

Appendix 16

Traffic impact assessment





Energy Resources of Australia Ltd
Ranger 3 Deeps Project
Traffic Impact Assessment

May 2014

EXECUTIVE SUMMARY

Energy Resources of Australia Ltd (ERA) proposes to develop and operate an underground mine and associated facilities at the existing Ranger uranium mine in the Alligator Rivers Region of the Northern Territory. The Ranger 3 Deeps underground mine (the Project) is situated within the footprint of the current Ranger uranium mine, on the Ranger Project Area (RPA), located 260 km east of Darwin and 11 km east of the regional centre of Jabiru.

ERA is required to undertake an Environmental Impact Assessment for the Project in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Northern Territory Environmental Assessment Act*.

In preparing the draft Environmental Impact Statement (EIS), ERA is required to assess the impacts of traffic and transportation associated with the Project on public safety, the world heritage values of the surrounding Kakadu National Park and the wider environment.

This study focuses on traffic and transport movements predominantly along the Kakadu and Arnhem Highways, including the progression of an appropriate survey program, risk analysis and reporting for the draft EIS.

This report undertakes to fulfil the following objectives:

- Identify proposed routes for transport to and from the underground mine, of construction materials, consumables, personnel and product for the Project, including the use of existing roads.
- Identify existing traffic volumes on the road network and provide a comparison of the before and after Project development scenarios, and an indication of the traffic impacts that the Project will have on the existing road network.
- Consider projected traffic volumes associated with the Project in the context of the relative likelihood of incidents.
- Conduct a risk assessment of the maximum reasonable consequence to (a) public safety, and (b) the receiving environment, should an incident occur, based on quantitative analysis of incidents occurring along the identified haulage routes and assessment of the credible worst case consequence of the risk.
- Identify levels of any uncertainty about estimates of risk.
- Undertake an assessment of safeguards and mitigation measures adopted by ERA and its suppliers, in order to understand their adequacy to avoid or minimise the likelihood of an incident occurring, and their ability to take account of seasonality (wet/dry), nature of the consignment, truck / trailer configuration and design, and the biophysical nature of the local environment.

The central hazardous event considered during the risk assessment process was a vehicle incident on a public road, which may result in direct or indirect impact to the public and or the receiving environment. Sensitive environmental receptors identified as relevant to the transport of consumables and materials, and therefore considered in this risk assessment were:

- environmental values including world heritage and/or national heritage places
- listed threatened and migratory species
- public safety.

Risks to public safety from the traffic profile were assessed in the context of a vehicle incident on a public road anywhere in the study area. Risks to public safety included the following risk scenarios:

- a vehicle incident
- a vehicle incident involving a loss of containment
- a vehicle incident leading to fire/explosions.

In order to focus the risk assessment process on material risks, the risks identified for listed threatened and migratory species and environmental values were based on identified sensitive ecological areas along the primary transport routes.

A desktop assessment of the surrounding environment within a five kilometre buffer of the Arnhem, Kakadu and Stuart Highways was undertaken. Ecologically sensitive areas comprised wetland, floodplain and river habitats. These areas were high in species richness and recorded the highest abundance and diversity of threatened flora/fauna and migratory species.

Fourteen locations along the transport route were identified as sensitive in terms of listed threatened and migratory species, and of these 6 were identified as also containing environmental values including world heritage and/or national heritage places.

Risk was assessed based on the maximum reasonable consequence, and with existing controls in place. This is the largest realistic or credible consequence from an event, considering the credible failure of controls. It is generally a higher consequence than the 'most likely' consequence and less severe than the 'worst case' consequence, which considers the failure of all controls.

The risk identification process recorded 246 risk scenarios. The risk profile includes the following:

- 147 risk scenarios that address risks to listed threatened and migratory species at 14 locations, concerning the transport of 14 separate consumables and/or materials.
- 68 risk scenarios that address risks to environmental values at 6 locations, concerning the transport of 14 separate consumables and/or materials.
- 31 risk scenarios that address risks to public safety in the study area concerning the transport of 14 separate consumables and/or materials.

In total, the Ranger mine currently generates approximately 15 round trips per day, comprising 7 heavy vehicle trips and 8 light vehicle trips. Based on ERA projections (with and without the Project) to 2020, 2017 generates the highest number of round trips for the Ranger mine with the Project, equal to approximately 20 round trips per day. The Ranger 3 Deeps Project accounts for approximately 6 of these round trips. It is not anticipated that the Project would contribute any additional light vehicles to the road network in 2017, and so these 6 additional vehicles are all heavy vehicles. This additional heavy vehicle traffic on the road network represents less than 4 % contribution to traffic volumes in the study area in 2017.

Austrroads publishes guidance on the capacity of roads and traffic lanes (Austrroads, 2009). An assessment of estimated traffic volume on the road network in 2017 indicates there will be significantly less than the theoretical capacity of the roads in the study area. This means that the roads are capable of absorbing the additional Project traffic without affecting road performance.

The transport of the consumables under consideration, including hazardous substances and dangerous goods, is already undertaken by suppliers and carriers for existing operations at the Ranger mine. There are no new consumables that would be transported for the Project, therefore the existing haulage routes are expected to be retained. Based on the type of consumables, the current transport risk profile does not change.

In addition, considering the traffic volume changes (low increase) discussed in Sections 5.2 and 5.3 in association with the Project, the critical and high risks are not sensitive to, or necessarily influenced by, the small relative change in traffic volumes. That is, in the absence of the Project, the same levels of risk would still apply with regard to public safety.

In conclusion, this study has identified all existing controls (Appendix C) and undertaken an assessment of the expected effectiveness of the controls (Appendix F) implemented by both the transport carriers and ERA, in order to manage the risk associated with the transport of consumables to as low as reasonably practicable.

Controls have been identified to prevent or mitigate the identified hazardous events. No further additional or alternate controls were identified during the risk assessment process that could substantially reduce the likelihood or consequence of the hazardous events.

The reliability of controls is managed by ERA through a systematic contractor management system including pre-qualification evaluations and annual qualification reviews as well as contractor internal management systems. ERA also works closely with its suppliers and the Northern Territory Department of Transport via quarterly safety meetings, to identify opportunities to improve upon existing transport strategies where applicable.

Table of Contents

ACRONYMS & GLOSSARY.....	1
1. INTRODUCTION.....	3
1.1 BACKGROUND.....	3
1.2 PROJECT OBJECTIVES	6
2. EXISTING ENVIRONMENT	7
2.1 STUDY AREA.....	7
2.2 PHYSICAL ENVIRONMENT	9
2.3 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE	11
2.4 EXISTING ROAD NETWORK.....	19
2.5 EXISTING TRAFFIC VOLUMES	23
3. PROJECT DESCRIPTION.....	29
3.1 RANGER 3 DEEPS UNDERGROUND MINE	29
3.2 LOCATION AND VEHICLE ACCESS.....	29
3.3 CONSUMABLES.....	29
3.4 PROJECTED TRAFFIC VOLUMES.....	32
4. ASSESSMENT OF RISKS	35
4.1 OVERVIEW.....	35
4.2 RISK ASSESSMENT PROCESS.....	35
5. IMPACT ASSESSMENT.....	46
5.1 BACKGROUND TRAFFIC GROWTH.....	46
5.2 TRAFFIC VOLUME CHANGE	46
5.3 TRAFFIC VOLUME POTENTIAL IMPACTS	48
5.4 SUMMARY OF TRAFFIC IMPACTS.....	49
5.5 ECOLOGICALLY SENSITIVE AREAS.....	50
5.6 RISK EVALUATION	51
5.7 MITIGATION OF RISK AND IMPACT	53
6. MITIGATION MEASURES.....	54
6.1 OVERVIEW.....	54
6.2 ERA PROJECT CONTROLS	54
7. CONCLUSION	61
8. LEGISLATIVE FRAMEWORK	62
8.1 LEGISLATION AND GUIDELINES.....	62
9. SCOPE AND LIMITATIONS.....	65
10. BIBLIOGRAPHY.....	66

Table Index

Table 1	EIS Guidelines	4
Table 2	Existing AADT volumes and round trip equivalent AADT volumes along each road section (2012)	24
Table 3	Average daily light vehicle counts 2012 – 2013 (ERA 2013)	24
Table 4	Existing ERA heavy vehicle volumes (Round trips, 2012).....	25
Table 5	Current Ranger mine heavy vehicle distributed volumes (Round trips, 2012)	27
Table 6	Classifications of consumables.....	30
Table 7	Consumables, vehicle types / capacity and proposed haulage routes.....	31
Table 8	Summary of generated round trips (2017).....	33
Table 9	Forecast heavy and light vehicle average daily volumes, standard operating conditions (2017)	33
Table 10	Transported consumables and product for Project.....	37
Table 11	Consequence descriptors, species of conservation significance	40
Table 12	Consequence descriptors, environmental values	41
Table 13	Consequence descriptors, public health and safety	41
Table 14	Likelihood definitions.....	43
Table 15	Risk matrix	43
Table 16	Risk acceptance thresholds.....	44
Table 17	Certainty descriptors	44
Table 18	Current (2012) and projected (2017) AADT traffic volumes per road section (DoT) without Ranger mine.....	46
Table 19	Projected AADT volumes (2017) and Ranger mine contribution with the Project.....	47
Table 20	Estimated hourly volumes and comparison to Austroads capacity guidelines (standard operating conditions, 2017)	49
Table 21	Summary cumulative risk profile based on risk register (Appendix E)	51
Table 22	List of controls applicable to ERA contractor management system	55
Table 23	List of controls applicable to dangerous goods regulations and code compliance	56
Table 24	List of controls applicable to National Heavy Vehicle Accreditation Scheme compliance.....	57
Table 25	List of controls applicable to hazard identification and risk management	58
Table 26	List of controls applicable to emergency preparedness	59
Table 27	Relevant legislation and guidelines	62
Table 28	Likelihood of occurrence and assessment of potential impact on listed threatened species and ecological communities in study area	71
Table 29	Example, heavy vehicle exposures – Arnhem Hwy (110 kilometres east of Stuart Hwy)	94

Table 30	Example, crash likelihood for diesel at KNP gate	95
Table 31	Loss of containment, escalation factors (US FMCSA 2001)	96
Table 32	Fatality, escalation factors (Northern Territory DoT 2013)	97
Table 33	Personal injury from loss of containment, escalation factors (Frank E Bird)	97
Table 34	Example, loss of containment likelihood for diesel at KNP gates	98
Table 35	Vehicle accident likelihood, by location and consumable (crashes p.a.).....	99
Table 36	Loss of containment likelihood, by location and applicable consumable (releases p.a.)	100
Table 37	Fire / explosion likelihood, by location and applicable consumable (fire / explosion p.a.).....	101
Table 38	Fatal vehicle incident likelihood, by location and consumable (fatalities p.a.)	102
Table 39	Personal injury from loss of containment likelihood, by location and consumable (incidents p.a.)	103

Figure Index

Figure 1	Study area road network.....	7
Figure 2	Land Use in the Study Area	8
Figure 3	Bioregions in the study area	9
Figure 4	Threatened flora species records	16
Figure 5	Threatened fauna species records	17
Figure 6	Migratory fauna species records.....	18
Figure 7	Study area road sections indicating defined route sections described above	20
Figure 8	2012 AADT volumes and Ranger mine contribution (%).....	26
Figure 9	Distributed Ranger mine annual heavy vehicle round trips during standard operating conditions in 2012.....	28
Figure 10	Average daily round trips (heavy and light vehicles) generated by the Ranger mine	32
Figure 11	Distributed Ranger mine annual heavy vehicle round trips during standard operating conditions in 2017	34
Figure 12	Risk management process (AS/NZS ISO 31000:2009)	36
Figure 13	Example schematic bowtie diagram	37
Figure 14	Zones of Increased Likelihood of an Incident	45
Figure 15	Forecast 2017 AADT volumes and Ranger mine contribution with the Project (%).....	48
Figure 16	Cumulative ERA traffic risk profile for sensitive environmental receptors	52
Figure 17	Event trees for escalating events.....	96
Figure 18	Hierarchy of monitor and review activities (SA/SNZ HB 436).....	106

Appendices

Appendix A - Likelihood of Occurrence of Threatened and Migratory Species

Appendix B – Workshop Participants

Appendix C - Bowtie Diagrams

Appendix D – Quantitative Likelihood Assessment

Appendix E – Risk Register

Appendix F – Controls Assessment

ACRONYMS & GLOSSARY

Term	Description
AADT	Annual average daily traffic. This is based on counts of traffic on a road, in both directions, in a 24-hour period. For the purposes of this report AADT has been converted into a round trip equivalent by dividing AADT by 2.
ADG	Australian Code for the Transport of Dangerous Goods by Road and Rail
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
CAMBA	China Australia Migratory Bird Agreement
DLRM	Northern Territory Department of Land Resource Management
DoT	Northern Territory Department of Transport
EIS	Environmental Impact Statement
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ERA	Energy Resources of Australia Ltd
ERP	Emergency Response Plan
GHD	GHD Pty Ltd
HSE	Health, Safety and Environment
HSEQ	Health, Safety, Environment and Quality
IBC	Intermediate Bulk Container
JAMBA	Japan Australia Migratory Bird Agreement
km	kilometres
km ²	square kilometres
km/h	kilometres per hour
KNP	Kakadu National Park
m	metres
MBTA	Mt Bunday Military Training Area
MNES	Matters of National Environmental Significance
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NHVAS	National Heavy Vehicle Accreditation Scheme
PMST	Protected Matters Search Tool
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
Round Trip	A trip is defined as a one-way movement from one place to another, and a round trip refers to a movement from one place to another, and then back again. For example a round trip would be a movement from Darwin to the Ranger mine and then back to Darwin.
Round trip equivalent	AADT data has been halved in order to convert into round trip equivalent data
RPA	Ranger Project Area

Term	Description
SDS	Safety Data Sheet
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now Department of the Environment)
TPWC Act	Territory Parks and Wildlife Conservation Act 2006
VKT	Vehicle kilometres travelled
vpd	vehicles per day

1. INTRODUCTION

1.1 BACKGROUND

Energy Resources of Australia Ltd (ERA) proposes to develop and operate an underground mine and associated facilities at the existing Ranger Uranium mine in the Alligator Rivers Region of the Northern Territory. The Ranger 3 Deeps underground mine (the Project) is situated within the footprint of the current Ranger uranium mine, on the Ranger Project Area (RPA), located 260 km east of Darwin and 11 km east of the regional centre of Jabiru.

ERA is required to undertake an Environmental Impact Assessment for the Project in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Northern Territory Environmental Assessment Act*.

In preparing the draft Environmental Impact Statement (EIS), ERA is required to assess the impacts of traffic and transportation associated with the Project on public safety, the world heritage values of the surrounding Kakadu National Park and the wider environment.

GHD has been engaged by ERA to prepare a traffic impact assessment that addresses the requirements of the EIS guidelines outlined in Table 1 below, associated with but not limited to the transportation of uranium oxide, explosives (bulk emulsion) and consumables, including dangerous goods, on public roads.

This study focuses on traffic and transport movements predominantly along the Kakadu and Arnhem Highways, including the progression of an appropriate survey program, risk analysis and reporting for the draft EIS.

Table 1 EIS Guidelines

EIS guideline	Reference in this report
<p><i>Section 3.3.3 Transport and consumables</i></p> <p>Identify proposed routes for transport to and from the underground mine, of construction materials, consumables, personnel and product for the proposal, including use of existing roads and airfields.</p> <p>Details of road use associated with the proposed activity should be provided including:</p> <ul style="list-style-type: none"> • type, size and number of vehicles required during all phases of the proposal; • estimated frequency of proposal-related vehicle use on public roads; • quantities of materials to be transported to the mine (e.g. heavy machinery, equipment, diesel, hazardous materials such as sulfuric acid); and • hours of operation. 	<p>Section 3</p>
<p><i>Section 4.3.4 Assessment of risks</i></p> <p>Aspects to be discussed include:</p> <ul style="list-style-type: none"> • potential risks relating to the environment and public safety from the transportation of uranium, explosives (bulk emulsion) and consumables, including dangerous goods, on public roads • general health and safety risks associated with the proposal including, but not limited to, safety risks to road users associated with increased traffic and use of the existing road networks. 	<p>Section 4 Appendix E</p>
<p><i>Section 4.5.4.2 Relevant potential impacts</i></p> <p>The EIS must include a description of the relevant potential impacts during the construction, operational and decommissioning phases of the proposal.</p> <p>The following information must be provided for listed threatened species:</p> <ul style="list-style-type: none"> • a detailed assessment of the potential impacts upon native fauna including consideration, where relevant, of risks associated with the transport or storage of hazardous chemicals (as outlined below, Section 4.5.5). 	<p>Section 5 Appendix E</p>
<p><i>Section 4.5.5.2 Relevant potential impacts</i></p> <p>The EIS must include a description of the relevant potential impacts during the construction, operational and decommissioning phases of the project. The following information must be provided for listed migratory species:</p>	<p>Section 5 Appendix E</p>

EIS guideline	Reference in this report
<ul style="list-style-type: none"> • a detailed assessment of the potential impacts upon native fauna including consideration, where relevant, of risks associated with the transport of hazardous chemicals. 	
<p><i>Section 4.9 Additional matters of national environmental significance</i></p> <p><i>Section 4.9.3 Relevant impacts</i></p> <p>The EIS must include a description of the relevant impacts during both the construction, operational and (if relevant) the decommissioning phases of the project. The following information must be provided for Kakadu National Park (KNP) World Heritage Property and National Heritage Place, Ramsar wetland, and Commonwealth land:</p> <ul style="list-style-type: none"> • a detailed assessment of potential impacts upon the values of the KNP World Heritage Property and National Heritage Place; • a detailed assessment of potential impacts upon the ecological character of the KNP Ramsar Wetland; • a detailed assessment of impacts upon the Commonwealth land of KNP; and • consideration, where relevant, of risks associated with the transport of hazardous chemicals. 	<p>Section 2</p> <p>Section 5</p> <p>Appendix E</p>
<p><i>Section 4.9.4 Proposed safeguards and mitigation measures</i></p> <p>The EIS must provide information on proposed safeguards and mitigation measures to deal with relevant impacts of the action on matters of NES that are protected under Part 3 of the EPBC Act. Specific and detailed descriptions of proposed measures must be provided and substantiated and must include the following elements:</p> <ul style="list-style-type: none"> • a description of proposed safeguards and mitigation measures to deal with relevant impacts of the action, including mitigation measures to be taken by State/Territory governments, local governments or the proponent; • assessment of the expected or predicted effectiveness of the mitigation measures; and • any statutory or policy basis for the mitigation measures 	<p>Section 6</p> <p>Appendix C</p> <p>Appendix F</p>

1.2 PROJECT OBJECTIVES

This report undertakes to consider the following key elements:

- Identify proposed routes for transport to and from the underground mine, of construction materials, consumables, personnel and product for the proposal, including the use of existing roads.
- Identify existing traffic volumes on the road network and provide a comparison of the before and after Project development scenarios, and an indication of the traffic impacts that the Project will have on the existing road network.
- Consider projected traffic volumes associated with the Project in the context of the relative likelihood of incidents.
- Conduct a risk assessment of the maximum reasonable consequence to (a) public safety, and (b) the receiving environment, should an incident occur, based on quantitative analysis of incidents occurring along the identified haulage routes and assessment of the credible worst case consequence of the risk.
- Identify levels of any uncertainty about estimates of risk.
- Undertake an assessment of safeguards and mitigation measures adopted by ERA and its suppliers, in order to understand their adequacy to avoid or minimise the likelihood of an incident occurring, and their ability to take account of seasonality (wet/dry), nature of the consignment, truck / trailer configuration and design, and the biophysical nature of the local environment.

