greater than 1 x 10^{-7} per year. **Section 3.6** presents the ranking and prioritisation results and the required level of risk assessment for the MCCO Project.

A summary of the estimation of consequences and probabilities of a toxic release resulting from the heating of AN and ANE and the detonation of the explosives stores (the aggregate of open cut and underground storage quantities) is attached at **Appendix 1**.

3.5 Estimation of Societal Risk

The risk to the public from each potentially hazardous activity is estimated by combining the estimated consequences to humans and the probabilities of major accidents.

Using the results of the assessments undertaken in **Section 4.2**, the activities are classified and grouped according to *Manual for Classification of Risk* (IAEA 1993). The details of the scenarios modelled are outlined in **Table 3.1**.

Table 3.1 Dangerous Goods Scenarios Modelled for Societal Risk

Descriptor	Substance	ADG Class	Activity	Hazardous Event	Description
S1	AN/ANE	5.1	Storage	Toxic gas release	External heating of AN/ANE resulting in release of NO_2
S2	Explosives	1.1	Storage	Explosion	Detonation of entire Magazine inventory
S3	AN/ANE	5.1	Storage	Explosion	External heating of AN/ANE resulting in explosion

3.6 Rank and Prioritise the Results

Figure 3.1 shows the cumulative risk associated with the toxic release and explosion hazards listed in **Table 3.1** relative to the societal risk criteria. A cumulative risk plotted in the Intolerable region is considered undesirable regardless of whether individual risk criteria are met. Cumulative risk plotted in the Negligible region is not considered significant while the focus for cumulative risk plotted within the As Low As Reasonably Possible (ALARP) region is on reducing risks as far as possible. Cumulative risk within the ALARP region is considered tolerable provided other quantitative and qualitative criteria of HIPAP 4 *Risk Criteria for Land Use Safety Planning* (HIPAP 4) are met. The end point of the cumulative risk curve for the MCCO Project hazards (refer to **Table 3.1**) is within the ALARP region which indicates that a Level 2 semi-quantitative risk assessment is required to demonstrate that HIPAP 4 criteria can be met for the MCCO Project. However, if off-site impacts associated with the toxic gas release scenario were eliminated by increasing the separation distance to off-site land users the cumulative risk curve endpoint would be in the negligible region of the societal risk plot (refer to **Figure 3.2**).

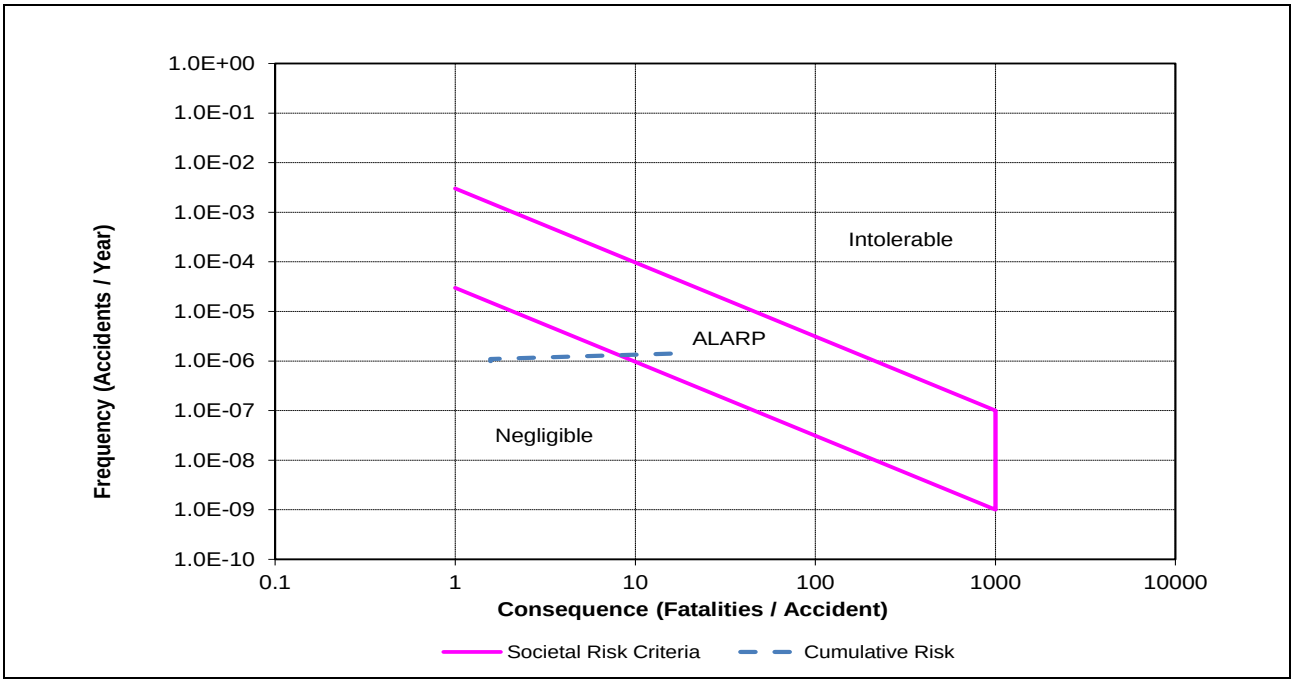


Figure 3.1 Societal Risk Plot Including Toxic Release Scenario

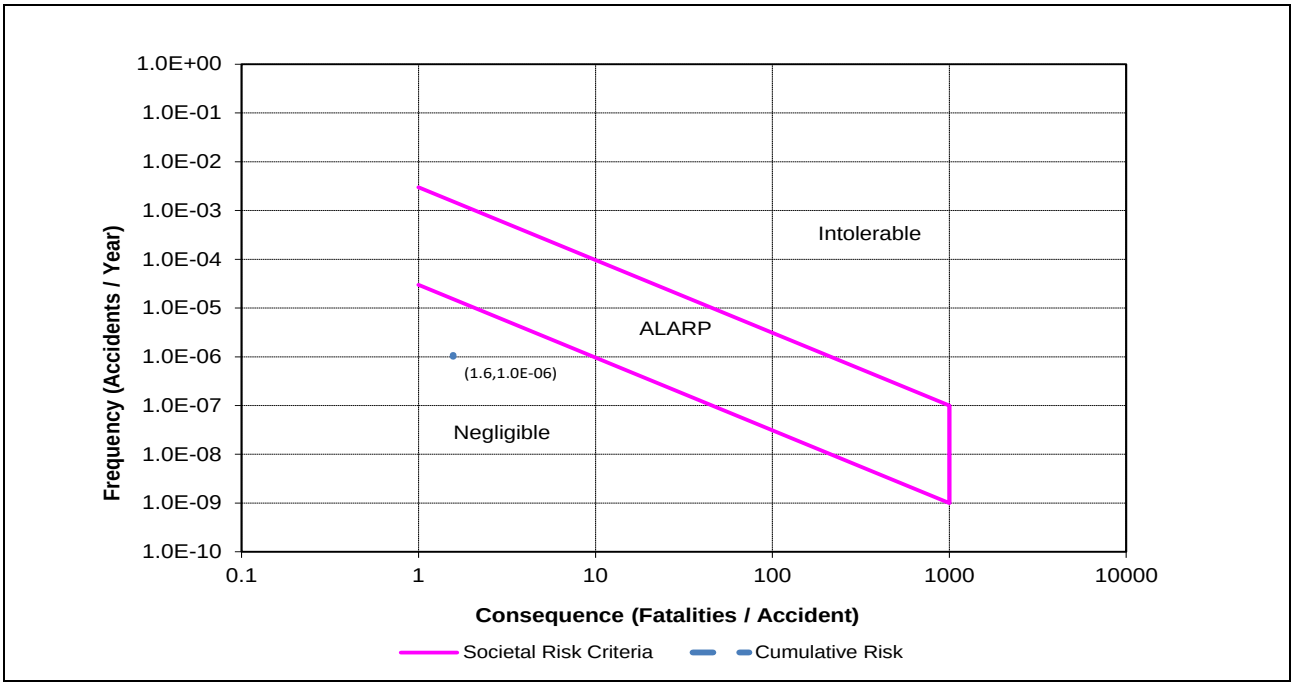


Figure 3.2 Societal Risk Plot Excluding Toxic Release Scenario

The maximum effect distance associated with the toxic gas release scenario in *IAEA Table III: Effect Categories: Maximum Distance and Area of Effect* is 1,000 metres (refer to **Appendix 1**). If required to be relocated, Mangoola will locate the AN/ANE store such that a buffer of at least 1,000 meters continues to be maintained between the AN/ANE store and off-site receptors. As such a Level 1 Qualitative risk assessment is considered to be the appropriate assessment method for the MCCO Project under DPE guidelines.