The Northern Territory Environment Protection Authority (NT EPA) and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC)¹ guidelines for the preparation of an EIS for the Project require a specific emphasis on the identification, analysis and mitigation of risk.

¹ Now the Department of the Environment

2. EXISTING ENVIRONMENT

2.1 STUDY AREA

The Ranger 3 Deeps underground mine (the Project) will be developed within the existing Ranger Project Area in the Alligator Rivers Region in the Northern Territory, approximately eight km east of Jabiru and 260 km east of Darwin. The extent of the study area for this traffic impact assessment is shown in Figure 1.

Key roadways within the study area include Berrimah Road and Tiger Brennan Drive in Darwin, and the Stuart, Arnhem, and Kakadu Highways. The road network is discussed in more detail in Section 2.4 below.

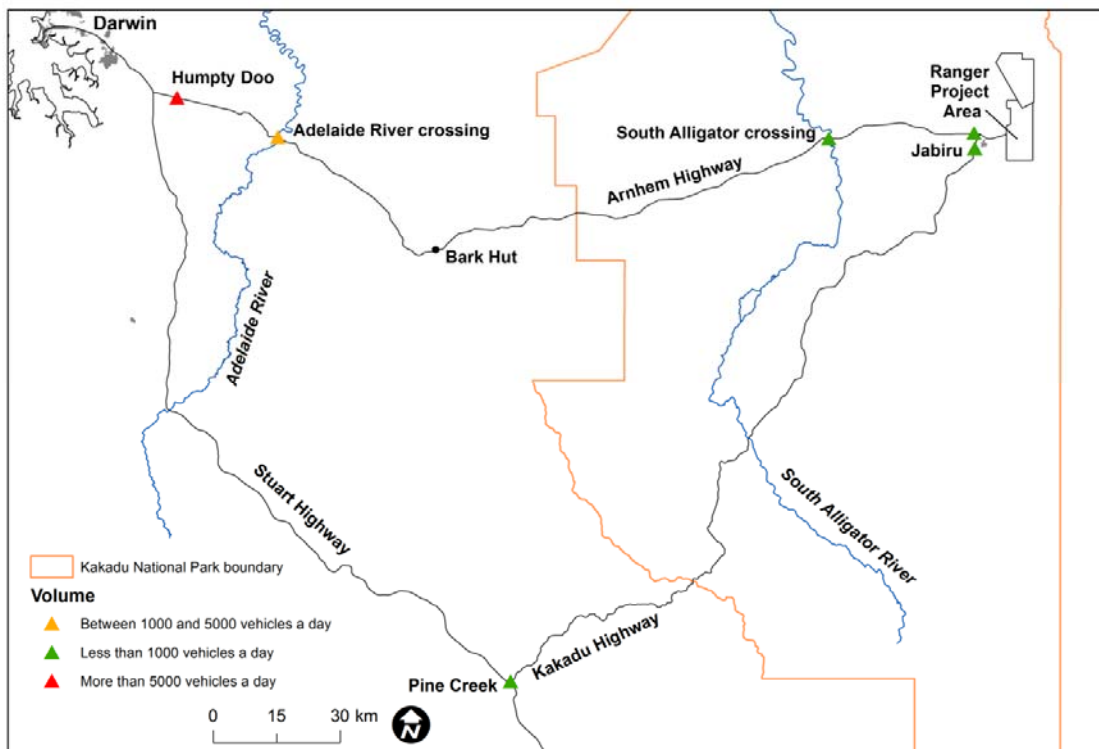
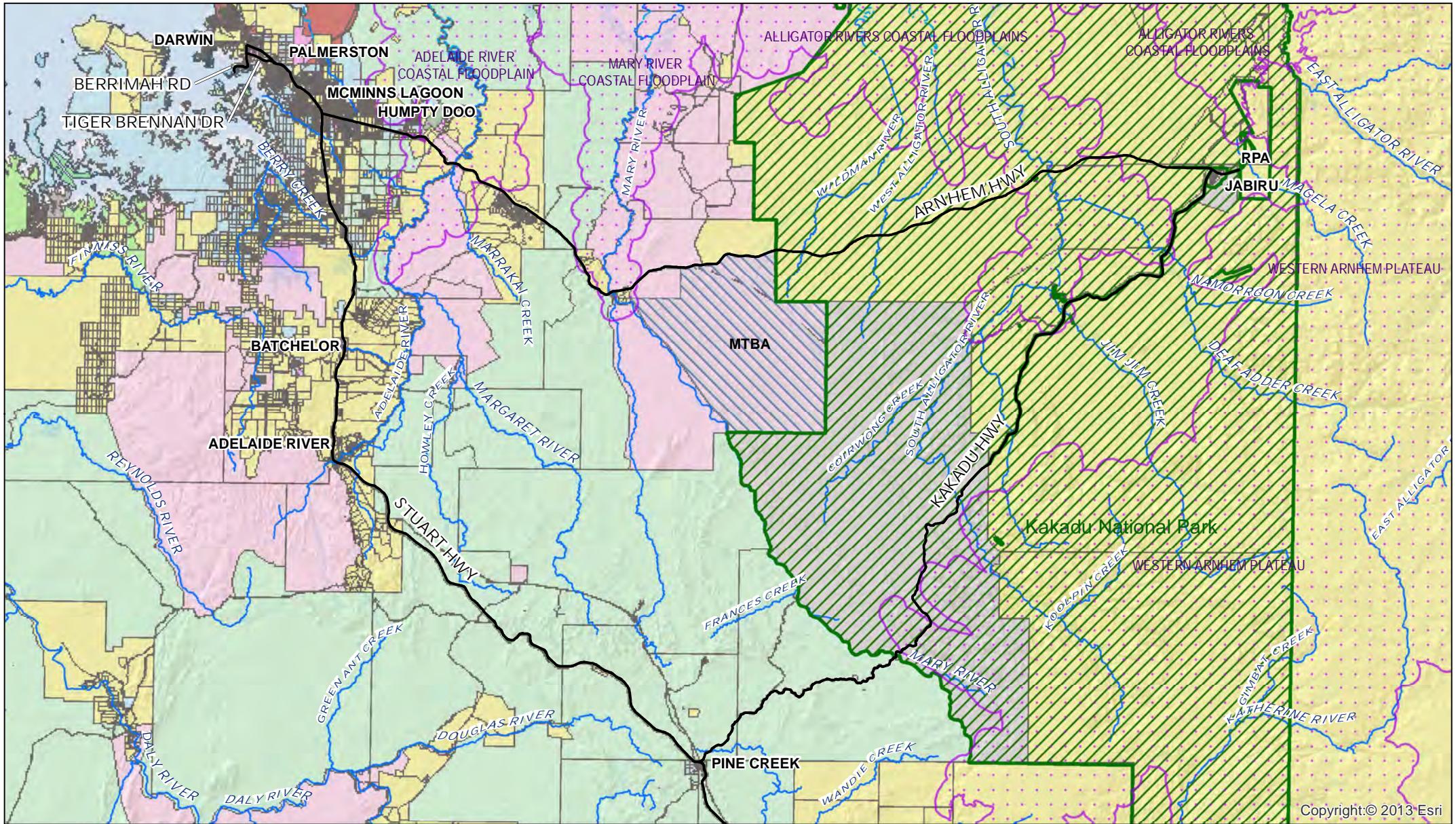


Figure 1 Study area road network

2.1.1 Existing Land Use

Existing land use (Figure 2) along the proposed routes includes residential land, agriculture and horticulture, grazing, a military training area and quarry on the Arnhem Highway; and large tracts of land set aside for conservation and tourism within Northern Territory and Commonwealth National Parks. These conservation areas are discussed in more detail in Section 2.3.

There are residential and light industrial areas, and areas under agriculture and horticulture in town centres at Jabiru, Pine Creek, Adelaide River, Humpty Doo, McMinn's Lagoon and Darwin. Pastoral land is concentrated on the Stuart Highway between Adelaide River and Pine Creek, with some grazing areas on the Kakadu Highway between Pine Creek and the Mary River.



Copyright: © 2013 Esri

Paper Size A4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

LEGEND

- Highway
- Kakadu NP
- MTBA
- Sites of Conservation Significance

Tenure Types

	Freehold		Crown Lease Perpetual
	Vacant		Right to Freehold Title
	Perpetual Pastoral Lease		Special Purpose Lease
	Reserve		Pastoral Lease
	Government		Registered Mining Lease
	Crown Lease Term		Other Lease

Energy Resources of Australia Ltd
Ranger 3 Deeps

Job Number 43-22105
Revision C
Date 21 Mar 2014

Land Use in the Study Area **Figure 2**

N:\AU\Darwin\Projects\43\22105\GIS\Maps\Deliverables (Optional)\4322105_Z001_Landuse_A4.mxd
 © 2014. Whilst every care has been taken to prepare this map, GHD (and Geoscience Australia, DLPE, DLRM) make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data source: Geoscience Australia, 250K Topo Map, 2008; DLPE NT, Tenure DCDB, 2014; SCS, DLRM. Created by:cwllson
 5/66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E dnmail@ghd.com W www.ghd.com

2.2 PHYSICAL ENVIRONMENT

2.2.1 Bioregions

Key roadways within the study area occur within three northern Australian biogeographic regions (Figure 3). Most of the route occurs within the Pine Creek bioregion, but the north western end of the Arnhem Highway lies within the southern extent of the Darwin Coastal bioregion; and the Kakadu Highway intercepts the Arnhem Plateau bioregion in the south east section of highway. A brief description of each bioregion below provides an overview of the landscape features that intersect the transport corridor.

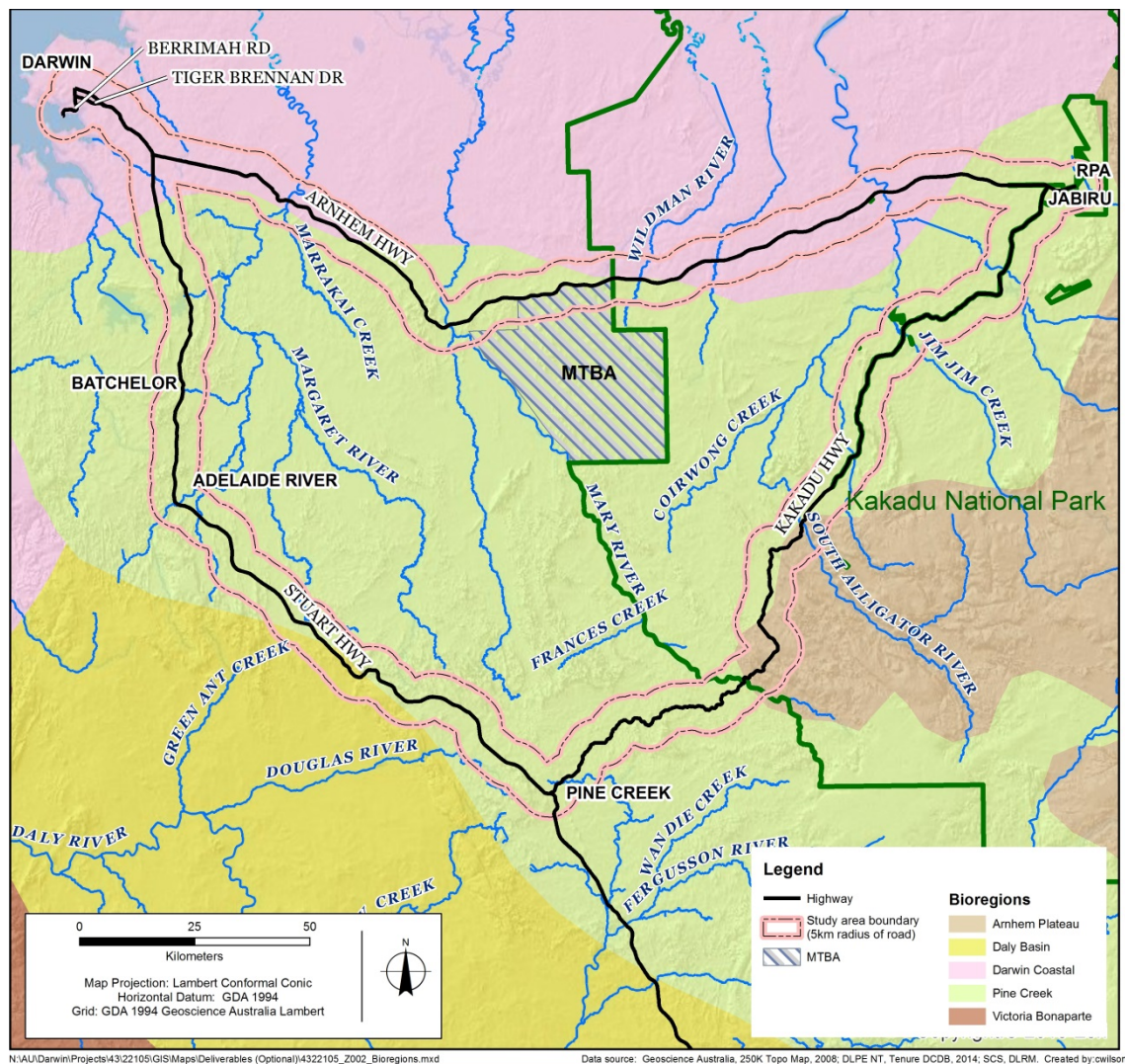


Figure 3 Bioregions in the study area

Pine Creek Bioregion

The Pine Creek bioregion comprises foothill environments below and to the west of the western Arnhem Land sandstone massif. Its main defining feature is the highly mineraliferous Pine Creek Geosyncline, comprising Archaean granite and gneiss overlain by Palaeoprotozoic sediments. Land types of the Pine Creek bioregion are mainly hilly to rugged ridges with undulating plains. Vegetation communities include eucalypt woodlands, patches of monsoon forests, Melaleuca woodlands, riparian vegetation and tussock grasslands.

The major vegetation types are eucalypt tall open forests typically dominated by Darwin woollybutt (*Eucalyptus miniata*) and Darwin stringybark (*E. tetradonta*), and woodlands (dominated by species including *E. grandifolia*, *E. latifolia*, *E. tintinnans*, *E. confertiflora* and *E. tectiflora*); with smaller areas of monsoon rainforest. Characteristic species include the granivorous birds such as Gouldian finch (*Erythrura gouldiae*), hooded parrot (*Psephotus dissimilis*) and partridge pigeon (*Geophaps smithii*). This relatively small bioregion has not been divided into subregions (DLRM 2013, SEWPaC 2008d).

There is significant fire activity in the bioregion (particularly in the late dry season) due to large tracts of grazing land that have nil to low levels of pastoral development and consequent minimal firebreaks and control measures (SEWPaC 2008d). Feral animals (pigs, cattle, horses and buffalo) and weeds (especially mission grass and gamba grass) are widespread.

Arnhem Plateau Bioregion

The Arnhem Land plateau is topographically complex, including sheer escarpments, deep narrow gorges, spectacular waterfalls, and the headwaters of some of the largest river systems in the Northern Territory, including the Katherine (Daly), Mary, South Alligator, East Alligator, and Mann Rivers, plus tributaries of the Roper River.

The plateau is the most significant region in the Northern Territory for biodiversity. It contains far more of the Northern Territory's endemic species than anywhere else (including at least 160 plant species found nowhere else and an unusually high number (at least 32) of threatened species (Woinarski et al. 2006).

The Arnhem Land plateau also supports a high proportion of the Northern Territory's monsoon rainforest, including almost all of the distinctive rainforest associations dominated by the endemic tree *Allosyncarpia ternata* (Woinarski et al. 2006). The vegetation also includes sandstone heathlands, hummock grasslands and woodlands (SEWPaC 2008a).

The rugged nature of this bioregion affords its species some protection from threatening processes that have affected biodiversity elsewhere.

The most significant management issue within the bioregion is the control and management of fire, particularly late dry-season burns. Invasive animal control programs are implemented opportunistically on conservation areas and reserves, but are not sufficiently coordinated to extend to Aboriginal or pastorally managed lands (DLRM 2013).

Darwin Coastal Bioregion

The Darwin Coastal bioregion comprises gently undulating plains on lateritised Cretaceous sandstones and siltstones; sandy and loamy red and yellow earths and siliceous sands from near the mouth of the Victoria River to just west of Cobourg Peninsula. The most notable vegetation feature is the extensive and diverse floodplain environment associated with the lower reaches of the many large river systems. The

Darwin Coastal bioregion is generally flat, low-lying country, drained by several large rivers (DLRM 2013, DOTE 2008c).

Vegetation communities include eucalypt forest and woodlands with tussock and hummock grass understorey. There are also substantial areas of mangroves, and rainforest and other riparian vegetation fringing the rivers. Inland from the coast, the dominant vegetation type is eucalypt tall open forest, typically dominated by Darwin woollybutt (*E. miniata*) and Darwin stringybark (*E. tetradonta*).

A major regional issue in the Darwin Coastal bioregion is weed infestation, including the transformation of floodplain areas by the woody weed *Mimosa pigra*; and of Eucalyptus forests by the rapid spread of pastoral species including Gamba grass. Floodplains are also reported to be undergoing floristic change associated with altered fire regimes (DLRM 2013.)

2.3 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

2.3.1 Desktop Assessment of MNES

A desktop assessment was undertaken of the surrounding environment within a five kilometre buffer of the Arnhem, Kakadu and Stuart Highways. A desktop review of background information and data included:

- Department of the Environment Protected Matters Search Tool (PMST) was used to identify MNES potentially occurring in the study area
- Northern Territory Department of Land Resource Management (DLRM) Fauna Atlas database records (not predictions) from the study area
- mapping of surface water features (Bureau of Meteorology)
- geology mapping (GeoScience Australia)
- land systems and soils mapping (DLRM)
- vegetation mapping (DLRM)

2.3.1 Listed Threatened Ecological Communities

The PMST results include identification of the Endangered Arnhem Plateau Sandstone Shrubland Complex as likely to occur within the study area.

The Arnhem Shrubland Complex occurs on the Arnhem Plateau and outliers such as Ubirr, Nawurlandja (Little Nourlangie Rock), Burrunggui (Nourlangie Rock) and the Marawal Plateau. The community occurs predominantly at higher elevations (200m to 400m) on sandstone rock pavements and also in low nutrient acid soils derived from shallow sandsheets, in areas with major rocky components.

The Arnhem Shrubland Complex may adjoin or intergrade with monsoon vine forest or with savanna open woodland and forest that have a wider distribution on the Arnhem Plateau; but the ecological community is able to be distinguished from these various woodlands and forest types by the lack of a distinct and well developed tree canopy (SEWPaC 2012).

Due to the dissected geology of the Plateau, the ecological community is naturally fragmented, but its capacity to intergrade with other, more extensive woodland and forest communities ensures connectivity.

An indicative distribution map (SEWPaC 2011a) puts the community largely in areas to the west and northwest of the study area, with the 'may occur' boundary of its distribution intersecting with the edge of the Arnhem Plateau and Kakadu Highway in the vicinity of the South Alligator River and Mary River crossings. Based on available information (SEWPaC 2012) about the habitat preferences and likely distribution of the ecological community, it is not considered likely to occur in the study area.

2.3.2 Listed Threatened Species

The PMST only considers flora and fauna species listed in one or more provisions of the EPBC Act, and is based on the predicted distributions of flora and fauna species and/or their habitat, rather than known records.

The PMST and DLRM database results, accessed in December 2013, identified 13 threatened flora species and 43 threatened fauna species predicted or known to occur in the study area (threatened under both the EPBC and TPWC Acts) (Figure 4 and Figure 5). This includes 11 mammals, 14 birds, 12 reptiles, 1 amphibian and 5 fish.

The PMST and DLRM database results identified 56 migratory species predicted or known to occur in the study area (under the EPBC Act) (Figure 6). This includes three mammals, 46 birds and 7 reptiles.

Likelihood of Occurrence of Threatened and Migratory Species

The likelihood of occurrence of threatened and migratory species within a five kilometre buffer of the Arnhem, Kakadu and Stuart Highways was assessed based on desktop searches and literature review.

Desktop review of biophysical data from the study area highlighted areas of higher diversity, indicated by an abundance of species records. These 'hotspots' for biodiversity correlated closely with wetland and floodplain areas along the transport route. Figure 4, Figure 5 and Figure 6 depict the geographical distribution of threatened species records along the transport route, for listed threatened flora, fauna and migratory species respectively.

Likelihood of occurrence of listed threatened species/community was assessed on a 3-tier scale:

- Possible - suitable habitat occurs within the study area.
- Unlikely - suitable habitat unlikely to occur within the study area, or suitable habitat substantially modified, or suitable habitat present but species not recorded for over 50 years.
- Highly unlikely - no suitable habitat present within the study area and individuals not recorded within study area.

The complete results of this likelihood assessment can be seen in Appendix A. The key results of the assessment can be summarised as follows:

- no listed threatened ecological community was assessed as possibly occurring within a five kilometre buffer of the Arnhem, Kakadu and Stuart Highways
- 11 listed threatened mammals were assessed as possibly occurring
- 50 listed threatened birds were assessed as possibly occurring
- 7 listed threatened reptiles were assessed as possibly occurring
- 1 listed threatened amphibian was assessed as possibly occurring

- 5 listed threatened fish were assessed as possibly occurring
- 13 listed threatened plants were assessed as possibly occurring.

2.3.3 Kakadu National Park

Approximately 50 % of the Arnhem Highway and 75 % of the Kakadu Highway are contained within the Kakadu National Park (KNP). KNP covers an area of 20,000 km² within the Alligator Rivers Region. It extends from the coast in the north to the southern hills and basins 150 km to the south, and 120 km from the Arnhem Land sandstone plateau in the east through wooded savanna to the western boundary.

The Park is geologically and biologically diverse. Major landforms and habitats within the Park include the sandstone plateau and escarpment, extensive areas of savanna woodlands and open forest, rivers, billabongs, floodplains, mangroves, mudflats, coastal areas and monsoon forests (SEWPaC 2011).

The value of the natural and cultural heritage of the Park to the world has been recognised by its inscription on the World Heritage List under the World Heritage Convention. The Park is also on the National Heritage List and Commonwealth Heritage List under the EPBC Act. It is an important area for a number of indigenous groups and is also an important place for Northern Territory tourism.

The entire KNP is also listed as a wetland of international importance under the Ramsar Convention, and many species that occur in the Park are protected under international agreements such as the Bonn Convention for conserving migratory species and Australia's migratory bird protection agreements with China (CAMBA), Japan (JAMBA) and the Republic of Korea (ROKAMBA) (SEWPaC 2011).

2.3.4 Wetlands of International Importance (Listed Under the Ramsar Convention)

The KNP Ramsar site encompasses the entire National Park. The site is a mosaic of contiguous wetlands comprising the catchments of two large river systems, the East and South Alligator rivers, seasonal creeks and the lower reaches of the East Alligator River. It also includes the Magela Creek floodplain, the lower South Alligator floodplain, virtually the entire West Alligator River system and nearly all the Wildman River system (SEWPaC 2011).

The KNP (Stage I including wetland components of Stage III) Ramsar site comprises all lands and waters in the eastern portion of the KNP, following the eastern boundary of the Park along the East Alligator River and including the Nourlangie, Jim Jim and Barramundi Creeks. In 1995, the boundaries of site number two were extended to include only the wetland habitats within the eastern and southern areas of KNP (Stage III).

KNP (Stage II) Ramsar site encompasses all lands and waters situated in the northern and western part of the National Park, including the Wildman, West Alligator and South Alligator River systems and their floodplains, following the western KNP boundary. The Stage II area also included both Field Island and Barron Island within Van Diemen Gulf to the low water mark.

In April 2010, the two Ramsar sites were combined to form a single Ramsar site. In addition, the site was extended by approximately 600,000 hectares to include all remaining areas of Stage III. The merger and extension brought the Ramsar boundary in line with the existing boundary of the national park (SEWPaC 2011).

2.3.5 Mt Bunday Military Training Area

The Mt Bunday Military Training Area (MBTA) contributes to biodiversity conservation due to its contiguous relationship to the east and south with Kakadu National Park, and along its western boundary with McKinlay Conservation Reserve and due to the removal of grazing in 1996 (Department of the Environment 2013a). It is a listed place on the Commonwealth Heritage List.

The MBTA has a high diversity of significant fauna habitats represented by the seasonal melaleuca and grassland floodplains and permanent waterholes of the Mary and Wildman Rivers. The seasonal floodplain of the Mary River provides important early wet season feeding and breeding habitat for waterbirds, crocodiles and amphibians. The seasonal floodplains, permanent freshwater billabongs, swamps and waterholes of the Mary and Wildman Rivers are valuable dry season refuges. The savanna woodlands and open forest provide valuable feeding habitat for the nationally endangered Gouldian finch (*Erythrura gouldiae*) and the species has been recorded in the Craig Creek catchment in the southern portion of the place where they feed on *Sorghum* spp. grasslands in the dry season. The MBTA also contains vine thicket (monsoon rainforests) patches, which comprise less than 0.2 % of the vegetation cover in the Northern Territory.

2.3.6 Northern Territory Sites of Conservation Significance (SOCS)

Scientists from the Northern Territory DLRM have identified areas that are recognised as areas of national or international significance for biodiversity conservation. Four of these sites intersect the Project study area (see Figure 2 above) and are described briefly below (DLRM 2013a).

Adelaide River Coastal Floodplain

The Adelaide River coastal floodplain lies 50 km east of Darwin and intersects the Arnhem Hwy in the vicinity of the Adelaide River crossing. The floodplain is a large seasonally-inundated freshwater floodplain that is traversed by the Adelaide River, a major and permanent tidal river. The floodplain comprises a mix of tidal and seasonal wetland habitats and is dominated by grass and sedge communities (DLRM 2013a).

The Adelaide River floodplain regularly supports large numbers of waterbirds including internationally significant numbers of many species such as Magpie Geese and Whistling-Ducks. The upper and middle parts of the floodplain provide core nesting habitat for Magpie Geese, and the largest waterbird breeding colony in the Northern Territory is found in mangroves in the lower reaches of the Adelaide River. Significant numbers of at least three species of migratory shorebird periodically use inland wetland areas on the floodplain, such as Lake Finniss (DLRM 2013a).

Mary River Coastal Floodplain

The Mary River coastal floodplain intersects the Arnhem Highway at the Mary River crossing and is unusual in the Top End in lacking a single major river channel through the floodplain to the ocean. The floodplain is poorly drained and the inflow channel diffuses into vast seasonal swamps before reaching the sea through a number of tidal channels (DLRM 2013a).

Compared to other coastal floodplains in the Northern Territory, this feature results in greater areas of wetland habitats flooded over extended periods and an extremely complex and productive system. The floodplain is dominated by a mix of sedge and

grass communities and large paperbark forests in the north, and fringed by open eucalypt woodland and pockets of monsoon forest.

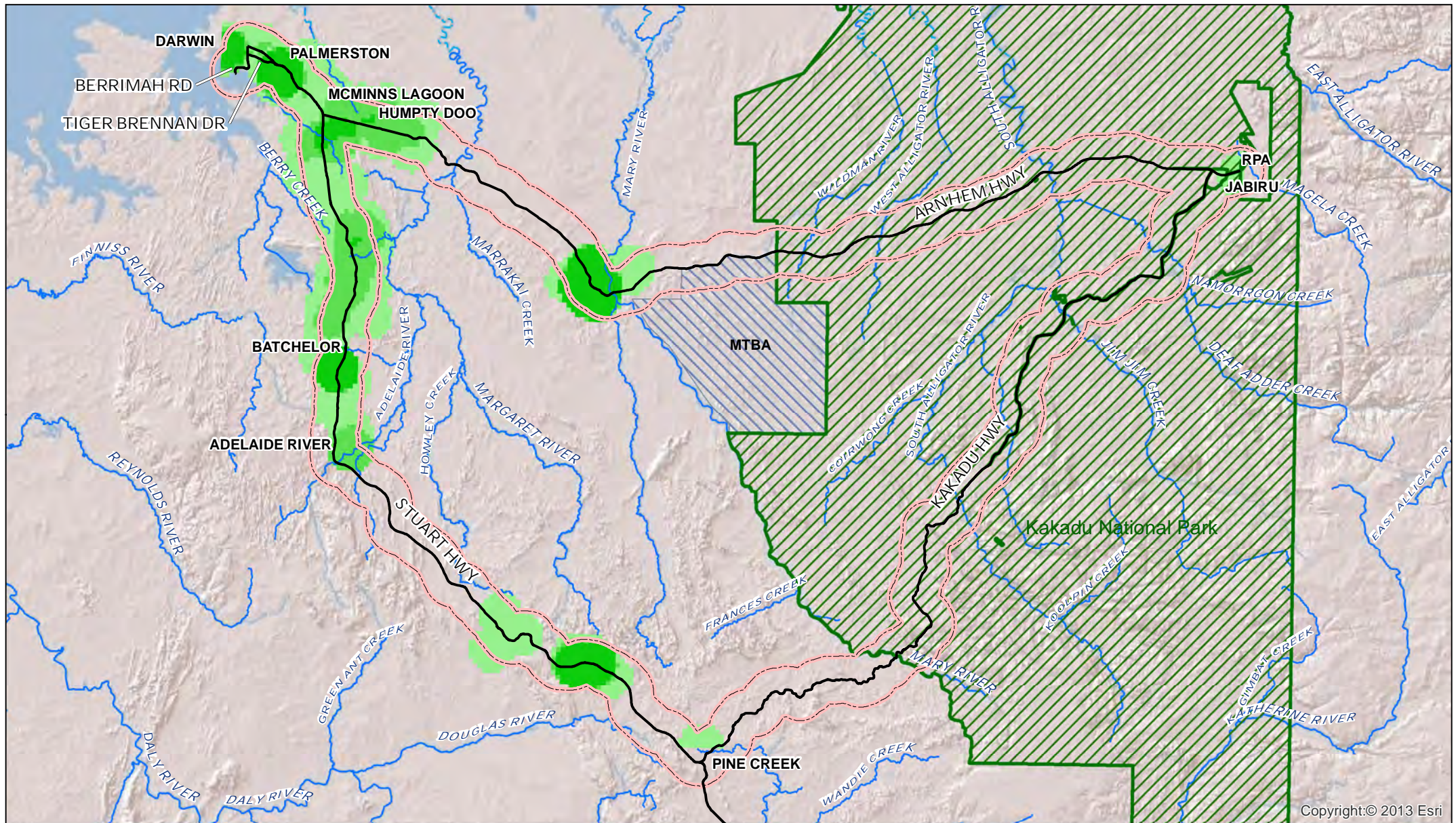
The floodplain is the most significant and reliable breeding site for Magpie Geese in the Northern Territory, and numbers exceed 400,000 birds in some years. The floodplain environment also provides a major breeding area for many fish species (DLRM 2013a).

Alligator Rivers Coastal Floodplains

The Alligator Rivers coastal floodplains include four large adjacent floodplains that form the southern coastline of Van Diemen Gulf. These are the iconic wetlands of Kakadu National Park, approximately 190 km east of Darwin. The site of conservation significance intersects the Arnhem and Kakadu Highways at the south Alligator River crossing and Nourlangie Creek crossing. The floodplains extend along the major rivers (Wildman, and West, South and East Alligator) and seasonal creeks (notably Magela, Nourlangie and Murganella) in the region. The floodplains form a continuous wetland system with the Mary River and Adelaide River floodplains. This diverse wetland area includes seasonally flooded freshwater floodplains and swamps, and tidally influenced mud flats and mangroves in the lower river reaches (DLRM 2013a).

Western Arnhem Plateau

The sandstone plateau of western Arnhem Land extends over an area of about 32,000 km². It intersects the Kakadu Highway in the vicinity of the South Alligator River and Mary River crossings. Its distinction, in geology, topography and biodiversity, from the surrounding lowlands is so marked that it is recognised as comprising its own entire bioregion as discussed above (DLRM 2013a).

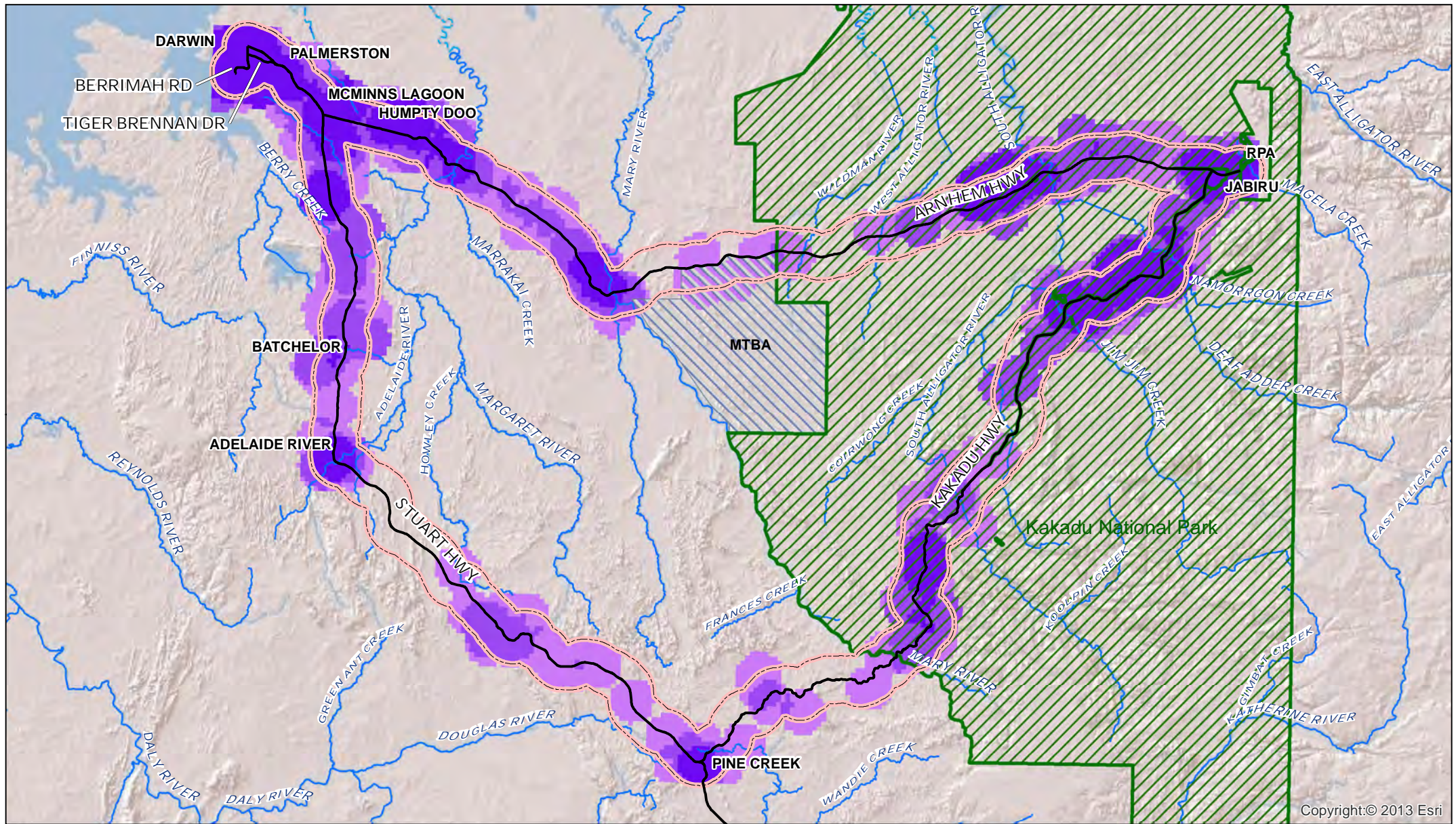


Copyright:© 2013 Esri

<p>Paper Size A4</p> <p>Kilometres</p> <p>Map Projection: Transverse Mercator Horizontal Datum: GDA 1994 Grid: GDA 1994 MGA Zone 52</p>		<p>LEGEND</p> <ul style="list-style-type: none"> Highway Record search area (5km radius of road) Kakadu NP MTBA <p>Density of threatened flora records</p> <ul style="list-style-type: none"> High abundance Medium abundance Low abundance 		<p>Energy Resources of Australia Ltd Ranger 3 Deeps</p> <p>Job Number 43-22105 Revision C Date 21 Mar 2014</p>
---	--	---	--	--

Density of threatened flora species records **Figure 4**

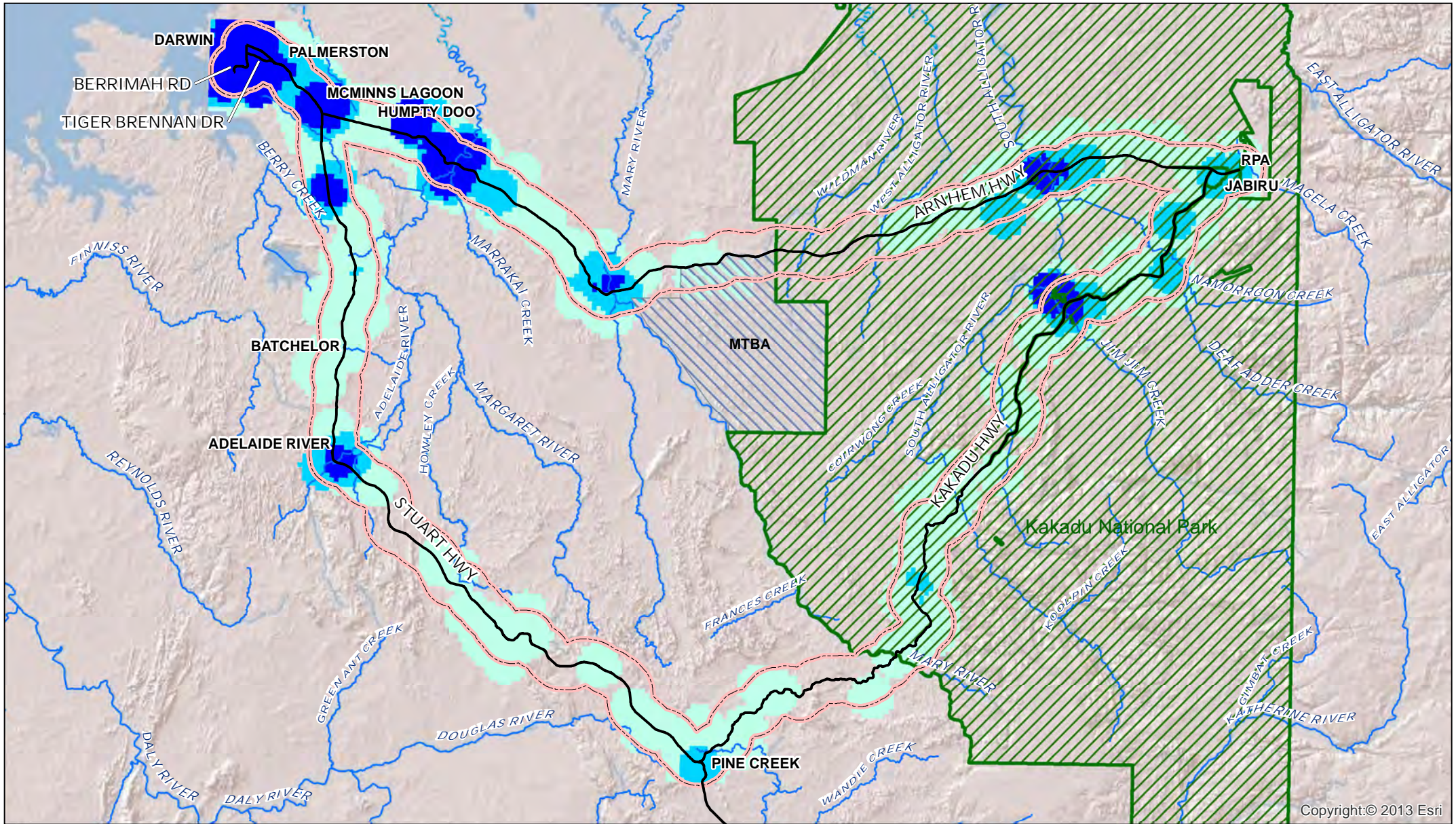
G:\43\22105\GIS\Maps\Deliverables (Optional)\4322105_2003_ThreatenedFloraRecordsRelativeDensity_A4.mxd
 5/66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E dnwmail@ghd.com W www.ghd.com
 © 2014. Whilst every care has been taken to prepare this map, GHD (and Geoscience Australia, DLRM) make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data source: Geoscience Australia, 250K Topo Map, 2008; Species Atlas, DLRM, 2013. Created by:cwilson