4.0 Level 1 Qualitative Risk Assessment

A Level 1 assessment is associated with a qualitative analysis that uses words and descriptive scales to determine the risk of each of the hazard scenarios identified in **Section 3.5**. This risk is then assessed against qualitative criteria to determine whether the facility could cause an accident of a magnitude significant in terms of risk to people or property, or harm to the biophysical environment.

Low and acceptable risks can be allowed with minimal further treatment, however, if the risks are significant a higher level of analysis is required.

4.1 Methodology

A Level 1 assessment requires (as a minimum):

- hazard identification using word diagrams, simplified fault/event trees and checklists
- generalised consequence analysis of key risk contributors to demonstrate that their consequences are confined within the MCCO Project boundaries. This analysis should incorporate the results of the preliminary screening and risk classification and prioritisation assessments
- evaluation of the risks against the qualitative criteria in HIPAP No. 4 Risk Criteria for Land Use Safety Planning (DoP 2011e)
- demonstration of adequacy of the proposed technical and management controls to ensure ongoing safety of the proposed development
- should include all facilities which reported exceedances of initial screening thresholds.

4.2 Level 1 Risk Criteria

The risk criteria from Australian Standard *AS 4360:2004 – Risk Management* was used for this Level 1 assessment. The risk criteria for consequence severity, frequency estimation and risk matrix are provided in **Appendix 2**.

4.3 Hazard Identification

4.3.1 Hazardous Materials

A brief summary of the properties of the hazardous materials associated with the MCCO Project is provided below. Although risk screening (refer to **Section 2.2**) has shown that LPG and diesel do not trigger screening thresholds, these materials have also been included in the Level 1 assessment to ensure all credible hazardous events are considered.

Explosives

An explosive material is a reactive substance that contains a large amount of potential energy that when released produces an explosion resulting in the release of light, heat and pressure. The explosives stored at Mangoola are Class 1.1 and Class 1.4, include detonators and boosters and are stored in the Magazine (refer to **Table 2.1**). Class 1.1 explosives are considered to be a mass explosion hazard where almost all of the material is affected instantaneously. Class 1.4 explosives are considered a minor explosion hazard with the explosion largely confined to the package and no projection of fragments of appreciable size or range.

Ammonium Nitrate and Ammonium Nitrate Emulsion

Solid AN and ANE are a Class 5.1 oxidising agent and will support combustion of other materials as it 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. **Table 4.1** contains the one hour duration acute exposure guidelines for NO_2. Only NO_2 release has been assessed as it is considered to be the most toxic of the products of combustion.

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.

Table 4.1 One Hour Duration NO2 Acute Exposure Guidelines

Criteria	Concentration (ppm)	Definition
AEGL-1	0.5	Is the airborne concentration above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling, and are transient and reversible upon cessation of exposure.
AEGL-2	12	Is the airborne concentration above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
AEGL-3	20	Is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Source: Acute Exposure Guideline Levels for Nitrogen Dioxide, NAC for AEGL's, 2008.

Liquefied Petroleum Gas (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 per cent v/v to 9.5 per cent v/v) 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.

Diesel

Diesel is a combustible liquid which means that it has the potential to produce flammable vapours, which are able to be ignited. As a combustible liquid, diesel is not a hazardous substance unless stored in association with Class 3 flammable liquids. Mangoola maintains adequate separation distances in accordance with AS1940 between the Mangoola Mine bulk combustible liquids storages and flammable liquids storages. The MCCO Project will maintain adequate separation distances between bulk combustible liquids storages and flammable liquids storages.

4.4 Hazard Study Results

The two primary hazards identified associated with the MCCO Project were the explosion of Class 1.1 materials and the potential for nitrogen dioxide release from AN and ANE when exposed to a significant source of heat such as fire. **Appendix 2** contains the hazard identification worksheets.

The qualitative risks for each of these hazards have been assigned conservatively assuming the storage may be close to the site boundary and/or off-site land users. For this reason the risks for toxic release and explosion have a high ranking. **Table 4.2** shows the required separation distances from off-site land users to ensure no off-site impacts. Mangoola has committed to design any future storage facilities to satisfy these buffer requirements.

Table 4.2 Separation Distances

Storage	Hazard	Distance to Off-Site Receptors
Magazine	Explosion	500 [1]
AN/ANE	Toxic release	1,000 [2]

Note 1: Based on *Applying SEPP 33* Figure 5 – Class 1.1 Explosives Overpressure Effects.

Note 2: Based on *Multi-level Risk Assessment* IAEA Table III – Effect Categories – Maximum Distance and Area of Effect.

Mangoola will locate the explosives and AN/ANE storage to maintain the separation distances from off-site land users set out in **Table 4.2**. Should, for currently unforeseen circumstances, the explosives and/or AN/ANE need to be stored closer to off-site land users than shown in **Table 4.2** the potential for off-site impacts would need to be further assessed. **Figure 4.1** presents the areas within the MCCO Project Area that are offset 500 metres and 1,000 metres from any off-site land users including public roads.

It is important to note that even if the storage locations are closer to off-site land users than shown in **Table 4.2** it does not mean the development is hazardous, just that further assessment would be required.

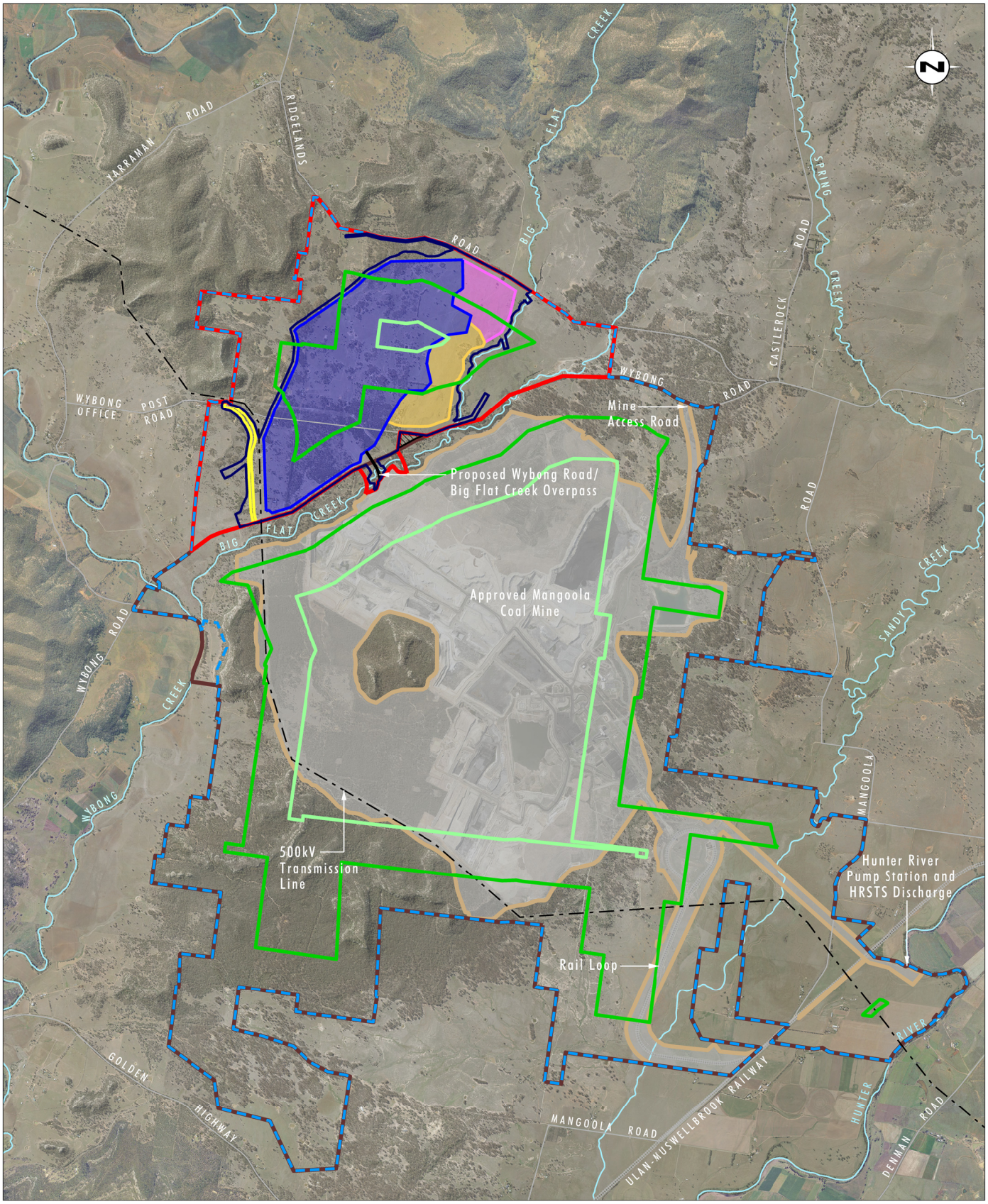


Image Source: Glencore (April 2018)
Data Source: Glencore (2019)

0 1.0 2.0 3.0 km

Legend

- MCCO Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Footprint
- Proposed Additional Mining Area
- Proposed Emplacement Area
- Proposed Topsoil Stockpile Area
- Wybong Post Office Road Realignment
- Crown Land (TSR) Excluded from MCCO Project Area
- Area Offset by 500m from Boundaries
- Area Offset by 1000m from Boundaries

FIGURE 4.1

Areas Suitable for Hazardous Materials Storage

File Name (A4): R16/4004_190.dgn
20190327 12.17

5.0 Risk Management

The control of risks is a continuous process where strategies are put into place to eliminate risks wherever possible, mitigate the residual risks identified using appropriate control measures, safeguards and procedures, and, lastly, accept the residual risk and manage the impacts should the hazardous event occur. The risk control strategies and their effectiveness are broadly described as:

- engineering control to either completely eliminate the risk (100 per cent effectiveness) or to implement physical controls and safeguards (minimum 90 per cent effectiveness)
- administrative control based around procedures (maximum 50 per cent effectiveness)
- personnel control using training and the control of work methods (maximum 30 per cent effectiveness).

The qualitative risk assessment identified a range of technical control measures and non-technical safeguards and procedures that will be put in place to eliminate or mitigate the level of risk associated with the operation of the facility.

Technical safeguards are those controls that are incorporated into the process or control system hardware, software or firmware. Non-technical controls are management and operational controls, such as security policies, operational procedures, maintenance procedures and training. Technical and non-technical safeguards can also be divided into preventive controls which inhibit or prevent hazardous events from occurring and detective controls such as control system alarms that warn of unacceptable process deviations, or security monitoring systems that initiate an alarm in the event of violations of security protocols.

The technical control measures identified in **Appendix 2** that will be implemented as part of the MCCO Project include:

- locate the Class 1.1 explosives and AN/ANE storages in accordance with the buffer distances specified in **Table 4.2**
- ensure that when relocated, the separation distance between Magazine and the AN/ANE store is maintained in accordance with the AEISG code for storage of UN3375 (ANE) (January 2015) and other relevant standards and codes
- design of diesel tanks and refuelling systems in accordance with relevant standards and codes
- review hazardous area classification (HAC) for relocated flammable liquids, flammable gases and LPG storages. A hazardous area classification defines the hazardous envelope around a flammable liquid or flammable gas storage or handling area where there is the likelihood that a flammable atmosphere may exist. The HAC also defines the rating of suitable electrical equipment that is safe to use within the defined hazardous area envelope. All potential ignition sources are to be excluded from the hazardous area envelope and the ignition source exclusion area appropriately identified (line markings and placard).
- design of hazardous materials storage area surface drainage systems to prevent spills or runoff from storage areas entering surrounding land/waterways
- storage of dangerous goods in dangerous goods compliant stores (in accordance with relevant Australian Standards) and appropriate segregation of incompatible dangerous goods.

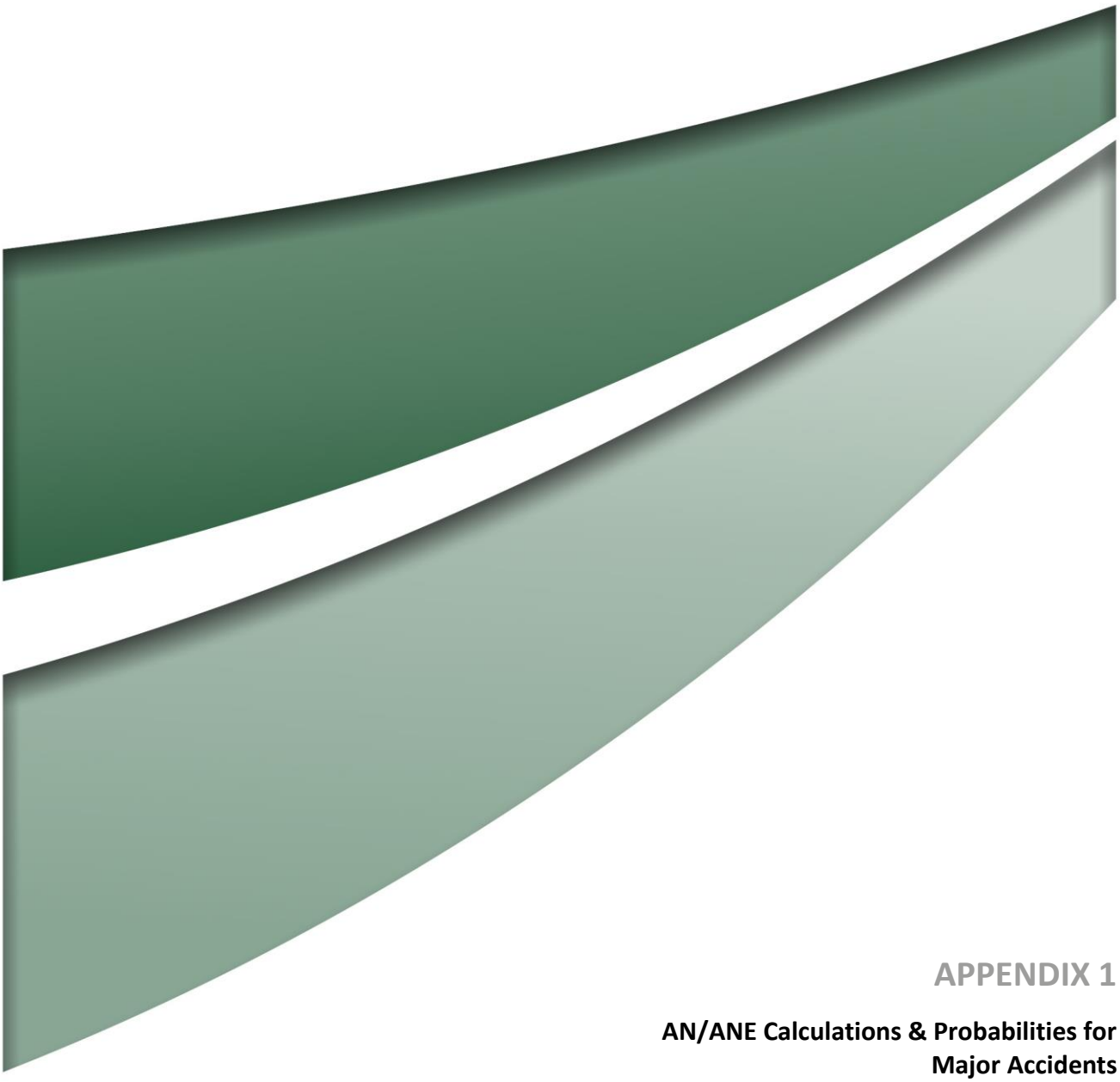
The non-technical safeguards and procedures identified in **Appendix 2** include:

- update Mangoola emergency response plans and security plans in consideration of the relocated hazardous materials storages (if the storages are relocated)
- implement appropriate housekeeping to minimise combustible materials within 30 metres of explosives storages, AN/ANE and combustible/flammable liquids stores
- on site speed limits and designated traffic flow directions to consider new storage locations
- ensure all equipment/vehicles associated with the handling of explosives and AN/ANE are regularly inspected and maintained fit for duty in accordance with relevant standards
- ensure all personnel involved in the handling and storage of explosives and AN/ANE are appropriately trained
- ongoing implementation of appropriate hot work/safe work procedures for works in the vicinity of hazardous materials.