Copyright:© 2013 Esri

<p>Paper Size A4</p> <p>Kilometres</p> <p>Map Projection: Transverse Mercator Horizontal Datum: GDA 1994 Grid: GDA 1994 MGA Zone 52</p>		<p>LEGEND</p> <ul style="list-style-type: none"> Highway Kakadu NP MTBA Record search area (5km radius of road) <p>Density of threatened fauna records</p> <ul style="list-style-type: none"> High abundance Medium abundance Low abundance 		<p>Energy Resources of Australia Ltd Ranger 3 Deeps</p> <p>Job Number 43-22105 Revision C Date 21 Mar 2014</p> <p>Density of threatened fauna species records</p>	<p>Figure 5</p>
---	--	---	--	--	------------------------

G:\43\22105\GIS\Maps\Deliverables (Optional)\4322105_Z004_ThreatenedFaunaRecordsRelativeDensity_A4.mxd
 © 2014. Whilst every care has been taken to prepare this map, GHD (and Geoscience Australia, DLRM) make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data source: Geoscience Australia, 250K Topo Map, 2008; Species Atlas, DLRM, 2013. Created by:cwilson
 5/66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E dnwmail@ghd.com W www.ghd.com



Copyright:© 2013 Esri

<p>Paper Size A4</p>  <p>Kilometres</p> <p>Map Projection: Transverse Mercator Horizontal Datum: GDA 1994 Grid: GDA 1994 MGA Zone 52</p>		<p>LEGEND</p> <ul style="list-style-type: none">  Highway  Kakadu NP  MTBA  Record search area (5km radius of road) 	<p>Density of migratory species records</p> <ul style="list-style-type: none">  High abundance  Medium abundance  Low abundance 		<p>Energy Resources of Australia Ltd Ranger 3 Deeps</p>	<p>Job Number 43-22105 Revision C Date 21 Mar 2014</p>
--	---	--	--	---	---	--

Density of migratory species records

Figure 6

G:\43\22105\GIS\Maps\Deliverables (Optional)\4322105_Z005_MigratorySpeciesRecordsRelativeDensity_A4.mxd
 © 2014. Whilst every care has been taken to prepare this map, GHD (and Geoscience Australia, DLRM) make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data source: Geoscience Australia, 250K Topo Map, 2008; Species Atlas, DLRM, 2013. Created by:cwilson
 5/66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E dnwmail@ghd.com W www.ghd.com

2.4 EXISTING ROAD NETWORK

Key roadways within the study area are Berrimah Road, Tiger Brennan Drive, and the Stuart, Arnhem, and Kakadu Highways. For the purposes of traffic assessment and analysis the road network has been broken up into road sections, depicted in Figure 7 below. Road sections marked in black (Figure 7) are not included in the study area. Road sections included in the study area are:

- Berrimah Road south of the intersection with Tiger Brennan Drive (6.8 km)
- Tiger Brennan Drive between Berrimah Road and Stuart Highway (6.3 km)
- Stuart Highway has been divided into three road sections
 - approximately 16 km between Tiger Brennan Drive and Arnhem Highway
 - 190 km between Arnhem Highway and the town of Pine Creek
 - 200 km between the town of Pine Creek and the town of Mataranka
- Arnhem Highway has been divided into two sections
 - approximately 223 km between Stuart Highway and the town of Jabiru
 - approximately 5 km between the town of Jabiru and the RPA
- Kakadu Highway entire length from Jabiru to Pine Creek (approximately 210 km).

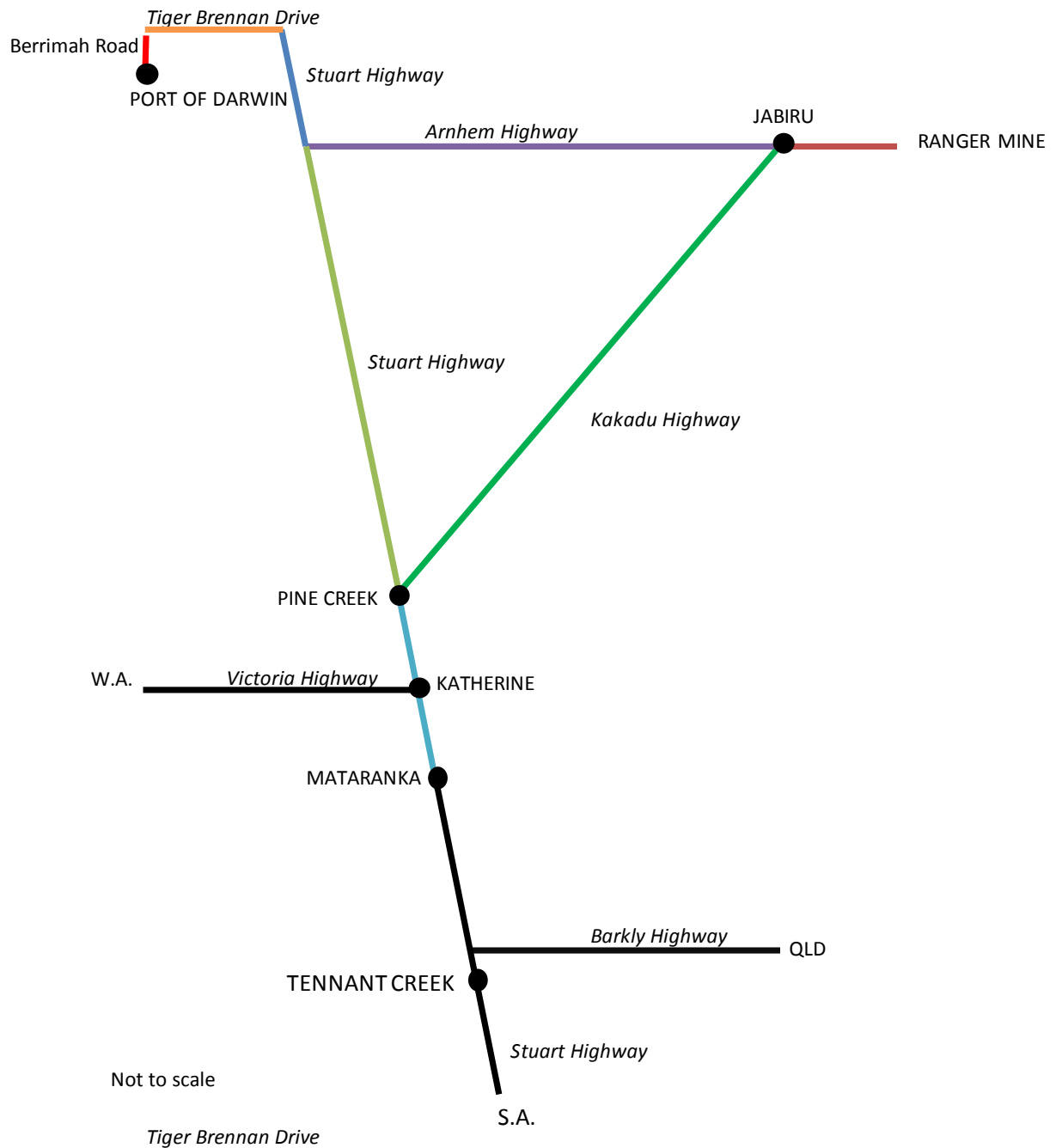


Figure 7 Study area road sections indicating defined route sections described above

A site inspection was undertaken on 28-29 November 2013 along the key roads in the study area. The site inspection was carried out in order to:

- familiarise the project team with the existing road conditions and types of vehicles utilising these roads
- identify any major road condition or road design issues including very steep roads or tight alignments.

The following section summarises the existing conditions along the key roads within the study area.

2.4.1 Berrimah Road

The study area includes 6.8 km of Berrimah Road south of the intersection with Tiger Brennan Drive. This is a two-lane, two-way road separated by a painted median. The road is sealed and typically does not have shoulders. Sealed shoulders with a width of 0.5 m have been developed towards the intersection of Tiger Brennan Drive.

2.4.2 Tiger Brennan Drive

Tiger Brennan Drive between Berrimah Road and Stuart Highway is approximately 6.3 km in length. Tiger Brennan Drive has been upgraded to provide four lanes (two-way) with a vegetated median. The road is sealed and has shoulders on both sides.

2.4.3 Stuart Highway

The Stuart Highway (A1) is a national highway connecting Darwin, Katherine, Daly Waters, Tennant Creek, Alice Springs and Port Augusta in South Australia. It is a sealed, approximately 7 m wide, two lane single carriageway with one lane in each direction for most of its length. The maximum posted speed limit is 130 km/h, except for a 200 km road section directly north of Alice Springs, where an open speed limit trial commenced in February 2014. This highway has four lane sections north of Arnhem Highway. There are typically no shoulders on the side of the road, although there are sections with unsealed shoulders.

Stuart Highway between Tiger Brennan Drive and Arnhem Highway has a four lane cross-section and is separated by a vegetated median (Plate 1). The section between Arnhem Highway and Pine Creek is similar to the section between Tiger Brennan Drive and Arnhem Highway, but generally has a two lane undivided cross-section. The section between Pine Creek and Mataranka is typically a two lane two-way undivided road (Plate 2).



Plate 1 Stuart Hwy - two-way, four lane sealed roadway separated by vegetated median, located 31km from the Berrimah Road intersection



Plate 2 Stuart Hwy - two-way, two lane sealed roadway section, located 145 km from the Berrimah Road intersection

2.4.4 Arnhem Highway

The Arnhem Highway (A36) is a 220 km rural highway that links Jabiru, within the Kakadu National Park, to the Stuart Highway some 35 km south of Darwin. It is classified as an 'A' standard road within the Department of Transport road hierarchy, thereby theoretically providing high of standard driving conditions with two 3.5 m wide traffic lanes on a single carriageway, sealed shoulders, and signage and line-marking that is easily seen in all weather conditions (Plate 3 and Plate 4).

Running generally in an easterly direction from the Stuart Highway junction through to Jabiru, the topography is generally flat with long straights and broad curves to provide good sight lines.

A high proportion of traffic is recreational and freight orientated as a consequence of the many tourist attractions and supply needs of the Jabiru Township and Ranger uranium mine. The posted speed limit is 130 km/h, with short sections of 100 km/h and 80 km/h in the vicinity of Humpty Doo, South Alligator and Jabiru. Traffic flows along the Arnhem Highway may be affected by road restrictions and closures during the wet season (generally November – March) as the road becomes impassable through the low-lying flood plains near Adelaide River, Mary River and South Alligator River.



Plate 3 Arnhem Hwy - unsealed shoulders, 2.5 km from the Ranger mine



Plate 4 Arnhem Hwy - two-way, single lane sealed roadway section, 122km from Jabiru

2.4.5 Kakadu Highway

The Kakadu Highway (B21) is also a rural highway that runs generally in a south westerly direction from the Arnhem Highway at Jabiru to the Stuart Highway at Pine Creek a distance of approximately 210 km. It is classified as a 'B' standard road to theoretically provide two 3.3 m wide traffic lanes, gravel shoulders, and signage and line-marking to aid delineation and guidance (Plate 5 and Plate 6). The topography is similar to the Arnhem Highway, but it is more undulating and meandering in places, thus requiring lower speeds, particularly just north of the Mary River Roadhouse where there are steep grades and tight curves on approach to Ikoymarrwa Lookout.

Because of the numerous floodways and causeways along its length, the Kakadu Highway may become restricted or impassable for small low-clearance vehicles during the wet season. A high proportion of the traffic on this highway is associated with tourism and the movement of goods and services. The posted speed limit is 130 km/h, with short sections of 100 km/h and 80 km/h on approach to the Stuart Highway and the Arnhem Highway.



Plate 5 Kakadu Hwy - unsealed shoulders 190km from Jabiru



Plate 6 Kakadu Hwy - unsealed clear-zone 30km from Jabiru

2.5 EXISTING TRAFFIC VOLUMES

2.5.1 Background Traffic Counts

Traffic volumes have been obtained from the Department of Transport (DoT) 2012 Annual Traffic Report (DoT 2012). For the purposes of assessing traffic capacity, the highest traffic volume data collected within each section has been utilised for this report.

Permanent counting stations along sections of the roads have collated vehicle counts to produce annual average daily traffic (AADT) volumes along each road. AADT is based on counts of all the traffic travelling in both directions, for a typical 24 hour period. The Ranger mine traffic however, is expressed in terms of round trips because each load of consumables or materials that is freighted to the Ranger mine results in a return vehicle trip, typically on the same day.

In order to arrive at a 'round trip equivalent' AADT that could be compared to the traffic count for Ranger mine, both with and without the project, AADT has been halved in this report. This converts the AADT into a 'round trip equivalent', so that an assessment of the Ranger mine traffic volumes and impact can be carried out.

The existing traffic volumes in 2012 along each road section have been summarised in Table 2. These include the volumes of current ERA traffic travelling to the Ranger mine, including both heavy vehicles and light vehicles.

The DoT does not have any permanent counting stations along Tiger Brennan Drive between Berrimah Road and the Stuart Highway and thus, no volumes were available for this road section. Based on reported AADT volumes west of Berrimah Road however, Tiger Brennan Drive between Berrimah Road and the Stuart Highway is estimated (in Table 2) to carry in the range of 15,000 vehicles per day (vpd).

Average daily traffic volumes vary significantly along the transport corridor, ranging from 12,000 vehicles on the Stuart Highway between Tiger Brennan Drive and Arnhem Highway, reducing down to 2,900 on the Arnhem Highway between Stuart Highway and Kakadu Highway.

Kakadu Highway daily traffic volumes are relatively uniform at 300 vpd along the length of the highway.

Table 2 Existing AADT volumes and round trip equivalent AADT volumes along each road section (2012)

Road Section	AADT Volumes (2012)	Round trip equivalent AADT Volumes (2012)
Berrimah Road	5,200	2,600
Tiger Brennan Drive	15,000 (estimated) ²	7,500
Stuart Highway, between Tiger Brennan Drive and Arnhem Highway	12,000	6,000
Stuart Highway, between Arnhem Highway and Pine Creek	7,500	3,750
Stuart Highway, between Pine Creek and Mataranka	700	350
Arnhem Highway, between Stuart Highway and Jabiru	2,900	1,450
Arnhem Highway, between Jabiru and Ranger mine	1,000	500
Kakadu Highway from Jabiru to Pine Creek	300	150

2.5.2 Existing ERA Light Vehicle Volumes

Workers and visitors travelling to the Ranger mine from Darwin are required by ERA to sign in at the Bark Hut Inn on the Arnhem Highway. Workers are required to provide details of their origin/destination and travel times. Typically light vehicle trips are between Darwin and Ranger mine. Round trip profiles have been analysed over one-year period from November 2012 to November 2013. From this data, a round trip average of 8 light vehicles has been determined, as indicated in Table 3.

In addition to the trips to and from Ranger mine from Darwin, workers at the mine travel to and from the Ranger mine from Jabiru. ERA has advised that approximately 100 round trips per day are made between Jabiru and the mine, which brings to 108 the total number of light vehicle round trips generated by the mine each day.

Table 3 Average daily light vehicle counts 2012 – 2013 (ERA 2013)

Day of the Week	Eastbound Direction	Westbound Direction	Total Average Count (one-way trips)	Total Average Count (round trips)
Sunday	5	3	8	4
Monday	13	5	18	9
Tuesday	12	6	18	9
Wednesday	9	10	19	10
Thursday	6	10	17	9
Friday	4	13	17	9
Saturday	4	6	10	5
From Jabiru			200	100
Daily Average			215	108

² Traffic volume data is not available for Tiger Brennan Drive

2.5.3 Existing ERA Heavy Vehicle Volumes

Interstate deliveries to the Ranger mine originate mainly from South Australia and Queensland. The predominant routes where heavy vehicles converge are either the Arnhem or Kakadu Highways via the Stuart Highway, and so these routes are the focus of the study area.

Heavy vehicles transporting consumables will typically travel towards the Ranger mine from Darwin, and interstate vehicles will pass through Mataranka, 200 km south of the Kakadu Highway intersection on the Stuart Highway. For the purposes of this report, all interstate trips will converge on Stuart Highway south of Kakadu Highway; and the effective origin of Mataranka has been used for simplicity. Thus Darwin or Mataranka have been adopted as the effective point of origin for the purpose of assessing traffic capacity as presented in Table 4.

Various consumables are transported to and from the Ranger mine as part of existing operations. The volumes for each consumable transported have been considered for both incoming and outgoing directions. Based on an understanding of existing operations, it is assumed that the trucks carrying their particular consumables make delivery at the Ranger mine and return to their originating location empty.

The exception is the transport of uranium oxide, which is back freighted. The uranium oxide is transported from Ranger mine by heavy vehicles which have undertaken scheduled deliveries of other consumables to the mine. The transport of uranium oxide represents only a small fraction of ERA transport requirements, and is consistent with historic volumes. The transport of Uranium oxide is not a significant contributor to overall traffic volumes.

The transport of consumables in 2012 is listed in Table 4 and is summarised as annual and average daily round trips.

Table 4 Existing ERA heavy vehicle volumes (Round trips, 2012)

Consumable / Product	Actual Origin	Effective Origin	Annual round trips	Average Daily round trips
Sulfuric acid	Darwin	Darwin	1,686	5
Quicklime	Mataranka	Mataranka	393	<2
Flocculant (Magnafloc 139)	Darwin	Darwin	93	<1
Diesel	Darwin	Darwin	338	1
Pyrolusite (Manganese oxide (IV) powder)	Darwin	Darwin	126	<1
Alamine 336	Adelaide	Mataranka	4	<1
ShellSol 2046 (kerosene)	Adelaide	Mataranka	26	<1
Anhydrous ammonia	Queensland	Mataranka	44	<1
Sodium hydroxide	Darwin	Darwin	7	<1
Miscellaneous	Darwin	Darwin	24	<1
Uranium oxide ³	Ranger mine	Ranger mine	-	-

³ Deliveries of uranium oxide are back freighted to Darwin and are therefore not counted separately.

2.5.4 Summary ERA Traffic Volumes

In summary, Ranger mine currently generates approximately 115 round trips per day, comprising 7 heavy vehicle trips and 108 light vehicle trips. Approximately 100 of these light vehicle trips are limited to travel between Jabiru and the Ranger mine, a distance of about 12 km.