6.0 Conclusions

An assessment of the risks associated with the storage and transport of hazardous materials associated with the MCCO Project, conducted in accordance with NSW Hazardous Industry Planning and Assessment guidelines has found that the level of risk associated with the MCCO Project to the surrounding land users is tolerable. Therefore the MCCO Project is not hazardous as defined by SEPP 33.

The risk screening and classification process undertaken has shown that if the explosives Magazine is located at least 500 metres from off-site land users then no off-site impacts will result from an explosion incident involving the maximum storage inventories of Class 1.1 materials. The risk classification and prioritisation process undertaken has also shown that if the AN/ANE storage is located at least 1,000 metres from off-site land users then no off-site impacts will result from an external heating (e.g. truck fire) incident resulting in a toxic release involving the maximum storage inventory of AN and ANE.



APPENDIX 1

AN/ANE Calculations & Probabilities for Major Accidents

IAEA Risk Classification and Prioritisation

Estimation of External Consequences

Hazardous Material: Magazine (Class 1.1 Explosives)

Select the appropriate effect category from Table II

IAEA Table II(a): Classification of Substances by Effect Categories

Ref. No.	Type of substance	Description of substance	Activity	Quantity (t) 0.2-1	1-5	5-10	10-50	50-200	200-1000	1000-5000	5000-10000	>10000
1	Flammable liquid	Vapour pressure <0.3 bar at 20°C	Storage with tank pit	-	-	-	-		AI	BI	BI	CI
2			Pipeline	-	-	-	-	-	-	-	-	-
3			Other	-	-	-	AI	BI	CI	DII	X	X
4		Vapour Pressure 0.3 bar at 20°C	Storage with tank pit	-	-	-	-	-	BI	CII	CII	DII
6			Other	-	-	-	BII	CII	DII	E II	X	X
7	Flammable gas	Liquefied by pressure	Rail, road, overground storage	-	AI	BI	C I	D I	E I	X	X	X
9			Other	-	BII	CIII	CIII	DIII	E III	X	X	X
10		Liquefied by cooling	Storage with tank pit	-	-	-	-	-	BI	CII	CII	DII
11			Other		-	-	BII	CII	DII	E II	X	X
13		Under pressure > 25 bar: high toxicity	Storage of cylinders (25-100kg)	-	-	CIII	CII	CI	CI	X	X	X
14	Explosive	In bulk (causing single explosion)		AI	BI	BI	CI	CI	DI	X	X	X
15		In packages (e.g. shells)		BIII	BIII	CIII	CI	CI	DI	X	X	X
16	Toxic liquid	Low toxicity	Storage with tank pit	-	-	-	-		A II	A II	B II	C III
17			Other	-	-	-	A III	A II	B II	C II	C II	C II
18		Medium toxicity	Storage with tank pit	-	-	-	A III	B III	D III	E III	F III	F III
21			Other	-	BII	C III	D III	E III	F III	F III	X	X
22		High toxicity	Storage with tank pit	-	-	A II	B III	C III	E III	F III	G III	G III
25			Other	BII	CII	D III	E III	F III	F III	G III	X	X
26		Very high toxicity	Storage with tank pit	AII	BII	C III	E III	F III	G III	G III	H III	H III
29			Other	CIII	DIII	E III	F III	G III	H III	H III	X	X
30	Toxic gas	Liquefied by pressure: low toxicity		AII	BII	B II	CIII	C II	DIII	D III	D III	E III
31		medium toxicity		BII	CII	C II	DIII	E III	F III	F III	G III	H III
32		high toxicity		CII	DIII	E III	E III	F III	G III	G III	X	X
33		very high toxicity		DIII	EIII	F III	G III	G III	H III	-	X	X
34		extreme toxicity		EIII	FIII	G III	H III	H III	X	X	X	X
35		Liquefied by cooling: low toxicity	In the case of activities on water	-	-	-	A II	A II	B II	B II	C II	DIII
36		medium toxicity	use 30-34 instead of 35-39	-	AII	B II	C II	D III	D III	E III	F III	G III
37		high toxicity		BII	CII	D III	E III	E III	F III	F III	G III	H III
38		very high toxicity		DIII	EIII	F III	F III	G III	G III	X	X	X
39		extreme toxicity		EIII	FIII	G III	H III	H III	X	X	X	X

***Note**: For flammable liquids in underground tanks, the quantity should be divided by 5 and the substance treated as 'other' i.e. Refs 3 or 6.*

***Symbols**: 'X' means the combination of that substance and that amount does not usually exist in practice. It is suggested that a full QRA should be carried out in any such case. '-' means that the effects are small enough to be ignored.*

Comments regarding selection

Effect Category: CI

Based on the selected effect category, identify maximum effect distance and/or area from Table III.

IAEA Table III: Effect Categories: Maximum Distance and Area of Effect (*A*)

Effect distance (m)		Effect area category (ha)		
Category	Max. Distance (m)	I	II	III
A	0-25	0.2	0.1	0.02
B	25-50	0.8	0:4	0.1
C	50-100	3	1.5	0.3
D	100-200	12	6	1
E	200-500	80	40	8
F	500-1000	-	-	30
G	1000-3000	-	-	300
H	3000-10 000	-	-	1000

Comments

Maximum Effect Distance (m): 100

Effect Area (ha): 3

If known enter population density of surrounding land or use Table IV as an estimate.

IAEA Table IV: Population Density (*d*)

Description of the area	Density (persons/ha)
Farmland, scattered houses	5
Individual dwellings	10
Village, quiet residential area	20
Residential area	40
Busy residential area	80
Urban area, shopping centres, centre of city	160

Comments

Population Density (persons/ha): 0.5

Surrounding land is either mining or rural with scattered houses.

Select population correction factor from Table V.

IAEA Table V: Population Correction Factor (f_A)

Effect area	Populated fraction (%) of circular area				
Category	100%	50%	20%	10%	5%
I	1	0.6	0.2	0.1	0.05
II	1	1	0.4	0.2	0.1
III	1	1	1	1	1

Comments

Population Correction Factor, f_A: 0.05

Select mitigation correction factor from Table VI.

IAEA Table VI: Correction Factor for Mitigation (f_m)

Substances (reference numbers)	Factor
Flammables (1-12)	1
Flammables (13)	0.1
Explosives (14, 15)	1
Toxic liquid (16-29, 43-46)	0.05
Toxic gas (30-34, 37-39, 40-42)	0.1
Toxic gas (35-36)	0.05

Comments

Mitigation Correction Factor, f_m: 1

ESTIMATE OF EXTERNAL CONSEQUENCES

$C_{a,s} = A \times d \times f_A \times f_m$

$C_{a,s} = 0.07854$

IAEA Risk Classification and Prioritisation

Estimation of Probability and Frequency

Select the average probability number from Table VI

IAEA Table VII: Average Probability Number ($N^{*}_{i,s}$)

Substances	Activity	
(reference numbers)	Storage	Plant
Flammable liquid (1-3)	8	7
Flammable liquid (4-6)	7	6
Flammable gas (7)	6	5
Flammable gas (9)	7	6
Flammable gas (10,11)	6	-
Flammable gas (13)	4	-
Explosive (14,15)	7	6
Toxic liquid (16-29)	5	4
Toxic gas (30-34)	6	5
Toxic gas (35-39)	6	-
Toxic gas (42)	5	4
Combustion products (43-46)	3	-

Comments

Average Probability Number, $N^{*}_{i,s}$: 7

Select probability number correction parameter for frequency of loading/unloading operations from Table VIII

IAEA Table VIII: Probability Number Correction Parameter (n_l) For Loading/Unloading Operations Frequency

Frequency of loading/ unloading (per year)	Parameter
1-10	+0.5
10-50	0
50-200	-1
200-500	-1.5
500-2000	-2

***Note** that this does not apply to cylinders (Ref No 13)*

Comments

Loading/Unloading Correction Parameter, nl 0

If the hazardous material is flammable select appropriate correction parameters from Table IX

IAEA Table IX: Probability Number Correction Parameter (n_f) for Flammables

Substance	Safety measures	Factor
Flammable gas (7, 13)	Sprinkler system	+0.5
Flammable gas (10)	Double containment	+1
Flammable gas (13)	Fire wall	+1
	Sprinkler system	+0.5
	5-50 stored cylinders	+1
	50-500 stored cylinders	0
	>500 stored cylinders	-1

Comments

Flammables correction Parameter, nf 0

Select organisational safety probability correction parameter from Table X.

IAEA Table X: Probability Number Correction Parameter (n_o) for Organisational Safety

Above average industry practice	+0.5
Average industry practice	0
Below average industry practice	-0.5
Poor industry practice	-1
Non-existent safety practices	-1.5

Note: *Several factors are included: safety management, age of the plant, maintenance, documentation and procedures, safety culture, training, emergency planning etc.*

Comments

Organisational Safety Correction Parameter, no: 0

Select wind direction correction parameter from Table XI.

IAEA Table XI: Probability Number Correction Parameter (n_p) for Wind Direction Towards Populated Area(s) in the Affected Zone

Effect area category	Part of the area (%) where people are living				
	100%	50%	20%	10%	5%
I	0	0	0	0	0
II	0	0.5	0.5	0.5	0.5
III	0	0.5	0.5	1	1.5

Comments

Wind Direction Correction Parameter, n_p: 0

ESTIMATE OF PROBABILITY NUMBER AND FREQUENCY

$N_{i,s} = N^*_{i,s} + n_l + n_f + n_o + n_p$

$N_{i,s} = 7$

P = 1.00E-07

IAEA Risk Classification and Prioritisation

Estimation of External Consequences

Hazardous Material: AN/ANE Explosion

Select the appropriate effect category from Table II

IAEA Table II(a): Classification of Substances by Effect Categories

Ref. No.	Type of substance	Description of substance	Activity	Quantity (t) 0.2-1	1-5	5-10	10-50	50-200	200-1000	1000-5000	5000-10000	>10000
1	Flammable liquid	Vapour pressure <0.3 bar at 20°C	Storage with tank pit	-	-	-	-		AI	BI	BI	CI
2			Pipeline	-	-	-	-	-	-	-	-	-
3			Other	-	-	-	AI	BI	CI	DII	X	X
4		Vapour Pressure 0.3 bar at 20°C	Storage with tank pit	-	-	-	-	-	BI	CII	CII	DII
6			Other	-	-	-	BII	CII	DII	E II	X	X
7	Flammable gas	Liquefied by pressure	Rail, road, overground storage	-	AI	BI	C I	D I	E I	X	X	X
9			Other	-	BII	CIII	CIII	DIII	E III	X	X	X
10		Liquefied by cooling	Storage with tank pit	-	-	-	-	-	BI	CII	CII	DII
11			Other		-	-	BII	CII	DII	E II	X	X
13		Under pressure > 25 bar: high toxicity	Storage of cylinders (25-100kg)	-	-	CIII	CII	CI	CI	X	X	X
14	Explosive	In bulk (causing single explosion)		AI	BI	BI	CI	CI	DI	X	X	X
15		In packages (e.g. shells)		BIII	BIII	CIII	CI	CI	DI	X	X	X
16	Toxic liquid	Low toxicity	Storage with tank pit	-	-	-	-		A II	A II	B II	C III
17			Other	-	-	-	A III	A II	B II	C II	C II	C II
18		Medium toxicity	Storage with tank pit	-	-	-	A III	B III	D III	E III	F III	F III
21			Other	-	BII	C III	D III	E III	F III	F III	X	X
22		High toxicity	Storage with tank pit	-	-	A II	B III	C III	E III	F III	G III	G III
25			Other	BII	CII	D III	E III	F III	F III	G III	X	X
26		Very high toxicity	Storage with tank pit	AII	BII	C III	E III	F III	G III	G III	H III	H III
29			Other	CIII	DIII	E III	F III	G III	H III	H III	X	X
30	Toxic gas	Liquefied by pressure: low toxicity		AII	BII	B II	CIII	C II	DIII	D III	D III	E III
31		medium toxicity		BII	CII	C II	DIII	E III	F III	F III	G III	H III
32		high toxicity		CII	DIII	E III	E III	F III	G III	G III	X	X
33		very high toxicity		DIII	EIII	F III	G III	G III	H III	-	X	X
34		extreme toxicity		EIII	FIII	G III	H III	H III	X	X	X	X
35		Liquefied by cooling: low toxicity	In the case of activities on water	-	-	-	A II	A II	B II	B II	C II	DIII
36		medium toxicity	use 30-34 instead of 35-39	-	AII	B II	C II	D III	D III	E III	F III	G III
37		high toxicity		BII	CII	D III	E III	E III	F III	F III	G III	H III
38		very high toxicity		DIII	EIII	F III	F III	G III	G III	X	X	X
39		extreme toxicity		EIII	FIII	G III	H III	H III	X	X	X	X

***Note**: For flammable liquids in underground tanks, the quantity should be divided by 5 and the substance treated as 'other' i.e. Refs 3 or 6.*

***Symbols**: 'X' means the combination of that substance and that amount does not usually exist in practice. It is suggested that a full QRA should be carried out in any such case. '-' means that the effects are small enough to be ignored.*

Comments regarding selection

Effect Category: CI

Based on the selected effect category, identify maximum effect distance and/or area from Table III.

IAEA Table III: Effect Categories: Maximum Distance and Area of Effect (*A*)

Effect distance (m)		Effect area category (ha)		
Category	Max. Distance (m)	I	II	III
A	0-25	0.2	0.1	0.02
B	25-50	0.8	0:4	0.1
C	50-100	3	1.5	0.3
D	100-200	12	6	1
E	200-500	80	40	8
F	500-1000	-	-	30
G	1000-3000	-	-	300
H	3000-10 000	-	-	1000

Comments

Maximum Effect Distance (m): 100

Effect Area (ha): 3

If known enter population density of surrounding land or use Table IV as an estimate.

IAEA Table IV: Population Density (*d*)

Description of the area	Density (persons/ha)
Farmland, scattered houses	5
Individual dwellings	10
Village, quiet residential area	20
Residential area	40
Busy residential area	80
Urban area, shopping centres, centre of city	160

Comments

Population Density (persons/ha): 0.5

Surrounding land is either mining or rural with scattered houses.

Select population correction factor from Table V.

IAEA Table V: Population Correction Factor (f_A)

Effect area	Populated fraction (%) of circular area				
Category	100%	50%	20%	10%	5%
I	1	0.6	0.2	0.1	0.05
II	1	1	0.4	0.2	0.1
III	1	1	1	1	1

Comments

Population Correction Factor, f_A: 0.05

Select mitigation correction factor from Table VI.

IAEA Table VI: Correction Factor for Mitigation (f_m)

Substances (reference numbers)	Factor
Flammables (1-12)	1
Flammables (13)	0.1
Explosives (14, 15)	1
Toxic liquid (16-29, 43-46)	0.05
Toxic gas (30-34, 37-39, 40-42)	0.1
Toxic gas (35-36)	0.05

Comments

Mitigation Correction Factor, f_m: 1

ESTIMATE OF EXTERNAL CONSEQUENCES

$C_{a,s} = A \times d \times f_A \times f_m$

$C_{a,s} = 0.07854$

IAEA Risk Classification and Prioritisation

Estimation of Probability and Frequency

Select the average probability number from Table VI

IAEA Table VII: Average Probability Number ($N^{*}_{i,s}$)

Substances	Activity	
(reference numbers)	Storage	Plant
Flammable liquid (1-3)	8	7
Flammable liquid (4-6)	7	6
Flammable gas (7)	6	5
Flammable gas (9)	7	6
Flammable gas (10,11)	6	-
Flammable gas (13)	4	-
Explosive (14,15)	7	6
Toxic liquid (16-29)	5	4
Toxic gas (30-34)	6	5
Toxic gas (35-39)	6	-
Toxic gas (42)	5	4
Combustion products (43-46)	3	-

Comments

Average Probability Number, $N^{*}_{i,s}$: 7

Select probability number correction parameter for frequency of loading/unloading operations from Table VIII

IAEA Table VIII: Probability Number Correction Parameter (n_l) For Loading/Unloading Operations Frequency

Frequency of loading/ unloading (per year)	Parameter
1-10	+0.5
10-50	0
50-200	-1
200-500	-1.5
500-2000	-2

***Note** that this does not apply to cylinders (Ref No 13)*

Comments

Loading/Unloading Correction Parameter, nl 0

If the hazardous material is flammable select appropriate correction parameters from Table IX

IAEA Table IX: Probability Number Correction Parameter (n_f) for Flammables

Substance	Safety measures	Factor
Flammable gas (7, 13)	Sprinkler system	+0.5
Flammable gas (10)	Double containment	+1
Flammable gas (13)	Fire wall	+1
	Sprinkler system	+0.5
	5-50 stored cylinders	+1
	50-500 stored cylinders	0
	>500 stored cylinders	-1

Comments

Flammables correction Parameter, nf 0

Select organisational safety probability correction parameter from Table X.