The 2012 round trip equivalent AADT volumes are distributed to the road network in Figure 8 with the proportion of traffic generated by the Ranger mine indicated in brackets.

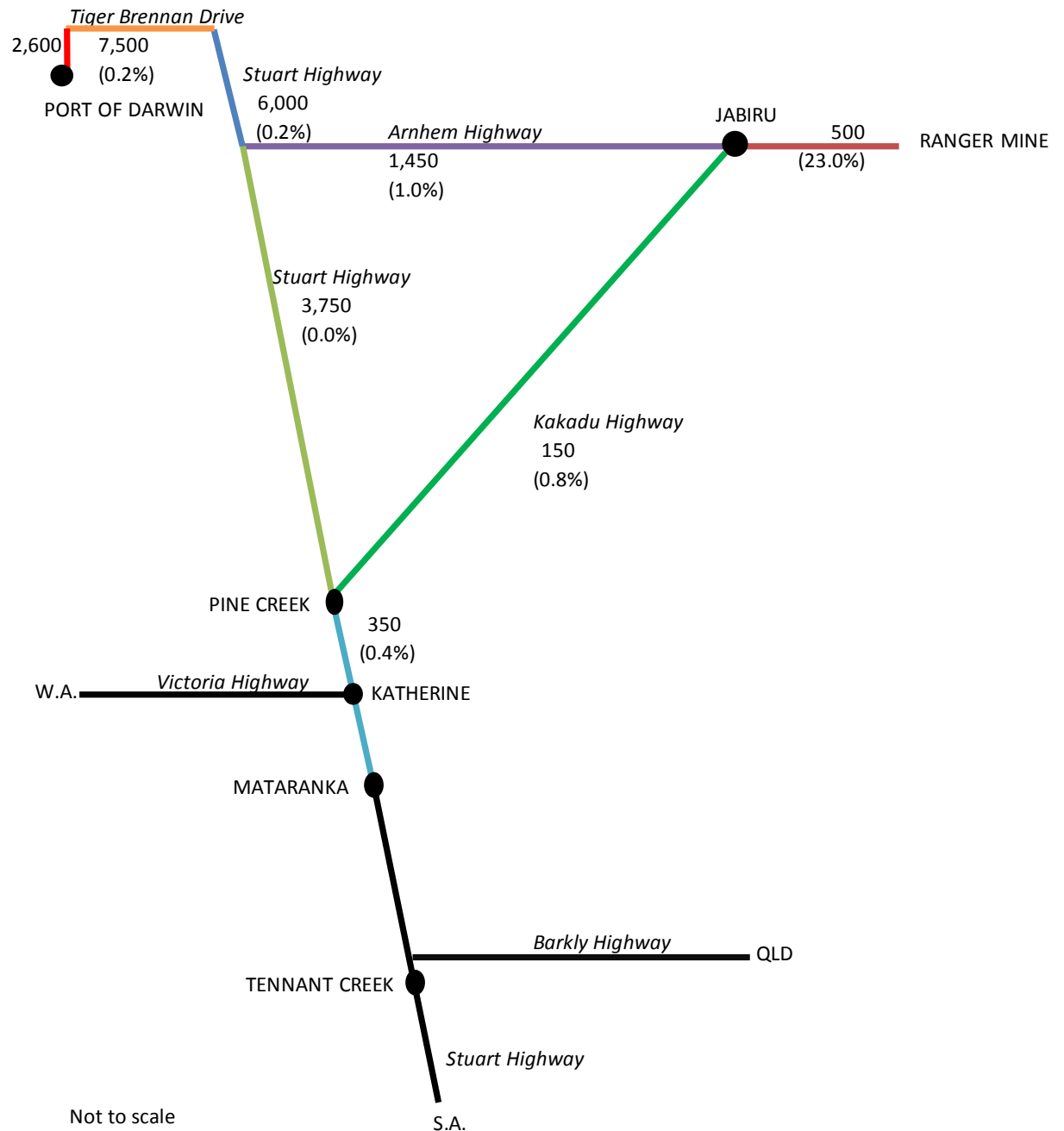


Figure 8 2012 AADT volumes and Ranger mine contribution (%)

2.5.5 Flooding of Arnhem Highway

During the wet season, the Arnhem Highway between Stuart Highway and Kakadu Highway may become inaccessible due to flooding. As a result, road closures may be implemented by the Department of Transport. Based on a review of data from the Road Access Report website for the study area (2004 – 2011), and following discussions with ERA; it is estimated that Arnhem Highway would be closed on average less than 2 weeks per year.

During this time, traffic that normally uses this section of Arnhem Highway is diverted south along Stuart Highway to Kakadu Highway, and the Kakadu highway may experience a small increase in traffic volumes. Given the short period of time in which this road closure occurs however, a detailed assessment of the extent of the traffic increase is not warranted.

2.5.6 Distribution of Existing ERA Heavy Vehicles

Based on the existing haulage routes for the transport of consumables, the heavy vehicle trips have been distributed to the road network within the study area in Table 5 and Figure 9 below. This represents the volume of heavy vehicles related to existing operations at the Ranger mine.

Table 5 Current Ranger mine heavy vehicle distributed volumes (Round trips, 2012)

Road Section	Standard Operating Conditions	
	Annual Volume	Daily Volume
Berrimah Road	2,273	6
Tiger Brennan Drive	2,273	6
Stuart Highway, between Tiger Brennan Drive and Arnhem Highway	2,273	6
Stuart Highway, between Arnhem Highway and Pine Creek	30	<1
Stuart Highway, between Pine Creek and Mataranka	466	<2
Arnhem Highway, between Stuart Highway and Jabiru	2,303	6
Arnhem Highway, between Jabiru and Ranger mine	2,740	8
Kakadu Highway from Jabiru to Pine Creek	437	<2

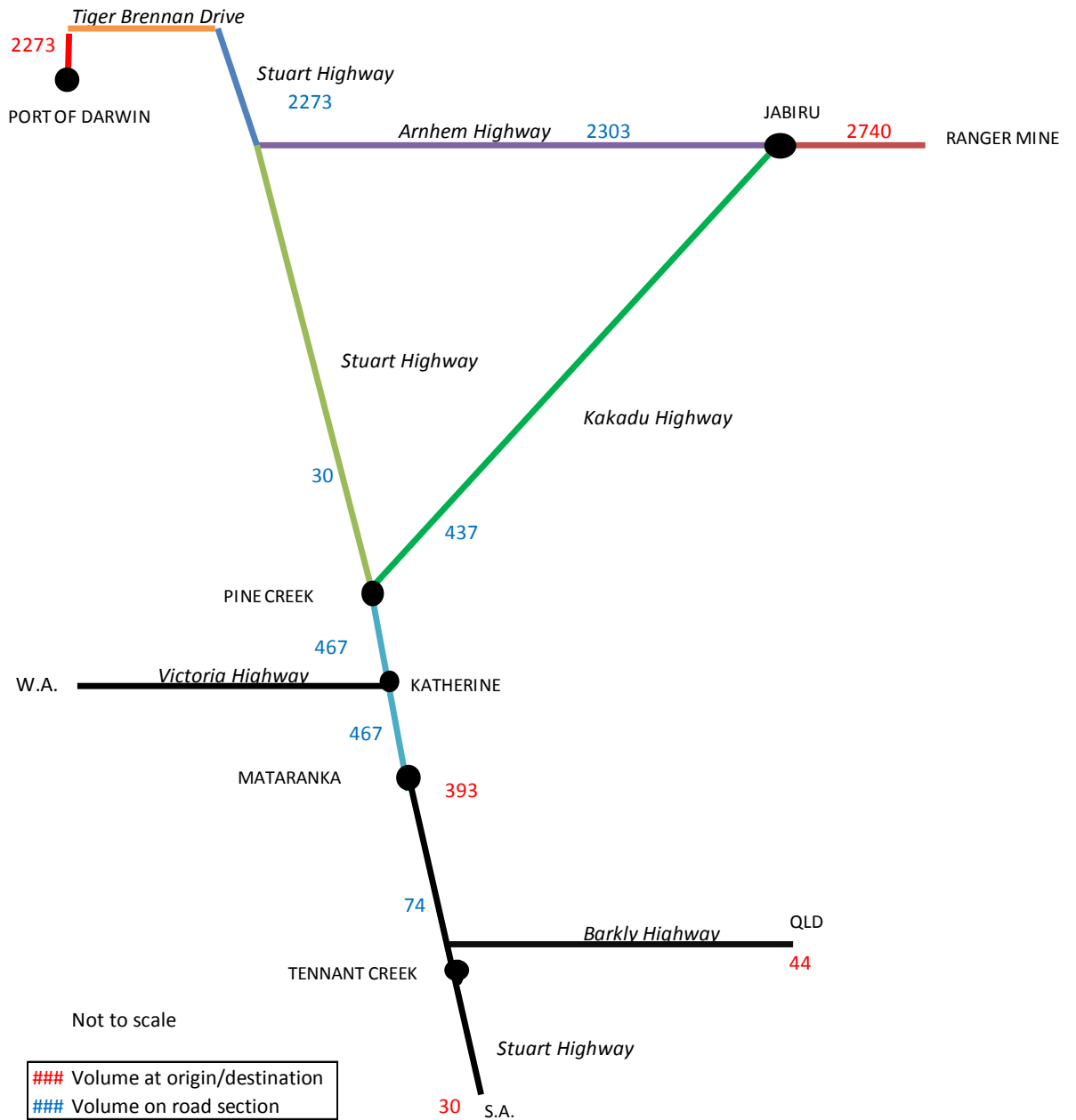


Figure 9 Distributed Ranger mine annual heavy vehicle round trips during standard operating conditions in 2012

3. PROJECT DESCRIPTION

3.1 RANGER 3 DEEPS UNDERGROUND MINE

ERA proposes to mine the Ranger 3 Deeps mineral resource using underground mining methods. Mining and processing would commence as soon as practicable following regulatory approval and feasibility studies, and would cease by January 2021 with rehabilitation occurring within the period 2021 to 2026.

In terms of ERA's traffic profile, the Ranger 3 Deeps Project may require additional sulfuric acid in order to process material that is of higher carbonate content, thus resulting in additional sulfuric acid deliveries. Similarly, power generation requirements to support underground ventilation and refrigeration will require increased diesel deliveries to the mine. There will also be additional construction materials and equipment required for the Project.

3.1.1 "No Proposed Action" Option

In the absence of the Project, consumables will continue to be transported to enable continued processing of existing stockpiled low grade ore.

Additionally, ERA is currently undertaking a progressive rehabilitation program which includes the treatment of the existing process water inventory. Commissioned in 2013, a brine concentrator process water treatment plant will require continued diesel fuelled power generation.

3.2 LOCATION AND VEHICLE ACCESS

The Project lies predominantly within the existing Ranger mine footprint, located in the southern portion of the RPA. It comprises an area of disturbance, including the Jabiru airport, of approximately 2,270 ha (ERA 2013).

Vehicle access to the Project would use the existing vehicle access to Ranger mine, which is from the easternmost extent of Arnhem Highway approximately 5 km from Jabiru.

3.3 CONSUMABLES

Consumables required for the Project include a range of hazardous and dangerous goods, as well as construction equipment and other miscellaneous deliveries. These are listed in Table 6. There are no new consumables that would be transported for the Project, that are not currently transported to the Ranger mine. Table 6 identifies the consumables and the associated hazardous and dangerous goods classifications, where relevant.

A substance is deemed to be a hazardous substance if it meets the classification criteria specified in the *Approved Criteria for Classifying Hazardous Substances* published by Safe Work Australia. Many hazardous substances are also classified as dangerous goods. Dangerous goods are substances that, because of their properties, are considered to present an immediate hazard to people, property or the environment. The criteria used to determine whether substances are classified as dangerous goods are contained in the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (ADG).

Table 6 Classifications of consumables

Consumable	Hazardous Classification as per Safe Work Australia	Dangerous Goods Classification as per ADG
Sulfuric acid	Hazardous substance	Class 8 Corrosive
Quicklime	Hazardous substance	Class 8 Corrosive (air transport only)
Flocculant (Magnafloc 139)	Hazardous substance	-
Diesel	Hazardous substance	Class 3 Flammable liquid
Pyrolusite Manganese oxide (IV) powder	Hazardous substance	Class 5.1 Oxidising substance
Alamine 336	Hazardous substance	Class 3 Flammable liquid
ShellSol 2046 (kerosene)	Hazardous substance	-
Anhydrous ammonia	Hazardous substance	Class 2.3 Toxic gas
Cement	Hazardous substance	-
Sand/aggregate	-	-
Uranium oxide	Hazardous substance	Class 7 Radioactive material
Sodium hydroxide	Hazardous substance	Class 8 Corrosive
Explosive (ammonium nitrate, ammonium nitrate emulsion)	Hazardous substance	Class 5.1 Oxidizing substances
Construction materials (various)	-	-

3.3.1 Proposed Haulage Routes

Where a consumable is currently transported under existing operations, the haulage route is expected to be retained for the Project. Haulage routes for the transport of consumables for the Project have been developed by ERA and the transport operator. For each consumable, the origins, destinations, vehicle types and haulage routes are presented in Table 7.

Table 7 Consumables, vehicle types / capacity and proposed haulage routes

Consumable	Origin	Effective origin	Destination	Vehicle type / capacity	Proposed haulage route
Sulfuric acid	Darwin		Ranger mine	Quad road train (104 tonne capacity) or triple road train (74 tonne capacity)	Berrimah Road, Tiger Brennan Drive, Stuart Highway, Arnhem Highway
Quicklime	Mataranka		Ranger mine	B-double road train, 60 tonne capacity	Stuart Highway, Kakadu Highway, Arnhem Highway
Flocculant (Magnafloc 139)	Darwin		Ranger mine	Rigid truck, carrying 4.2 tonne bags or 750 kg IBCs	Berrimah Road, Tiger Brennan Drive, Stuart Highway, Arnhem Highway
Diesel	Darwin		Ranger mine	Quad road train, 130,000 litre capacity	Berrimah Road, Tiger Brennan Drive, Stuart Highway, Arnhem Highway
Pyrolusite (Manganese oxide (IV) powder)	Darwin		Ranger mine	Quad road train (side tipping), 90 tonne capacity	Berrimah Road, Tiger Brennan Drive, Stuart Highway, Arnhem Highway
Alamine 336	Adelaide	Mataranka	Ranger mine	Single trailer, carrying 18 IBCs of 1,000 litre capacity each	Stuart Highway, Arnhem Highway
ShellSol 2046 (kerosene)	Adelaide	Mataranka	Ranger mine	Triple road train, 90,000 litre capacity	Stuart Highway, Arnhem Highway
Anhydrous ammonia	Queensland	Mataranka	Ranger mine	B-double road train, 40 tonne capacity	Stuart Highway, Kakadu Highway, Arnhem Highway
Cement	Mataranka		Ranger mine	B-double road train, 60 tonne capacity	Stuart Highway, Kakadu Highway, Arnhem Highway
Sand/aggregate	Mataranka		Ranger mine	Quad road train (side tipping), 60 tonne capacity	Stuart Highway, Kakadu Highway, Arnhem Highway
Uranium oxide	Ranger mine		Darwin	Single trailer, carrying two freight containers each with 18 tonnes of drummed product	Arnhem Highway, Stuart Highway Tiger Brennan Drive, Berrimah Road
Sodium hydroxide	Darwin		Ranger mine	Single trailer, carrying 18 IBCs of 1,000 litre capacity each	Berrimah Road, Tiger Brennan Drive, Stuart Highway, Arnhem Highway
Explosives (ammonium nitrate, ammonium nitrate emulsion)	Queensland	Mataranka	Ranger mine	B-double road train, 60 tonne capacity	Stuart Highway, Kakadu Highway, Arnhem Highway
Construction materials	Darwin		Ranger mine	Various	Berrimah Road, Tiger Brennan Drive, Stuart Highway, Arnhem Highway
Miscellaneous	Darwin		Ranger mine	Rigid truck, 60 tonne capacity	Berrimah Road, Tiger Brennan Drive, Stuart Highway, Arnhem Highway

3.4 PROJECTED TRAFFIC VOLUMES

3.4.1 Traffic Generation

Forecast demand rates for consumables have been sourced from ERA for the existing Ranger mine and for the proposed Project. A separate set of historical demand rates for consumables over a period of 10 years has been sourced from ERA for the existing Ranger mine without the Project.

As identified in Section 2.5.2, the average light vehicle volumes are assumed to apply for ongoing operation of the Ranger mine and the Project is not expected to result in an increase to the volume of light vehicle trips. Figure 10 presents the average number of daily heavy and light vehicle trips generated by the Ranger mine, with and without the Project.

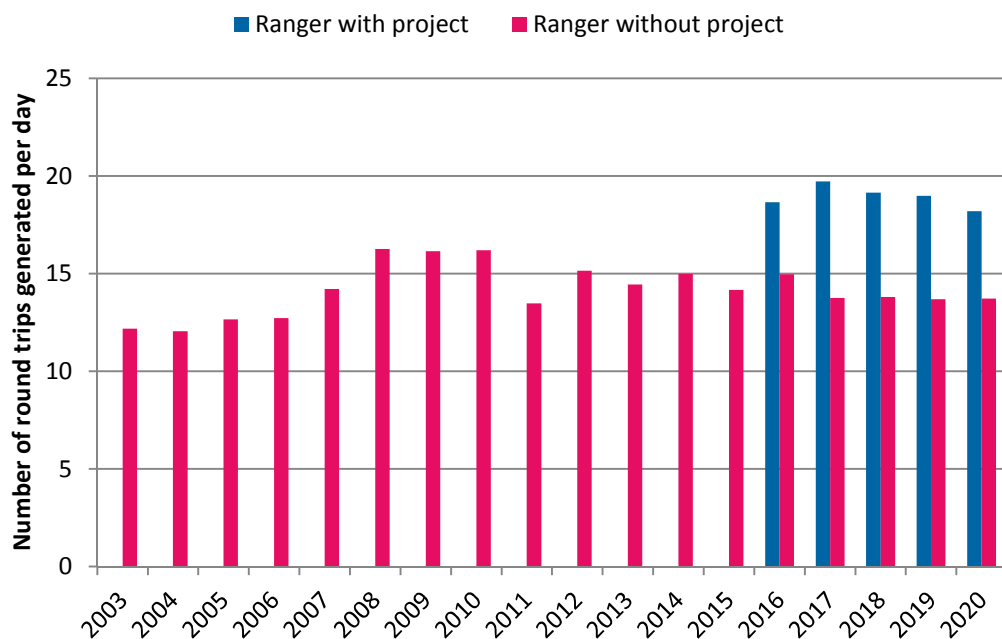


Figure 10 Average daily round trips (heavy and light vehicles) generated by the Ranger mine

Based on projections, 2017 generates the highest number of round trips for Ranger with the Project, equal to approximately 20 round trips a day. This is equivalent to 4,425 heavy vehicle round trips per annum and 2,781 light vehicle round trips per annum (Table 8).

Project construction is forecast to take place during 2016 – 2017, as well as ongoing existing mining operations. The additional 6 round trips per day that are directly attributable to the Project in 2017 (Figure 10), account for a 30% difference in traffic generated by Ranger mine with the project during 2017. The impact of this increase on the road network in 2017 is discussed in detail in Section 5.3.

The traffic volume in 2017 is the conservative forecast for traffic operations and is the basis for the assessment of the impact on road performance. The traffic generated by the existing Ranger mine with the Project in 2017 is summarised as annual and daily trips as shown in Table 8. The relative change in traffic due to the Project is also shown.

Table 8 Summary of generated round trips (2017)

Time period	Heavy Vehicles	Light Vehicles	Total
Annual trips			
Ranger mine with Project	4,305	2,781	7,086
Ranger mine without Project	2,198	2,781	4,979
Project change per annum	2,107	0	2,107
Daily trips			
Ranger mine with Project	12	8	20
Ranger mine without Project	6	8	14
Project change per day	6	0	6

3.4.2 Traffic Distribution

Based on the proposed haulage routes, the trips generated by the Ranger mine with the Project in 2017 have been distributed to the road network in Table 9 and Figure 11 below; in the same way as for the existing Ranger mine in Table 5 and Figure 9 above. The forecast heavy and light vehicles have been distributed to the road network.

Table 9 Forecast heavy and light vehicle average daily volumes, standard operating conditions (2017)

Road Section	Ranger mine without Project	Ranger mine with Project	Project change
Berrimah Road	12	14	+2
Tiger Brennan Drive	12	14	+2
Stuart Highway, between Tiger Brennan Drive and Arnhem Highway	12	14	+2
Stuart Highway, between Arnhem Highway and Pine Creek	< 1	< 1	0
Stuart Highway, between Pine Creek and Mataranka	2	5	+3
Arnhem Highway, between Stuart Highway and Jabiru	12	14	+2
Arnhem Highway, between Jabiru and Ranger mine	14	19	+5
Kakadu Highway from Jabiru to Pine Creek	2	5	+3

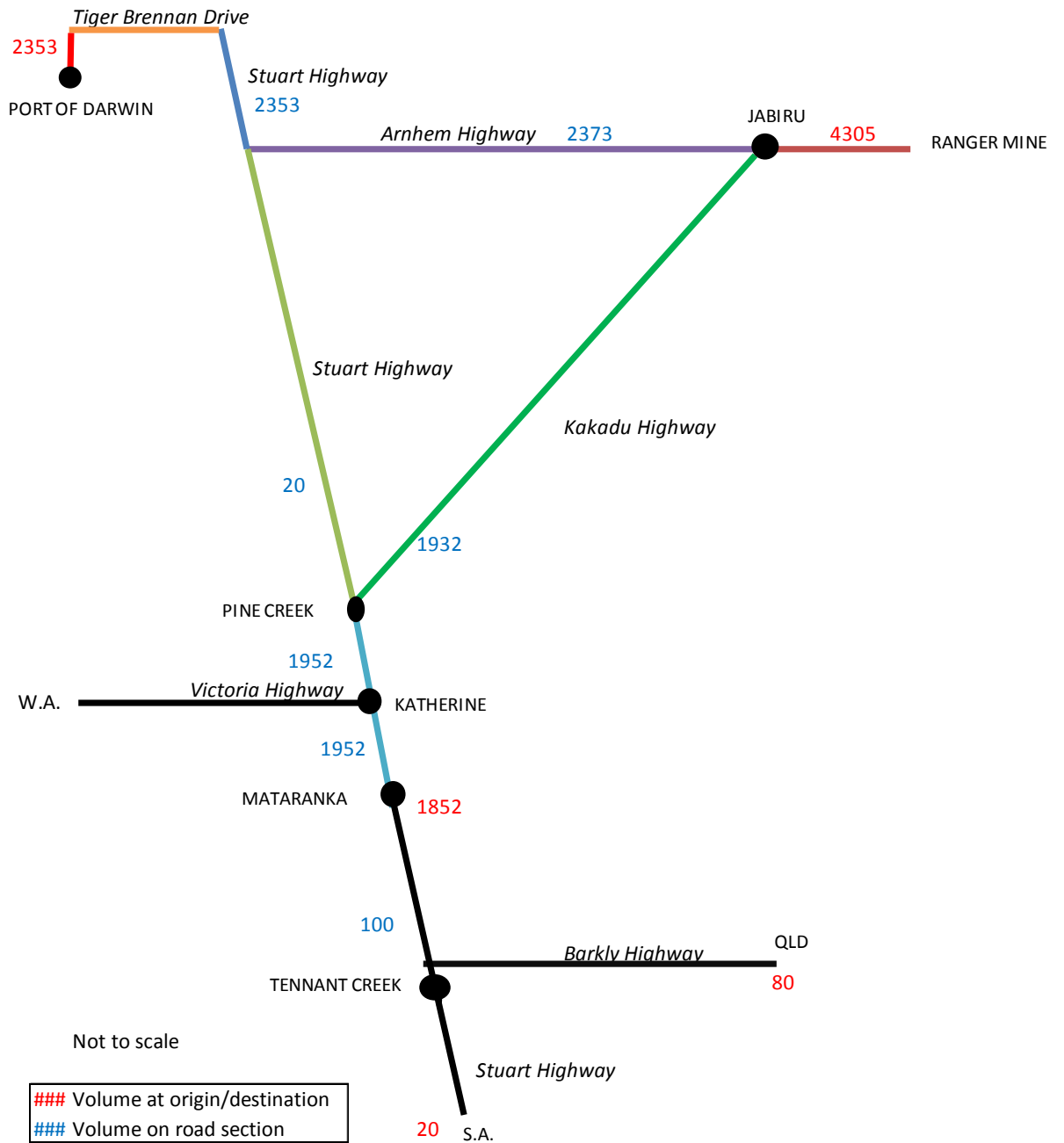


Figure 11 Distributed Ranger mine annual heavy vehicle round trips during standard operating conditions in 2017

4. ASSESSMENT OF RISKS

4.1 OVERVIEW

This section of the report describes the risk assessment process and provides the risk rankings. The key findings of the risk assessment are presented in Section 5.6.

Specific to this study is the transport of consumables associated with the Project, on public roads, and the potential risks to public safety and the environment; particularly MNES. Transport activity which occurs within the Ranger mine operational area is excluded from this assessment.

The scope of the risk assessment included activities related to construction, operation and (if relevant) decommissioning of the Project.

4.2 RISK ASSESSMENT PROCESS

The risk assessment process has been undertaken using a systematic risk-based approach consistent with current standards including:

- AS/NZS ISO 31000:2009: Risk management - Principles and Guidelines (Standard)
- HB 436:2004: Risk Management Guidelines Companion to AS/NZS 4360:2004 (Handbook)
- HB 158:2010: Delivering assurance based on ISO 31000:2009 Risk management – Principles and Guidelines (Handbook)
- HB 203:2012: Managing environment-related risk (Handbook).

The risk assessment also complies with the following:

- Section 3 and 4 of the Guidelines for the Preparation of an Environmental Impact Statement for Ranger 3 Deeps
- ERA Standard – HSEQ Hazard Identification and Risk Management.

The process adopted for the traffic impact assessment has included a comprehensive identification and analysis of risks. The risk assessment process is schematically presented in Figure 12.

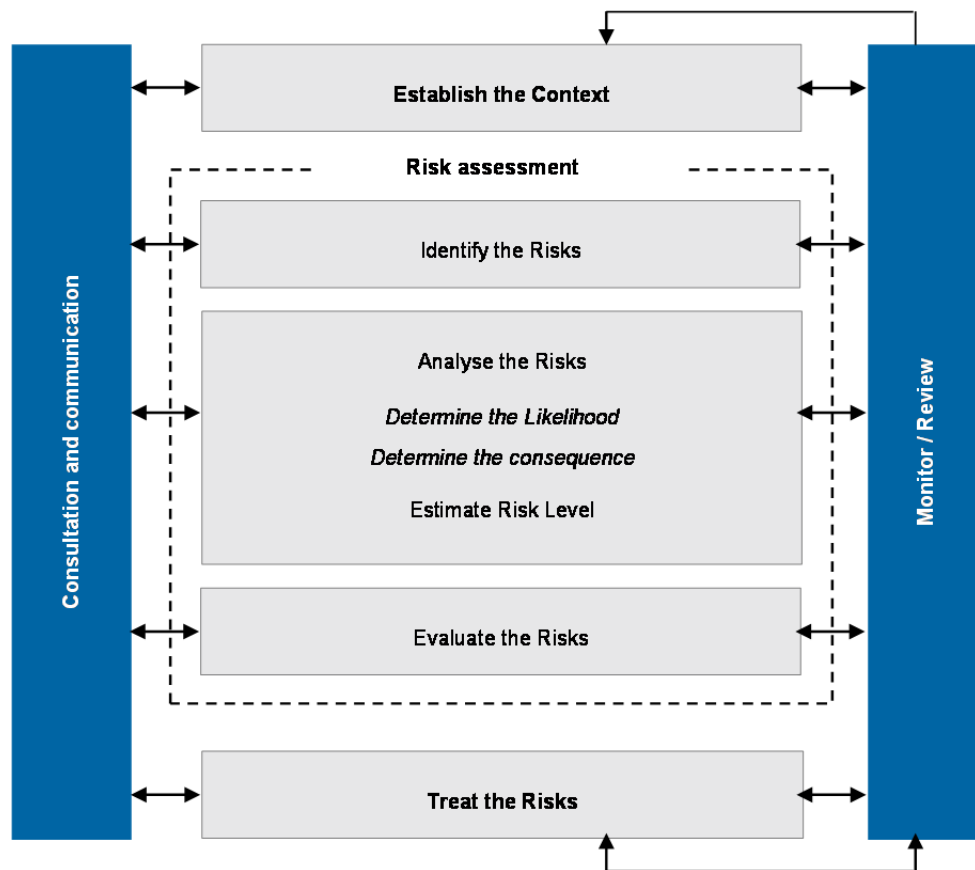


Figure 12 Risk management process (AS/NZS ISO 31000:2009)

4.2.1 Risk Identification

Risk identification was undertaken in an independently facilitated workshop held on 05 December 2013. Workshop participants included ERA and its suppliers, represented by chemical product specialists and supply chain managers of key consumables; a representative from the Northern Territory Department of Transport, and project ecologists and risk specialists from GHD. Workshop attendees are listed in Appendix B.

Hazard Identification

Workshop participants were involved in identifying the hazards (i.e. activities that pose a threat) and the impact pathways; in order to determine the link between each hazard and its potential consequence on the environment.

The key hazard is a vehicle incident on a public road that would potentially result in a loss of containment and/or impact to public safety.

For each consumable that would be transported to or from the Ranger mine over the life of the Project, a risk assessment process was undertaken. Consumables included those listed in Table 10.

Table 10 Transported consumables and product for Project

Consumable / Product	
Sulfuric acid	Quicklime
Diesel	Anhydrous ammonia
Sodium hydroxide	Cement
Uranium oxide	Explosives (ammonium nitrate, ammonium nitrate emulsion)
ShellSol 2046 (kerosene)	Sand / aggregate
Alamine 336	Construction material
Flocculant (Magnafloc 139)	Pyrolusite (Manganese oxide (IV) powder)

4.2.2 Bowtie Diagram Development

Workshop participants developed Bowtie diagrams for the transport of each consumable. The bowtie approach provides a graphical representation of how a hazardous event may occur (the causes), the potential outcomes and the linkages between these. It also clearly identifies the controls that are in place to protect against each cause or the escalation to an outcome. The overall structure of a Bowtie diagram is shown in Figure 13.

Key features of the Bowtie include:

- Cause – the basic cause giving rise to an event (yellow boxes).
- Controls – any device, characteristics or action that reduces the chance of a cause leading to an event occurring, or mitigates or reduces the severity of the outcome if an event does occur (white in-filled boxes).
- Consequence outcome – the end result of a failure of both preventative and mitigation controls, which is an impact on the environment (orange boxes on the right hand side of the Bowtie).

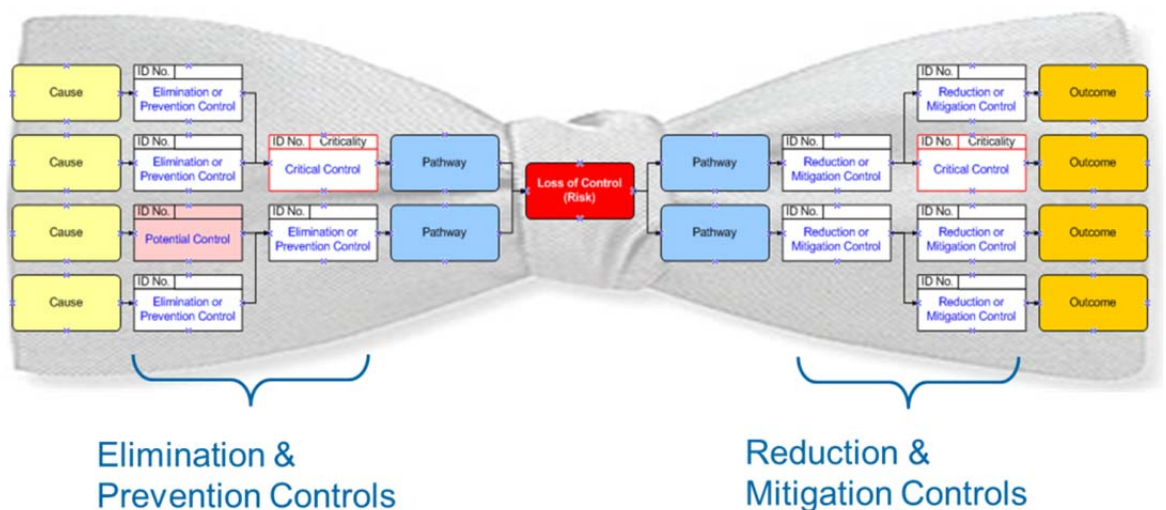


Figure 13 Example schematic bowtie diagram

The transport of each consumable has been represented in a Bowtie diagram. The central hazardous event is a vehicle incident on a public road, which may result in a loss of containment or impact to public safety.

The Bowtie diagrams have been used throughout the risk assessment process as a reference tool to understand the risk scenarios, and as an analysis tool for identifying controls. A Bowtie diagram for each consumable is presented in Appendix C

4.2.3 Environmental Receptors

An environmental receptor is the specific component of the environment that would potentially be impacted. Sensitive environmental receptors identified as relevant to the transport of consumables, and therefore considered in this risk assessment were:

- environmental values including world heritage and/or national heritage places
- listed threatened and migratory species
- public safety.

Ecologically Sensitive Areas

Desktop assessment of the surrounding environment within a five kilometre buffer of the Arnhem, Kakadu and Stuart Highways was undertaken. Areas that recorded the highest abundance and diversity of threatened flora/fauna and migratory species, i.e. sensitive ecological areas, comprised wetland, floodplain and river habitats. Figure 4, Figure 5 and Figure 6 depict the geographical distribution of threatened species records along the transport route, for listed threatened flora, fauna and migratory species respectively.

In order to focus the risk assessment process on material risks, the risks identified for *listed threatened and migratory species* and *environmental values* were based on identified sensitive ecological areas or hotspots. Fourteen locations along the transport route were identified as sensitive in terms of listed threatened and migratory species, and of these, 6 were also identified as containing environmental values including world heritage and/or national heritage places.

Identified sensitive ecological locations included rivers and associated wetlands and floodplains that provide habitat for large numbers of migratory and threatened species. The 14 locations along the road network where a hazardous event may have a significant material impact on *listed species* were identified and are listed below. Of these locations, 6 locations were also material to the risk assessment in terms of *environmental values*.

The complete list of locations is provided below. Locations numbered 3 to 8 are areas containing both *environmental values* and *listed threatened and migratory species*. Ecological 'hotspots' are also depicted in Figure 4, Figure 5 and Figure 6.

1. Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain
2. Arnhem Hwy: (2) Mary River crossing and surrounding floodplains
3. Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains
4. Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine
5. Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain
6. Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding

floodplain * (Yellow Water Wetlands also in vicinity)

7. Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain
8. Kakadu Hwy: (8) Mary River crossing and surrounding floodplain
9. Kakadu Hwy: (9) 7 km east of Mary River crossing
10. Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy
11. Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek
12. Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain
13. Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining
14. Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy

The risk assessment process looked at sulfuric acid, for example, which would be transported approximately 260 km from the receiving terminal in Berrimah to the Ranger mine. In identifying the risks for the transport of sulfuric acid on *listed threatened and migratory species* the risk has been assessed for 14 locations along the transport corridor. In identifying the risks for the transport of sulfuric acid on *environmental values* risk has been separately assessed for 6 of the above 14 locations. These are locations where a hazardous event may have a significant material impact.

Public Safety

Risk associated with the transport of sulfuric acid, for example, has also been assessed in terms of risk to public safety. Risk to public safety from the transport of consumables was assessed (where relevant) against the following scenarios:

- risk to public safety from a vehicle incident
- risk to public safety from a vehicle incident involving a loss of containment
- risk to public safety from a vehicle incident leading to fire/explosions.

4.2.4 Consequence Descriptors

Consequence descriptors (Table 11, Table 12 and Table 13) have been developed specific to the identified environmental factors (receptors), and range on a scale of magnitude from 'minor' to 'catastrophic'. The consequence level was considered for each impact pathway as a function of the size of the impact, the location and spatial area affected, and expected recovery time of the ecological system, where relevant.

Due to the complexity of environmental systems, the consequence criteria used for environmental values has multiple criteria including impacts to fauna, soils and surface water. This provided a more comprehensive approach to the assignment of a maximum credible consequence level.

Table 11 Consequence descriptors, species of conservation significance

Minor	Medium	Serious	Major	Catastrophic
1	2	3	4	5
Minor local habitat modification* and/or lifecycle disruption for a listed species*	Moderate local habitat modification* and/or lifecycle disruption for a listed species*	Substantial local habitat modification* and/or lifecycle disruption for a listed species*	Moderate regional habitat modification* and/or lifecycle disruption for a listed species*	Substantial regional habitat modification* and/or lifecycle disruption for a listed species*
No loss of individuals of listed fauna species	Minor local decrease in size of population(s) of listed fauna species	Moderate local decrease in size of population(s) of listed fauna species	Substantial local decrease in size of population(s) of listed fauna species	Moderate or substantial regional decrease in size of population(s) of listed fauna species

* Habitat modification can include alteration of fire regimes, nutrient cycles and/or hydrological cycles; and lifecycle disruptions can include disruption of breeding, feeding, migration, resting behaviour, etc.

Table 12 Consequence descriptors, environmental values

Minor	Medium	Serious	Major	Catastrophic
1	2	3	4	5
Impact* will be very limited and have no discernible effect on environmental values, including sensitive populations, communities and assets.	Impact* will be limited and affect only minor environmental values. Recovery periods are relatively short.	Impact* will affect environmental values, disrupting some aspects of environmental structures or functions, but recovery periods are relatively short.	Impact* will seriously affect environmental values, disrupting many environmental structures or functions. Long periods of recovery.	Impact* will seriously affect environmental values, disrupting major environmental structures or functions. Potentially irreversible.
Negligible soil impact; chemical concentrations are above background but below ecological investigation levels (EILs) as defined in the NEPM	Localised soil impact; low level (<2 times) exceedance of ecological investigation levels (EILs) defined in the NEPM	Localised long term or widespread short term soil impact: chemical concentrations (2 to 5 times) exceedance of ecological investigation levels (EILs) defined in the NEPM	Widespread and/or long term impact; chemical concentrations (5 to 10 times) exceedance of ecological investigation levels (EILs) defined in the NEPM	Irreversible and/or extensive impact; chemical concentrations are greater than 10 times the ecological investigation levels (EILs) defined in the NEPM
No detectable change to background water quality; no exceedance of background and applicable ANZECC / ARMCANZ Water Quality guidelines	Local, short-term, minor exceedance of background and applicable ANZECC / ARMCANZ Water Quality guidelines	Local, long-term OR widespread, short-term, exceedance of background and applicable ANZECC / ARMCANZ Water Quality guidelines	Local, permanent OR widespread, long-term exceedance of background and applicable ANZECC / ARMCANZ Water Quality guidelines	Widespread, permanent exceedance of background and applicable ANZECC / ARMCANZ Water Quality guidelines

*includes an impact that would modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that a species is likely to decline and/or an impact to a world heritage and/or national heritage place (not excluding declared Ramsar wetland); and/or an impact to common flora and fauna such as an impact that would modify habitat and/or disrupt the lifecycle of common species

Table 13 Consequence descriptors, public health and safety

Minor	Medium	Serious	Major	Catastrophic
1	2	3	4	5
No injuries or first aid required	Basic first aid treatment required	Medical attention required	Permanent injury or illness	Loss of life
No increase in vehicle accidents	Increase of < 2 annual non-fatal vehicle accidents	Increase of 2-5 annual non-fatal vehicle accidents	Increase of 5-10 annual non-fatal vehicle accidents	increase of >10 annual non-fatal vehicle accidents fatal vehicle accident

4.2.5 Likelihood Assessment

The NT EPA and SEWPaC Guidelines require that sufficient quantitative analysis is provided to indicate whether risks are tolerable and that risk rankings assigned are fully justified.