IAEA Table X: Probability Number Correction Parameter (n_o) for Organisational Safety

Above average industry practice	+0.5
Average industry practice	0
Below average industry practice	-0.5
Poor industry practice	-1
Non-existent safety practices	-1.5

Note: *Several factors are included: safety management, age of the plant, maintenance, documentation and procedures, safety culture, training, emergency planning etc.*

Comments

Organisational Safety Correction Parameter, no: 0

Select wind direction correction parameter from Table XI.

IAEA Table XI: Probability Number Correction Parameter (n_p) for Wind Direction Towards Populated Area(s) in the Affected Zone

Effect area category	Part of the area (%) where people are living				
	100%	50%	20%	10%	5%
I	0	0	0	0	0
II	0	0.5	0.5	0.5	0.5
III	0	0.5	0.5	1	1.5

Comments

Wind Direction Correction Parameter, n_p: 0

ESTIMATE OF PROBABILITY NUMBER AND FREQUENCY

$N_{i,s} = N^*_{i,s} + n_l + n_f + n_o + n_p$

$N_{i,s} = 7$

P = 1.00E-07

IAEA Risk Classification and Prioritisation

Estimation of External Consequences

Hazardous Material: ANE and TGAN - Nitrogen Dioxide (NO_2)

Select the appropriate effect category from Table II

IAEA Table II(a): Classification of Substances by Effect Categories

Ref. No.	Type of substance	Description of substance	Activity	Quantity (t) 0.2-1	1-5	5-10	10-50	50-200	200-1000	1000-5000	5000-10000	>10000
1	Flammable liquid	Vapour pressure <0.3 bar at 20°C	Storage with tank pit	-	-	-	-		AI	BI	BI	CI
2			Pipeline	-	-	-	-	-	-	-	-	-
3			Other	-	-	-	AI	BI	CI	DII	X	X
4		Vapour Pressure 0.3 bar at 20°C	Storage with tank pit	-	-	-	-	-	BI	CII	CII	DII
6			Other	-	-	-	BII	CII	DII	E II	X	X
7	Flammable gas	Liquefied by pressure	Rail, road, overground storage	-	AI	BI	C I	D I	E I	X	X	X
9			Other	-	BII	CIII	CIII	DIII	E III	X	X	X
10		Liquefied by cooling	Storage with tank pit	-	-	-	-	-	BI	CII	CII	DII
11			Other		-	-	BII	CII	DII	E II	X	X
13		Under pressure > 25 bar: high toxicity	Storage of cylinders (25-100kg)	-	-	CIII	CII	CI	CI	X	X	X
14	Explosive	In bulk (causing single explosion)		AI	BI	BI	CI	CI	DI	X	X	X
15		In packages (e.g. shells)		BIII	BIII	CIII	CI	CI	DI	X	X	X
16	Toxic liquid	Low toxicity	Storage with tank pit	-	-	-	-		A II	A II	B II	C III
17			Other	-	-	-	A III	A II	B II	C II	C II	C II
18		Medium toxicity	Storage with tank pit	-	-	-	A III	B III	D III	E III	F III	F III
21			Other	-	BII	C III	D III	E III	F III	F III	X	X
22		High toxicity	Storage with tank pit	-	-	A II	B III	C III	E III	F III	G III	G III
25			Other	BII	CII	D III	E III	F III	F III	G III	X	X
26		Very high toxicity	Storage with tank pit	AII	BII	C III	E III	F III	G III	G III	H III	H III
29			Other	CIII	DIII	E III	F III	G III	H III	H III	X	X
30	Toxic gas	Liquefied by pressure: low toxicity		AII	BII	B II	CIII	C II	DIII	D III	D III	E III
31		medium toxicity		BII	CII	C II	DIII	E III	F III	F III	G III	H III
32		high toxicity		CII	DIII	E III	E III	F III	G III	G III	X	X
33		very high toxicity		DIII	EIII	F III	G III	G III	H III		X	X
34		extreme toxicity		EIII	FIII	G III	H III	H III	X	X	X	X
35		Liquefied by cooling: low toxicity	In the case of activities on water	-	-	-	A II	A II	B II	B II	C II	DIII
36		medium toxicity	use 30-34 instead of 35-39	-	AII	B II	C II	D III	D III	E III	F III	G III
37		high toxicity		BII	CII	D III	E III	E III	F III	F III	G III	H III
38		very high toxicity		DIII	EIII	F III	F III	G III	G III	X	X	X
39		extreme toxicity		EIII	FIII	G III	H III	H III	X	X	X	X

***Note**: For flammable liquids in underground tanks, the quantity should be divided by 5 and the substance treated as 'other' i.e. Refs 3 or 6.*

***Symbols**: 'X' means the combination of that substance and that amount does not usually exist in practice. It is suggested that a full QRA should be carried out in any such case. '-' means that the effects are small enough to be ignored.*

Comments regarding selection

Effect Category: GIII (Toxic gas 33)

60 T of solid technical grade ammonium nitrate (TGAN) and 80 T ammonium nitrate emulsion (ANE). Note that the yield of toxic NO2 would be < 20 T.

Based on the selected effect category, identify maximum effect distance and/or area from Table III.

IAEA Table III: Effect Categories: Maximum Distance and Area of Effect (*A*)

Effect distance (m)		Effect area category (ha)		
Category	Max. Distance (m)	I	II	III
A	0-25	0.2	0.1	0.02
B	25-50	0.8	0:4	0.1
C	50-100	3	1.5	0.3
D	100-200	12	6	1
E	200-500	80	40	8
F	500-1000	-	-	30
G	1000-3000	-	-	300
H	3000-10 000	-	-	1000

Comments

An NO2 release event will involve a fire and therefore the plume will be bouyant. Also, the rate of NO2 release will be progressive rather than a catastrophic release of full inventory. Therefore select minimum effect distance for category.

Maximum Effect Distance (m): 1000

Effect Area (ha): 314

If known enter population density of surrounding land or use Table IV as an estimate.

IAEA Table IV: Population Density (*d*)

Description of the area	Density (persons/ha)
Farmland, scattered houses	5
Individual dwellings	10
Village, quiet residential area	20
Residential area	40
Busy residential area	80
Urban area, shopping centres, centre of city	160

Comments

Surrounding land is either mining or rural with scattered houses.

Population Density (persons/ha): 0.5

Select population correction factor from Table V.

IAEA Table V: Population Correction Factor (f_A)

Effect area	Populated fraction (%) of circular area				
Category	100%	50%	20%	10%	5%
I	1	0.6	0.2	0.1	0.05
II	1	1	0.4	0.2	0.1
III	1	1	1	1	1

Comments

Population Correction Factor,

f_A: 1

Select mitigation correction factor from Table VI.