A quantitative assessment of the likelihood uses empirical data to determine the probability of a risk scenario occurring. The calculated probability can then be aligned to the corresponding likelihood level as part of the risk rating. For example, a risk scenario with a quantified likelihood of 5 % corresponds to likelihood level of 'Possible'.

Risk scenarios were identified as a vehicle incident involving a heavy vehicle transporting consumables for the project. For example:

- Risk ref. 1: Transport of sulfuric acid – vehicle incident leading to loss of containment – Adelaide River crossing on Arnhem Highway.

Each risk scenario is specific to a particular consumable being transported and to a particular location. Therefore, the objective of the likelihood assessment is to quantify the likelihood of an incident occurring at any location (or road length) along the identified haulage routes, for each consumable. Specifically, it is the likelihood that a risk scenario would result in the identified maximum reasonable 'consequence level'.

The likelihood of a crash for a heavy vehicle transporting consumable at a location (or road length) has been calculated as the product of two components:

- The probability of a crash at a specific location (or road length)
- The exposure, through the frequency of trips, of the heavy vehicle to that location (or road length)

For example, if one consumable has three times the number of deliveries as another consumable along the same route, then its exposure (and the likelihood of a crash at a particular location) is three times as high. The methodology to quantify these two components is separately described in Appendix D. The probability of a crash at a specific location has subsequently been mapped in Figure 14.

Due to limited overall traffic volumes on the Kakadu Highway, there are few instances of recorded vehicle crashes over the past five years. This creates gaps in the data – many sections of Kakadu Hwy with theoretically no likelihood of a crash. As a result, the average for Kakadu Hwy has been applied along its length, resulting in it being all yellow in Figure 14.

Industry practice and peer reviewed methodologies have been developed to identify crash rates. The approach adopted for this study followed guidance from the US Transportation Research Board, Research Report 410. More information about the approach, and data sources, is discussed in Appendix D.

The leading measure of crash rates for a section of route is crashes per million vehicle km travelled (VKT). For example, a crash rate of 1.0 crash per million VKT means that if one million vehicles traversed a one kilometre section of road, the expectation would be for one crash to occur. Of these potential vehicle incidents, an environmental impact would occur if the incident also involved a loss of consumable containment. Empirical release rates have been applied to determine the likelihood of a spill resulting from a vehicle incident for these scenarios.

A likelihood descriptor was then applied, aligned with the quantified likelihood. For example, a risk scenario with a quantified likelihood of 5 % is rated as Possible. These likelihood descriptors are listed in Table 14.

Table 14 Likelihood definitions

Likelihood		
A	Almost certain	Common repeating occurrence that is ongoing. Frequency interval (multiple events): more than twice per year; probability (single events): more than 25 %.
B	Likely	Known to occur or will probably occur at some time and in most circumstances. Frequency interval (multiple events): from once per year to twice per year; probability (single events): from 10 % to 25 %.
C	Possible	Could occur at some time but not often. Frequency interval (multiple events): from once in 10 years to once per year; probability (single events): from 1 % to 10 %.
D	Unlikely	Could potentially occur at some time but highly unlikely. Frequency interval (multiple events): from once in 100 years to once in 10 years; probability (single events): from 0.1 % to 1 %.
E	Rare	Practically impossible, will only occur in very rare circumstances. Frequency interval (multiple events): less than once in 100 years; probability (single events): less than 0.1 %.

4.2.6 Risk Criteria

The level of risk was determined using a risk matrix consistent with the ERA HSEQ risk management framework. The consequence descriptors in Tables 12, 13 and 14 when cross referenced with the likelihood descriptors in Table 15 establishes a risk rating.

Risk scenarios were evaluated to identify the consequence, likelihood and resulting risk rating. The risk matrix is presented in Table 15. For the risk ratings, Table 16 outlines risk classes and associated ERA response.

The level of data / information available, and therefore the degree of uncertainty relating to the assessment of the risk was considered in the categories listed in Table 17. The rating of data / information availability may be used to assist in determining if further actions should be focused in order to manage risks.

Table 15 Risk matrix

		Consequence				
		1 - Minor	2 - Medium	3 - Serious	4 - Major	5 - Catastrophic
Likelihood	A - Almost Certain	Moderate	High	Critical	Critical	Critical
	B - Likely	Moderate	High	High	Critical	Critical
	C - Possible	Low	Moderate	High	Critical	Critical
	D - Unlikely	Low	Low	Moderate	High	Critical
	E - Rare	Low	Low	Moderate	High	High

Table 16 Risk acceptance thresholds

Rating	Class	Risk rating response
Low	Class I	Risks that are below the risk acceptance threshold and do not require active management
Moderate	Class II	Risks that lie on the risk acceptance threshold and require active monitoring
High	Class III	Risks that exceed the risk acceptance threshold and require proactive management
Critical	Class IV	Risks that significantly exceed the risk acceptance threshold and need urgent and immediate attention

Table 17 Certainty descriptors

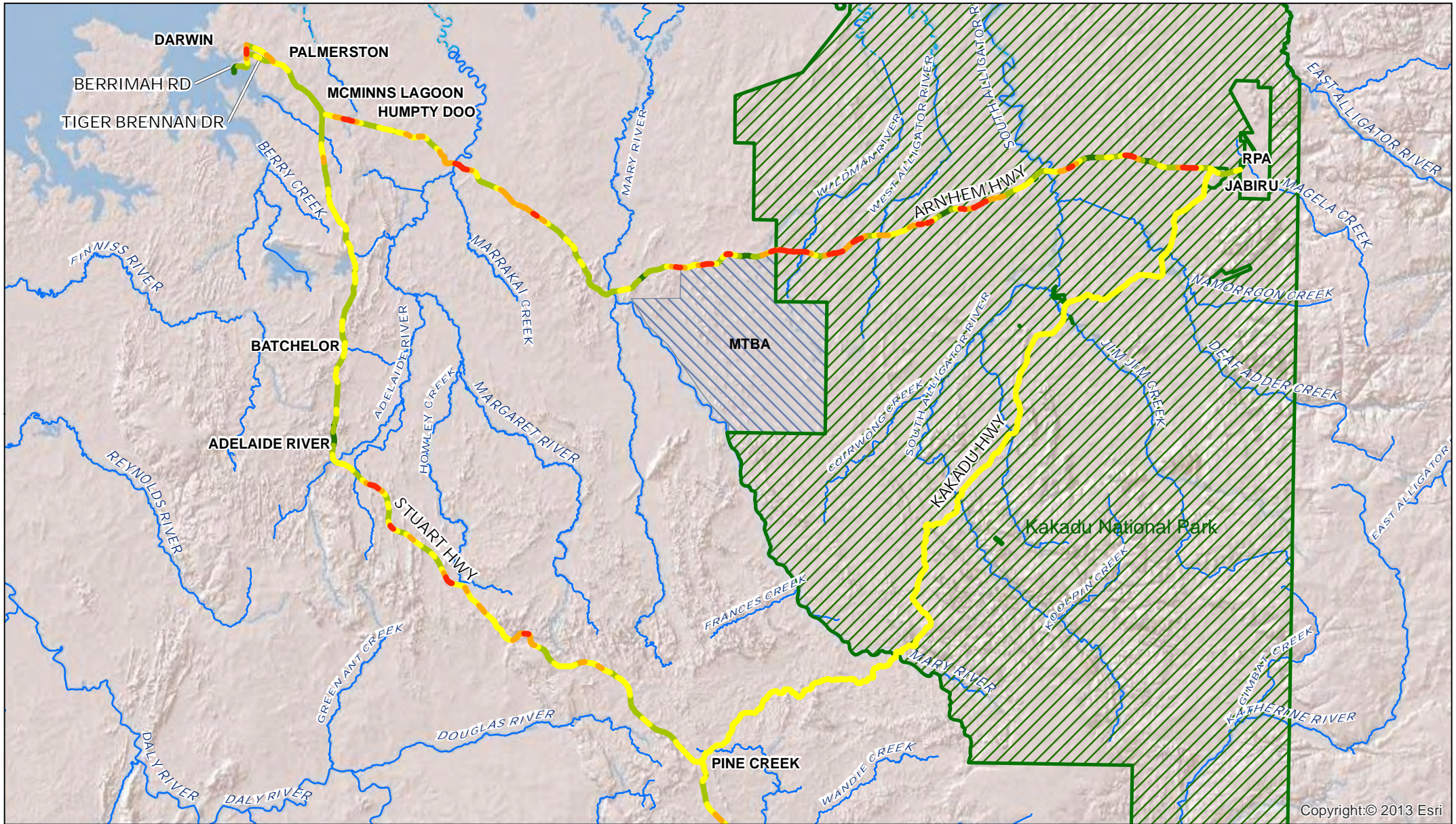
Low	Moderate	High
C1	C2	C3
Low	Medium	High
Risk ranking is based on subjective opinion or relevant past experience	Risk ranking is based on similar conditions being observed previously and/or qualitative analysis.	Risk ranking is based on testing, high fidelity modelling or simulation, use of prototype or experiments. Analysis is based on verified models and/or data. Assessment is based on an historical basis.

4.2.7 Risk Analysis

For the identified risks, the following method was used to analyse and evaluate the risk scenarios and assign risk ratings:

1. Using the consequence criteria, determine the maximum reasonable 'consequence level' associated with the identified risk scenario.
2. Determine the likelihood that the identified risk scenario would result in the maximum reasonable 'consequence level'. (see Appendix D)
3. From the consequence and likelihood levels assigned to the risk scenario, the Risk Matrix was used to determine the current risk rating.
4. The level of data / information availability associated with the risk assessment rating was also defined.

The key findings of the risk assessment are outlined in Section 5.6.



Copyright:© 2013 Esri

<p>Paper Size A4</p> <p>Kilometres</p> <p>Map Projection: Transverse Mercator Horizontal Datum: GDA 1994 Grid: GDA 1994 MGA Zone 52</p>		<p>LEGEND</p> <ul style="list-style-type: none"> Highway Kakadu NP MTBA 	<p>Zones of increased likelihood of an incident</p> <ul style="list-style-type: none"> Higher likelihood Medium to higher likelihood Medium likelihood Medium to lower likelihood Lower likelihood 		<p>Energy Resources of Australia Ltd Ranger 3 Deeps</p>	<p>Job Number 43-22105 Revision C Date 21 Mar 2014</p>
---	--	--	---	--	---	--

Zones of increased likelihood of an incident **Figure 14**

G:\43\22105\GIS\Maps\Deliverables (Optional)\4322105_Z006_ZonesIncreasedLikelihoodTrafficIncident_A4.mxd
 © 2014. Whilst every care has been taken to prepare this map, GHD (and Geoscience Australia, DLRM) make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and cannot accept liability and responsibility of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data source: Geoscience Australia, 250K Topo Map, 2008; Species Atlas, DLRM, 2013. Created by:cwilson
 5/66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E dnmail@ghd.com W www.ghd.com

5. IMPACT ASSESSMENT

5.1 BACKGROUND TRAFFIC GROWTH

As identified in Section 3.4 of this report, the highest number of trips is estimated to occur in 2017. The traffic volume in 2017 is therefore the conservative forecast for traffic operations, and thus is the basis for the assessment of impact on road performance.

The round trip equivalent AADT volumes counted in 2012 along each road section in Table 2 have been escalated to 2017 at 2.5 % per annum as per recommendations from DoT (B. O'Donnell pers comm, Oct 2013) in order to estimate the background traffic volumes (i.e. traffic volumes without Ranger mine) on the network in 2017. These are presented in Table 18 below. The escalation from observed 2012 volumes to these 2017 round trip equivalent AADT projections includes both heavy and light vehicles.

Table 18 Current (2012) and projected (2017) AADT traffic volumes per road section (DoT) without Ranger mine

Road Section	Round trip equivalent AADT (2012)	Projected Round trip equivalent AADT (2017)
Berrimah Road	2,600	3,000
Tiger Brennan Drive (est) ⁴	7,500 (est.)	8,500 (est.)
Stuart Highway, between Tiger Brennan Drive and Arnhem Highway	6,000	6,800
Stuart Highway, between Arnhem Highway and Pine Creek	3,750	4,300
Stuart Highway, between Pine Creek and Mataranka	350	400
Arnhem Highway, between Stuart Highway and Jabiru	1,450	1,700
Arnhem Highway, between Jabiru and Ranger mine	500	600
Kakadu Highway from Jabiru to Pine Creek	150	200

5.2 TRAFFIC VOLUME CHANGE

The forecast traffic volumes on each road section with and without the Project can be compared using the 2017 base volumes (without the Project). The percentage change can also be observed. This is presented in Table 19 and Figure 15 below. Note that the AADT volumes in Figure 15 are expressed as round trip equivalent so that they can be compared to Ranger mine contribution volumes. The proportion of traffic generation contributed by the Ranger mine in Figure 15 is indicated in brackets. The analysis indicates that the cumulative impact of traffic volume increase with the Project along each road section presented in Table 19 is less than 4 %.

⁴ Traffic volumes are not available for Tiger Brennan Drive.

Table 19 Projected AADT volumes (2017) and Ranger mine contribution with the Project

Road Section	Projected Round trip equivalent AADT (2017)	Ranger mine with Project round trip contribution	Total Round trip equivalent AADT	% Change
Berrimah Road	3,000	14	3,014	0.5%
Tiger Brennan Drive	8,500 (est.)	14	8,514	0.2%
Stuart Highway, between Tiger Brennan Drive and Arnhem Highway	6,800	14	6,814	0.2%
Stuart Highway, between Arnhem Highway and Pine Creek	4,300	<1	4,300	0.0%
Stuart Highway, between Pine Creek and Mataranka	400	5	405	1.3%
Arnhem Highway, between Stuart Highway and Jabiru	1,700	15	1,715	0.9%
Arnhem Highway, between Jabiru and Ranger mine	600	20	620	3.3%
Kakadu Highway from Jabiru to Pine Creek	200	5	205	2.6%

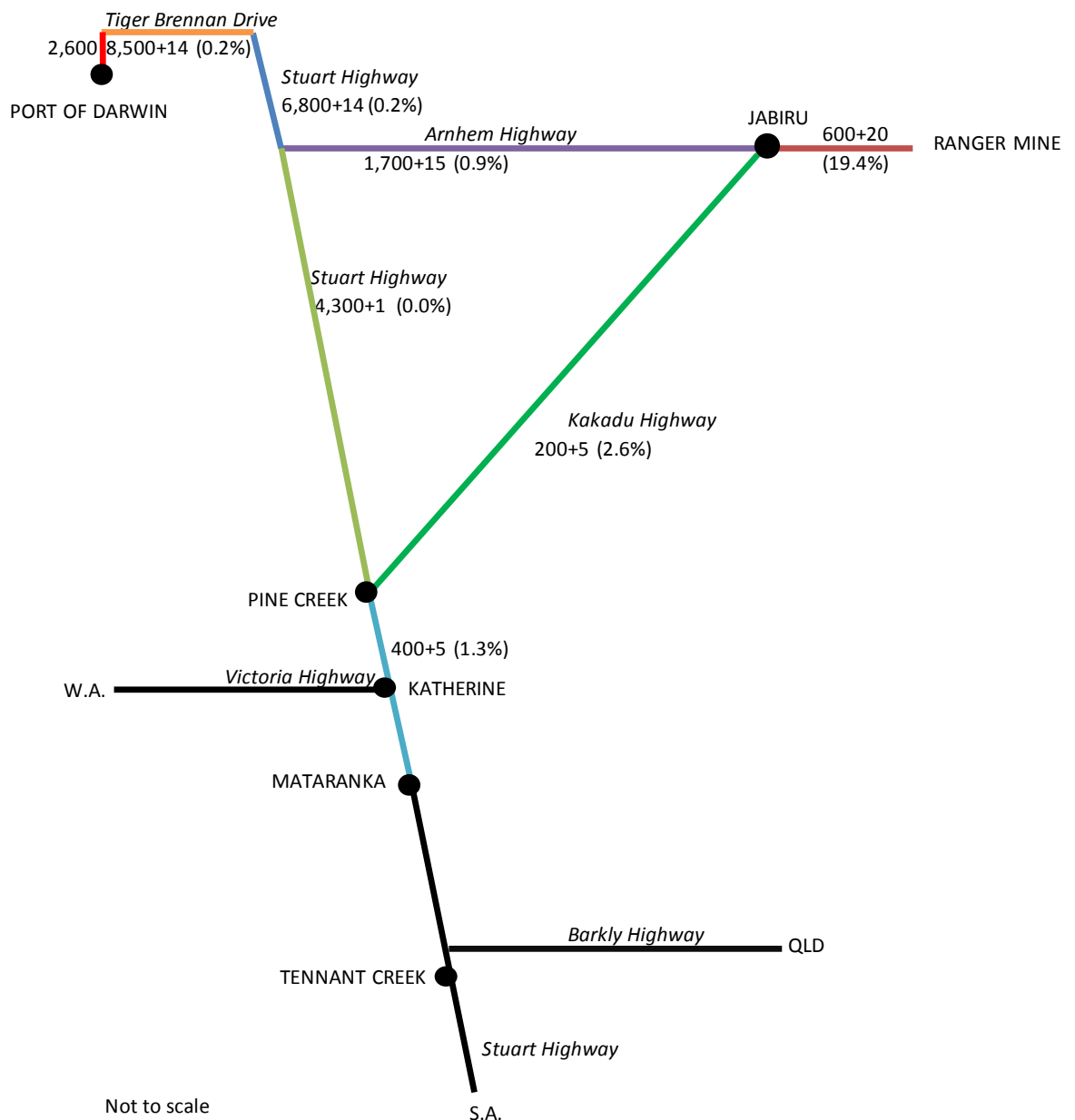


Figure 15 Forecast 2017 AADT volumes and Ranger mine contribution with the Project (%)

5.3 TRAFFIC VOLUME POTENTIAL IMPACTS

As shown in Table 19 increases in traffic volumes (based on cumulative Ranger mine contributions) on the roads are expected to be less than 4 % over an average day.

Austrroads publishes guidance on the capacity of roads and traffic lanes (Austrroads, 2009). The capacity of a traffic lane is expressed as a number of vehicles per hour (vph). In uninterrupted flow conditions (such as those usually found on rural highways) a traffic lane can carry about 1,800 vph. In interrupted flow conditions (such as on urban arterial roads) a traffic lane can carry about 900 vph.

Berrimah Road is the only road in the study area that could be classed as an ‘urban road’ due to the number of interruptions to traffic flow on Berrimah Road, including traffic signals, priority intersections, driveways and a weigh bridge. Berrimah Road therefore has a lane capacity of 900 vph. The other roads in the study area, with the

exception of the Kakadu Highway, are considered to be rural roads with lane capacities of 1,800 vph. The Kakadu Highway meanders and is steep and narrow in places, therefore a lane capacity of 900 vph has been assumed for Kakadu Highway.