IAEA Table VI: Correction Factor for Mitigation (f_m)

Substances (reference numbers)	Factor
Flammables (1-12)	1
Flammables (13)	0.1
Explosives (14, 15)	1
Toxic liquid (16-29, 43-46)	0.05
Toxic gas (30-34, 37-39, 40-42)	0.1
Toxic gas (35-36)	0.05

Comments

Mitigation Correction Factor,

f_m: 0.1

ESTIMATE OF EXTERNAL CONSEQUENCES

$C_{a,s}$ = A x d x f_A x f_m

$C_{a,s}$ = 15.70796

IAEA Risk Classification and Prioritisation

Estimation of Probability and Frequency

Select the average probability number from Table VI

IAEA Table VII: Average Probability Number ($N^*_{i,s}$)

Substances	Activity	
(reference numbers)	Storage	Plant
Flammable liquid (1-3)	8	7
Flammable liquid (4-6)	7	6
Flammable gas (7)	6	5
Flammable gas (9)	7	6
Flammable gas (10,11)	6	-
Flammable gas (13)	4	-
Explosive (14,15)	7	6
Toxic liquid (16-29)	5	4
Toxic gas (30-34)	6	5
Toxic gas (35-39)	6	-
Toxic gas (42)	5	4
Combustion products (43-46)	3	-

Comments

Average Probability Number, $N^*_{i,s}$: 6

Select probability number correction parameter for frequency of loading/unloading operations from Table VIII

IAEA Table VIII: Probability Number Correction Parameter (n_l) For Loading/Unloading Operations Frequency

Frequency of loading/ unloading (per year)	Parameter
1-10	+0.5
10-50	0
50-200	-1
200-500	-1.5
500-2000	-2

***Note** that this does not apply to cylinders (Ref No 13)*

Comments

Loading/Unloading Correction Parameter, nl -1

If the hazardous material is flammable select appropriate correction parameters from Table IX

IAEA Table IX: Probability Number Correction Parameter (n_f) for Flammables

Substance	Safety measures	Factor
Flammable gas (7, 13)	Sprinkler system	+0.5
Flammable gas (10)	Double containment	+1
Flammable gas (13)	Fire wall	+1
	Sprinkler system	+0.5
	5-50 stored cylinders	+1
	50-500 stored cylinders	0
	>500 stored cylinders	-1

Comments

Flammables correction Parameter, nf 0

Select organisational safety probability correction parameter from Table X.

IAEA Table X: Probability Number Correction Parameter (n_o) for Organisational Safety

Above average industry practice	+0.5
Average industry practice	0
Below average industry practice	-0.5
Poor industry practice	-1
Non-existent safety practices	-1.5

Note: *Several factors are included: safety management, age of the plant, maintenance, documentation and procedures, safety culture, training, emergency planning etc.*

Comments

Organisational Safety Correction Parameter, no: 0

Select wind direction correction parameter from Table XI.

IAEA Table XI: Probability Number Correction Parameter (n_p) for Wind Direction Towards Populated Area(s) in the Affected Zone

Effect area category	Part of the area (%) where people are living				
	100%	50%	20%	10%	5%
I	0	0	0	0	0
II	0	0.5	0.5	0.5	0.5
III	0	0.5	0.5	1	1.5

Comments

Wind Direction Correction Parameter, n_p: 1.5

ESTIMATE OF PROBABILITY NUMBER AND FREQUENCY

$N_{i,s} = N^*_{i,s} + n_l + n_f + n_o + n_p$

$N_{i,s} = 6.5$

P = 3.16E-07

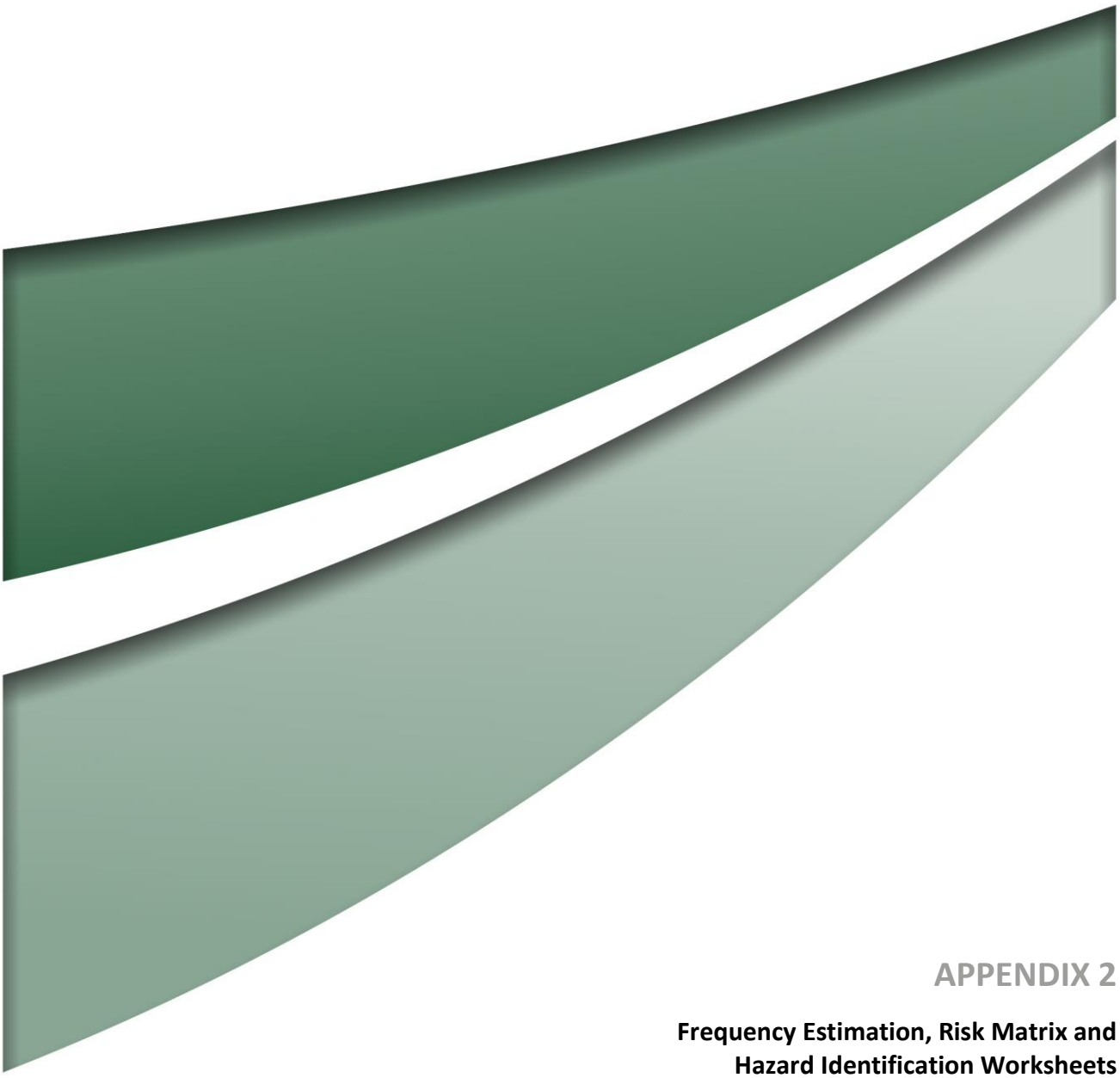
AN/ANE NO_2 Yield

Reference: *Ammonium Nitrate: Toxic Fume Risk from Fires in Storage (Atkinson and Adams, 2002)*

- Base on mass loss of ammonium nitrate and and production of NO and NO2 in experimental work
- Assume NO oxidises to NO_2 (ref Air Liquide MSDS for NO)

Calculation

150	g/s AN mass loss
0.9	g/s NO_2 produced
16	g/s NO produced
11%	NO_2 yield



APPENDIX 2

Frequency Estimation, Risk Matrix and Hazard Identification Worksheets

Risk Assessment Workshop

Date of Workshop: 30-Jul-18
Location: 75 York Street Teralba

Job Title: Mangoola Coal Continued Operations Project **Job Number:** 4004

Job Description:	Mangoola Coal Mine is an open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW (refer Figure 1.1). Mangoola has operated the Mangoola Coal Mine in accordance with Project Approval (PA) 06_0014 since mining commenced at the site in September 2010. The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations. The MCCO Project will extend the life of the existing operation providing for ongoing employment opportunities for the existing Mangoola workforce.
Purpose, Scope and Context:	The purpose of this risk assessment workshop is to identify hazards that may have off-site impacts associated with the Project. NSW Department of Planning Secretary's Environmental Assessment Requirements (SEARs) have identified hazard and risk as an area to be addressed in the EIS. Risk screening and prioritisation has shown that a Level 1 Qualitative risk assesment will be adequate. The risk assessment will focus on health and safety risks posed to the surrounding off-site land users and the risks posed to the surrounding biophysical environment. i.e. the risk rankings are relevant to off-site land users not on-site personnel.

Workshop Attendees

Name	Company	Position/Role	Part Day
Chris Bonomini	Umwelt	Senior Process Engineer	
Tim Procter	Umwelt	Principal Engineer	

AS 4360 Risk Scoring System

Scoring Matrix

Likelihood		1	2	3	4	5
Level		**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
A	Almost Certain	11	16	20	23	25
B	Likely	7	12	17	21	24
C	Possible	4	8	13	18	22
D	Unlikely	2	5	9	14	19
E	Rare	1	3	6	10	15

Legend

18 to 25:	EXTREME RISK; immediate action required;
10 to 17:	HIGH RISK; senior management attention needed;
6 to 9:	MODERATE RISK; management responsibility must be specified; and
1 to 5:	LOW RISK; managed by routine procedures.

Qualitative Measures of Likelihood

	Level	Description
A	Almost Certain	The event is expected to occur in most circumstances
B	Likely	The event will probably occur in most circumstances
C	Possible	The event might occur at some time
D	Unlikely	The event could occur at some time
E	Rare	The event may occur only in exceptional circumstances

Qualitative Measures of Consequence or Impact or Severity

	Level	People Losses	Environmental Harm	Equipment Damage	Production Loss
1	Insignificant	No injuries	No-off site effects	Low financial loss	No production loss
2	Minor	First aid treatment	On-site release immediately contained	Medium financial loss	Up to 1 day production loss
3	Moderate	Medical treatment	On-site release contained with outside assistance	High financial loss	Between 1 to 5 days production loss
4	Major	Extensive injuries	Off-site release with no detrimental effects	Major financial loss	Between 5 to 20 days production loss
5	Catastrophic	Death	Toxic release off-site with detrimental effect	Huge financial loss	More than 20 days production loss

Hazard Identification

Date: 30-Jul-18 **Job:** Mangoola Coal Continued Operations Project **Job #:** 4004

Section/Area: Explosives and ANE Storage

Ref	Asset	Hazard	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action
1	AN and ANE Storage	Toxic release	Tank heated by adjacent fire causing AN to decompose and release nitrogen dioxide.	Delivery truck fire or other combustibles in storage area on fire. Bushfire Lightning strike	Possible off-site fatality or injury to sensitive member of the community.	Separation distances between storage tank and combustibles to be maintained according to relevant Dangerous Goods codes and standards. ANE and explosives delivery contractors suitably trained and qualified. Site traffic/road rules.	5	E	15	IAEA classification and screening indicates that the maximum range of impact of a toxic release is 1000 m. If final storage location is within 1000 m of surrounding land users conduct dispersion modelling of nitrogen dioxide release and estimate risks. If final storage is greater than 1000 m of surrounding land users then no further assessment is required.

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2	Class 1.1 Magazine	Explosion	Fire or high impact inititaes detonation of entire storage quantity of explosives	Delivery truck fire or other combustibles in storage area on fire. Bushfire Lightning strike	Possible off-site fatality or injury to member of the community.	Explosives stored in accordance with relevant Dangerous Goods codes and standards. Explosives delivery contractors suitably trained and qualified. Hot work procedures. Site traffic/road rules.	5	E	15	Risk screening has shown that there will be no off-site overpressure impacts resulting from the detonation of 41 tonnes of explosives (assuming suitable separation from AN/ANE) provided the Magazine is located at least 500 m from surrounding land users. If final storage location is within 500 m of off-site land users conduct explosion overpressure modelling and estimate risks. Separation distance between Magazine and AN/ANE to be in accordance with the Australian Explosives Industry and Safety Group (AEISG) code (January 2015) for storage of UN3375 (ANE) and other relevant standards and codes.

3	An and ANE Delivery	Toxic release/ Environment	Truck crash and spillage of AN/ANE into on-site drainage system.	Motor vehicle accident.	AN/ANE entering natural watercoarse and impacting flora and fauna.	ANE and explosives delivery contractors suitably trained and qualified. Emergency spill response procedures. Site traffic/road rules.	3	C	13	Emergency response procedures will be updated when final location of ANE/ANFO tanks is known. Drainage systems to be designed to prevent contamination of surrounding land/waterways.
4	Class 1.1 Magazine and AN/ANE Storage	Security/ Explosion	Deliberate attempt to detonate explosives.	Malicious act.	Possible off-site fatality or injury to member of the community.	Site security.	5	E	15	Site security plan will be updated to accomodate new storage location if required.

5	AN and ANE Storage	Explosion	Fire or high impact initiates detonation of entire storage quantity of explosives	Delivery truck fire or other combustibles in storage area on fire. Bushfire Lightning strike	Possible off-site fatality or injury to member of the community.	Explosives stored in accordance with relevant Dangerous Goods codes and standards. Explosives delivery contractors suitably trained and qualified. Hot work procedures. Site traffic/road rules.	5	E	15	Risk screening has shown that there will be no off-site overpressure impacts resulting from the detonation of a net explosive quantity of 100 tonnes provided the AN/ANE store is located at least 650 m from surrounding land users. If final storage location is within 500 m of off-site land users conduct explosion overpressure modelling and estimate risks. If the AN/ANE store is located at a distance of 650 m or greater from surrounding land users no further assessment is required.

Hazard Identification

Date: 8-Nov-17 **Job:** Mangoola Coal Continued Operations Project **Job #:** 4004

Section/Area: LPG Storage Tank

Ref	Asset	Hazard	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action
1	LPG Tank	BLEVE	Adjacent fire or fire from LPG fitting leak initiates BLEVE.	Vehicle impact initiates fire. Introduced ignition source initiates fire.	Possible off site fatality or injury to sensitive member of the community.	LPG storage designed in accordance with AS/NZS 1596:2008 *The storage and handling of LP Gas* and other relevant DG codes and standards.	4	E	10	Review hazardous area classification for relocated LPG storage.
2	LPG Tank	Fire/Deflagration	Jet fire from leaking LPG fitting or deflagration of accumulated vapour from leak.	Vehicle impact initiates fire. Introduced ignition source initiates fire/deflagration.	Possible off site fatality or injury to sensitive member of the community.	LPG storage designed in accordance with AS/NZS 1596:2008 *The storage and handling of LP Gas* and other relevant DG codes and standards.	4	E	10	Review hazardous area classification for relocated LPG storage.

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Hazard Identification

Date: 8-Nov-17 **Job:** Mangoola Coal Continued Operations Project **Job #:** 4004

Section/Area: Combustible and Flammable Materials

Ref	Asset	Hazard	Scenario	Cause	Consequence	Current Barriers	C	L	R	Action
1	Combustible Liquids (e.g. diesel)	Fire	Adjacent fire leads to ignition of combustible liquid.	Vehicle fire.	Possible injury to off-site community member from radiant heat or smoke.	Combustible liquids storage in accordance with AS1940-2004 *The storage and handling of flammable and combustible liquids* . Diesel fuel is difficult to ignite (combustible liquid rather than flammable liquid).	3	E	6	Relocated fuel farm and other combustible liquids storages will be adequately separated from Class 3 flammable liquids as per AS1940 (otherwise combustible liquids would need to be assessed as flammable liquids).
2	Flammable Liquids	Fire/Deflagration	Ignition of flammable liquid vapours leading to fire or deflagration.	Ignition source introduced within hazardous area envelope.	Injury to on-site personnel from radiant heat or smoke.	Flammable liquids storage in accordance with AS1940-2004 *The storage and handling of flammable and combustible liquids* . Only minor quantities of flammable liquids stored on site.	4	D	14	Review hazardous area classification for relocated flammable liquids storages.
3	Flammable Gases	Fire/Deflagration	Ignition of flammable gas leading to jet fire or deflagration.	Ignition source introduced within hazardous area envelope.	Injury to on-site personnel from radiant heat or smoke.	Flammable gas storage in accordance with AS 4332-2004 (R2016) *The storage and handling of gases in cylinders* . Only minor quantities of flammable gases stored on site.	4	D	14	Review hazardous area classification for relocated flammable gas storages.

Umwelt Environmental Consultants

umwelt
Environmental & Social Consultants

Newcastle
75 York Street
Teralba NSW 2284

Perth
First Floor
12 Prowse Street
West Perth WA 6005
PO Box 783
West Perth WA 6872

Canberra
2/99 Northbourne Avenue
Turner ACT 2612
PO Box 6135
O'Connor ACT 2602

Sydney
50 York Street
Sydney NSW 2000

Brisbane
Level 13
500 Queen Street
Brisbane QLD 4000

Orange
Office 1
3 Hampden Street
Orange NSW 2800

T| 1300 79
3 267 E| info@umwelt.com.au www.umwelt.com.au