Table 20 indicates estimated hourly volumes that are significantly less than the theoretical capacities of the roads in the study area. This means that the roads are capable of absorbing the additional traffic without affecting their performance.

Table 20 Estimated hourly volumes and comparison to Austroads capacity guidelines (standard operating conditions, 2017)

Road Section	No. of lanes each way	Capacity of one lane (vph)	Total volume (vph) ⁵	Spare capacity (vph)
Berrimah Road	1	900	301	599
Tiger Brennan Drive	2 ⁶	1,800	851	949
Stuart Highway, between Tiger Brennan Drive and Arnhem Highway	2	1,800	681	1,119
Stuart Highway, between Arnhem Highway and Pine Creek	1	1,800	430	1,370
Stuart Highway, between Pine Creek and Mataranka	1	1,800	41	1,759
Arnhem Highway, between Stuart Highway and Jabiru	1	1,800	171	1,629
Arnhem Highway, between Jabiru and Ranger mine	1	1,800	62	1,738
Kakadu Highway	1	900	21	879

5.4 SUMMARY OF TRAFFIC IMPACTS

This assessment has considered the impacts of the proposed Project on the surrounding road network. The existing conditions of the network have been reviewed, including the volumes the roads currently carry. These volumes have been escalated to 2017 which is the design year for this assessment.

The projected number of trips generated by the Project has been translated into volumes of vehicles on each of the roads in the study area and these have been compared to the projected traffic volumes without the Project so that the relative changes can be determined.

Finally, cumulative ERA traffic volumes have been compared to the theoretical capacity of the roads to assess whether there is likely to be a material impact on the operation of the roads.

The broad conclusions relating to traffic volumes include the following:

- The design year for transport capacity assessment is 2017, as this is the year which generates the greatest number of combined Ranger mine trips.

⁵ Daily volumes have been converted into hourly volumes using the generally accepted rule of thumb relationship that the peak hour volume is about 10 % of the daily volume. The AADT is also expressed in two way volumes and therefore have been halved to provide a round trip equivalent volume.

⁶ It is anticipated that Tiger Brennan Drive will have been duplicated by 2017.

- In 2017, Ranger mine is expected to generate around 4,300 heavy vehicle round trips. This equates to approximately 12 heavy vehicle round trips per day on average.
- The existing average 8 light vehicle round trips per day is expected to continue into the future. This brings the total expected round trip generation of Ranger mine to approximately 20 per day (both heavy and light vehicles). Of these, the Project contributes approximately 6 round trips per day.
- When these trips are distributed to the road network, the maximum change on any road is less than 4 % of the projected 2017 base volumes.
- When the total volumes are compared to Austroads capacity guidelines, the analysis indicates that there is significant spare capacity on the road network.

5.5 ECOLOGICALLY SENSITIVE AREAS

Many of the species identified in the PMST and DLRM Fauna Atlas are possibly resident or visitors of the study area. Several of these species have been recorded on numerous occasions and are distributed throughout the study areas including the Partridge Pigeon, Northern Quoll, and Brush-tailed Phascogale.

The Northern Quoll has declined markedly since the colonisation of the Northern Territory by the Cane Toad (*Rhinella marina*). This species in particular is known to continue to persist within the study area, but in much lower numbers than reflected by the database records.

Along the Kakadu Highway where the Highway intercepts the Arnhem plateau there are recent records of the Arnhemland Egernia (*Bellatorias obiri*), which is endemic to the area and is likely to occur in close proximity to the Highway between 144 km and 145 km from the intersection of the Kakadu and Arnhem Highways. This species is listed as endangered at both Northern Territory and Commonwealth level and has declined in recent history.

This and other significant and potentially sensitive habitat areas were compared with areas of increased crash likelihood (derived from the likelihood assessment described in Section 4.2.6 and Appendix D, and illustrated in Figure 14), in order to identify locations along the road network where a hazardous event may have a significant material impact.

Identified sensitive ecological locations included rivers and associated wetlands and floodplains that provide habitat for large numbers of migratory and threatened species. The 14 locations where a hazardous event may have a significant material impact on ecologically sensitive areas are listed in Section 4.2.3.

The potential consequences of material impact to ecologically sensitive areas along the road network were assessed based on consideration of the environmental values and/or listed species that are likely to occur in ecologically sensitive areas. Consequences were also assessed in the context of the nature of the consumable (environmental impact) and the maximum reasonable amount of the loss/spill of the consumable in the event of a vehicle incident leading to a loss of containment.

The complete risk register is contained in Appendix E, including a description of the potential impact to the environment associated with a vehicle incident leading to a loss of containment of separate consumables and materials.

5.6 RISK EVALUATION

Given that the consumables are already being transported to the Ranger mine for the existing operation; *current* risk ratings were assigned based on the application of existing controls.

Risk was assessed based on the maximum reasonable consequence. This is the largest realistic or credible consequence from an event, considering the credible failure of controls. It is generally a higher consequence than the 'most likely' consequence and less severe than the 'worst case' consequence, which considers the failure of all controls.

The risk identification process recorded 246 risk scenarios in which ecologically sensitive locations and public safety were considered in the context of different consumables. The entire risk register is presented in Appendix E. The risk profile includes the following:

- 147 risk scenarios that address risks to listed threatened and migratory species at 14 environmentally sensitive locations, concerning the transport of 14 separate consumables and/or materials.
- 68 risk scenarios that address risks to environmental values at 6 environmentally sensitive locations, concerning the transport of 14 separate consumables and/or materials.
- 31 risk scenarios that address risks to public safety in the study area concerning the transport of 14 separate consumables and/or materials.

Table 21 and Figure 16 below provide a summary of the outcomes of the risk register in terms of the cumulative risk profile for the Project traffic assessment.

Table 21 Summary cumulative risk profile based on risk register (Appendix E)

Risk profile	Listed threatened and migratory species	Environmental values	Public health and safety	Total
Critical	0	0	4	4
High	21	11	15	47
Moderate	14	6	5	25
Low	112	51	7	170
Total	147	68	31	246

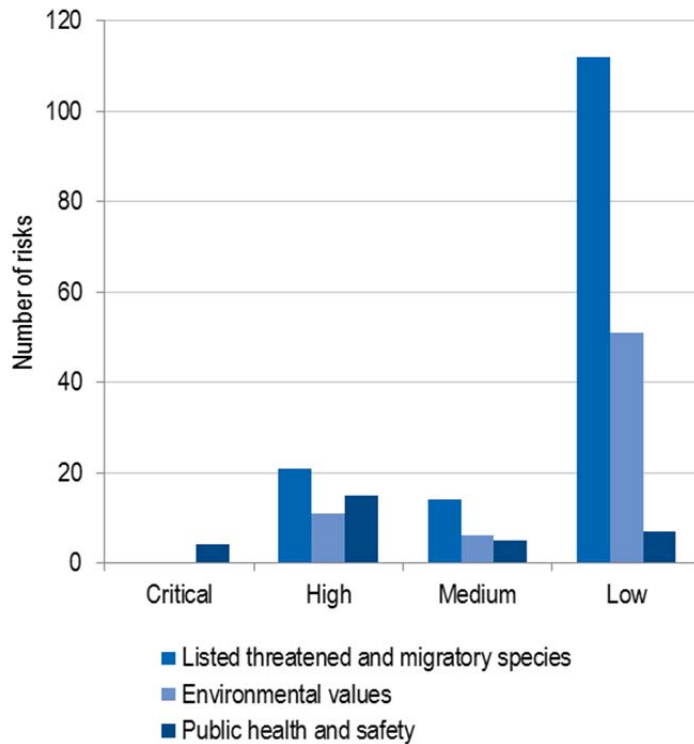


Figure 16 Cumulative ERA traffic risk profile for sensitive environmental receptors

5.6.1 Matters of National Environmental Significance

The highest risk consumables, diesel and anhydrous ammonia, were assessed as posing a risk of major consequence in terms of potential impact to listed species and environmental values at all identified ecologically sensitive locations along the route; but the likelihood of occurrence, was assessed as Rare (less than 0.1 %), based on the cumulative impact of Ranger mine with the Project. This resulted in a current risk rating of High. Transport of these two consumables accounts for 32 of the 47 High risk scenarios outlined in the risk register (the remaining High risk scenarios are associated with public safety).

Transport of diesel and anhydrous ammonia were assessed based on a worst credible loss of 36 kilolitres (liquid) or 23 tonnes (gas) respectively. Impact was assessed as direct impact from liquid or gas, and also as indirect impact from resultant fire or explosions.

The likelihood of environmental impact has been, for the most part, assessed as Rare (less than 0.1 %), except in the case of sulfuric acid, in which case the likelihood increases to Unlikely (0.1 % to 1.0 %) at 3 locations along the route. This increase in likelihood is largely a function of frequency of trips.

Transport of sulfuric acid accounts for 20 of the 25 Medium risk scenarios (the remaining 5 Medium risk areas are associated with public safety). The current risk of impact to listed species and/or environmental values associated with the transport of sulfuric acid is Medium based on a worst credible loss of 18 kilolitres of consumable.

Transport of all other consumables and materials was assessed as Low risk to environmental values and/or listed species at each ecologically sensitive area.

5.6.2 Public Safety

Impacts to public safety that were assessed included

- injury/fatality directly associated with a vehicle incident
- injury/fatality via loss of containment of a consumable
- injury/fatality from a vehicle incident leading to a fire/explosion.

The risk assessment process identified four critical risk areas, based on higher likelihood of an incident leading to an injury or fatality. Transport of sulfuric acid was assessed as being a Critical risk to public safety based on a Possible (1 % - 10 %) cumulative likelihood of an incident leading to an injury or fatality as a direct result of the incident.

Transport of quicklime, cement and diesel were also assessed as being a Critical risk to public safety based on an Unlikely (0.1 % – 1 %) cumulative likelihood of an incident leading to an injury or fatality as a direct result of the incident.

All other consumables were assessed as High risk to public safety, based on cumulative Rare likelihood of an incident leading to an injury or fatality.

Only anhydrous ammonia rated as a high risk consumable in the area of injury /fatality via loss of containment of a consumable.

Diesel, explosive (ammonium nitrate, ammonium nitrate emulsion), ShellSol 2046 (kerosene) and anhydrous ammonia were assessed as being High risk in the case of a vehicle incident leading to fire/explosion.

5.7 MITIGATION OF RISK AND IMPACT

Considering the traffic volume changes (low increase) discussed in Sections 5.2 and 5.3 in association with the Project, the cumulative Critical and High risks noted above are not sensitive to or necessarily influenced by this small relative change. That is, in the absence of the Project, the same levels of risk would still apply with regard to public safety.

ERA has provided details of existing controls for analysis in order to be able to manage the risk associated with the transport of consumables to as low as reasonably practicable.

This has been undertaken through the following:

- Controls to prevent or mitigate the identified hazardous events were analysed
- Through a risk assessment workshop, no further additional or alternate controls were identified which could substantially reduce the likelihood or consequence of the priority hazardous events.
- The reliability of controls is managed through pre-qualification evaluations and annual qualification reviews as part of the ERA Contractor Management System, as well as contractor internal management systems.

6. MITIGATION MEASURES

6.1 OVERVIEW

The NT EPA and SEWPaC guidelines for the preparation of an EIS require information on proposed safeguards and mitigation measures associated with the transport of consumables. In particular, the proponent is required to provide:

- a description of proposed mitigation measures (controls)
- an assessment of the expected effectiveness of the mitigation measures
- any statutory or policy basis.

The transport of consumables, including hazardous substances and dangerous goods, is already undertaken by suppliers and carriers for existing operations at the Ranger mine. Therefore, a range of mitigation measures relevant to the proposed Project are currently in place for existing operations. Consequently, analysis of mitigation measures has considered the effectiveness of existing controls as they apply to the proposed Project.

6.2 ERA PROJECT CONTROLS

Participants in an independently facilitated workshop (Appendix B) developed Bowtie diagrams (Appendix C) that identify the ERA controls, and the role that they play in (a) preventing an event from occurring and/or (b) mitigating the impact once an event has occurred. The Bowtie diagrams give each control a unique number, for example:

- 0071 - Electronic load filling system
- 0023 - Tanker selection assessment
- 0039 - Drug and alcohol policy.

Using the unique number, ERA controls outlined below are able to be cross referenced against the Bowtie diagrams presented in Appendix C.

ERA and its suppliers have identified 142 controls that are currently implemented in order to prevent a hazardous event from occurring or to mitigate the impact. Controls are able to be separated into five functional groups that are discussed in more detail below. The five groups are:

- ERA Contractor Management System
- Dangerous Goods Regulations and Code Compliance
- National Heavy Vehicle Accreditation Scheme (NHVAS) Compliance
- Hazard Identification and Risk Management
- Emergency Preparedness

6.2.1 ERA Contractor Management System

The transport of consumables is undertaken by suppliers and carriers for ERA. In order to facilitate contractor compliance with the environment, safety and health requirements of ERA when transporting goods, ERA has in place an internal Contractor Management System.

Specifically, the ERA Contractor Management System is designed to achieve the necessary effectiveness of the controls for the vehicle and driver, in order to prevent an incident from occurring. Contractor management also provides a mechanism for ERA

to specify particular requirements that may be over and above industry standards; for example, compliance with the National Heavy Vehicle Accreditation Scheme (NHVAS) which is currently voluntary in the Northern Territory.

The Contractor Management System has four steps:

1. Pre-qualification of contractors
2. Engagement of contractors
3. Managing HSE components of contractors
4. Monitoring the HSE performance of contractors

Pre-qualification of contractors, in accordance with Australian Standards, includes HSE Management System, independent third-party certification, risk management process and legislative compliance register in addition to a competence based training and maintenance system.

The ERA Contractor Management System specifies requirements for ongoing management and monitoring of HSE contractor performance, supported by annual qualification reviews. It is therefore consistent with the following standards:

- AS/NZS ISO 14001: 2004 Environmental Management Systems
- AS/NZS 4801: 2001 Occupational Health and Safety Management Systems
- Rio Tinto HSEQ Management System Standard
- Rio Tinto Freight Preparation Policy
- Code of Practice - Safe Transport of Radioactive Material (ARPANSA, 2008).

Table 22 identifies the supplier and carrier controls that are included within ERA contractor management.

Table 22 List of controls applicable to ERA contractor management system

Applicable Controls	Applicable Controls
0011 - ERA vehicle access permit system	0047 - Kalari health and wellbeing initiative
0012 - ERA Contractor Management System	0058 - Weekly operations review
0037 - Golden Rules	0064 - Driver competence
0040 - ERA random drug and alcohol testing	0071 - Electronic load filling system
0042 - ERA hydration testing	0072 - Weighbridge
0044 - ERA health and wellbeing initiative	0073 - Tanker specific key card
0006 - Fault reporting system	0112 - Programmed vehicle inspection (6 months)
0009 - Daily pre-start vehicle check, linked to fault reporting system	0115 - Driver bi-annual competency assessment
0027 - Driver induction program	0119 - DirectHaul health and wellbeing initiative
0028 - Driver annual competency assessment	0133 - Toll drug and alcohol testing (random and for cause)
0029 - Driver performance management	0135 - Toll Health and wellbeing initiative
0030 - Pre-employment driver assessment	0146 - Kalari drug and alcohol testing (random and for cause)
0032 - Defensive driver training	0147 - Orica health and wellbeing initiative
0039 - Drug and alcohol policy	0169 - Wrights health and wellbeing initiative
0041 - Chemtrans drug and alcohol testing (random and for cause)	0174 - Fill operator competence
0045 - Fitness for work self-assessment and voluntary declaration	0179 - Dedicated anhydrous ammonia carrier company

Applicable Controls	Applicable Controls
0046 - Employee assistance program	

6.2.2 Statutory and Code Compliance

In the Northern Territory, the transport of dangerous goods by road is regulated by NT WorkSafe. Operators are required to follow the requirements of the Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations. The regulations detail specific obligations with regard to:

- design, manufacture and licencing of vehicles, tanks, vessels and equipment
- training, competence and licencing of drivers
- procedures for marking, stowing and restraining and during transport
- emergency equipment, plans and procedures
- the powers of NT WorkSafe to revoke or suspend operators and impose penalties.

The regulations also refer to the Australian Code for the Transport of Dangerous Goods by Road & Rail (ADG). It is the leading technical document aligned with international best practice.

The transport of radioactive material has additional requirements and must also comply with the Australian Code of Practice for the Safe Transport of Radioactive Materials, and where applicable, the Northern Territory Radioactive Ores and Concentrates (Packaging and Transport) Act and Regulations. Taken together, compliance with the above Regulations and Codes provides a robust framework for controls, to ensure that dangerous goods are transported in a way that eliminates or minimises risk so far as is reasonably practicable.

ERA and its suppliers have demonstrated compliance with relevant controls that are outlined in Table 23 below and relate to the vehicle, tank, packaging and management of operations.

Table 23 List of controls applicable to dangerous goods regulations and code compliance

Applicable Controls	Applicable Controls
0003 - Maintenance in accordance with Australian Standards (AS 2809)	0102 - Pressure vessel design in accordance with Australian Standards
0004 - Tanker design	0103 - Pressure relief valves
0014 - Vehicle design	0113 - Electrical equipment compliance for hazardous areas
0015 - Vehicle selection assessment	0130 - Specification - drums in accordance with ISO
0016 - Performance-based standards	0132 - Company permit to transport (ARPANSA)
0017 - Electronic braking system	0137 - Drums mechanically sealed
0019 - Random regulatory compliance inspections	0138 - Double sealed container, tracked from site to end destination
0020 - Vehicle registration and permit conditions	0139 - Packing configurations in accordance with international approvals
0023 - Tanker selection assessment	0154 - Telephone advisory service
0024 - Compliance with Australian Dangerous Goods Code (ADG7)	0158 - Vehicle dangerous goods licence
0025 - Driver licencing and certification	0159 - Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) audits and compliance
0026 - Driver dangerous goods permits	0160 - Compliance with ARPANSA Code of Practice for Safe Transport of Radioactive Material

Applicable Controls	Applicable Controls
0043 - Driver medical assessment - pre-employment and annual	0166 - Pressure equipment maintenance in accordance with Australian Standards (AS 3788)

6.2.3 National Heavy Vehicle Accreditation Scheme (NHVAS) Compliance

The NHVAS is a formal process for recognising heavy vehicle operators who have robust safety and operational management systems in place. It is also increasingly being used to demonstrate compliance with general duty requirements under road transport law. The NHVAS is managed on a national basis by the Commonwealth Government National Heavy Vehicle Regulator (NHVR).

In the Northern Territory, the NHVAS is voluntary, however ERA has made specifications for compliance with the NHVAS mandatory, as part of contractor management for the transport of consumables (Control ID No. 0013).

Heavy vehicle operators apply for accreditation under NHVAS accreditation modules (NHVR 2013) that include the management controls listed in Table 24.

Table 24 List of controls applicable to National Heavy Vehicle Accreditation Scheme compliance

Applicable Controls	Applicable Controls
0005 - Maintenance in accordance with NHVAS	0048 - Roster management system
0013 - ERA specification for NHVAS	0049 - Fatigue management system

6.2.4 Hazard Identification and Risk Management

ERA has in place an HSE risk management framework that is consistent with the AS/ISO 31000 and Rio Tinto HSEQ Management System Standard. It is applied to all aspects of ERA operations.

The Rio Tinto HSEQ Management System Standard requires that action plans be developed to treat all HSE risks to as low as reasonably practicable. ERA maintains an integrated HSE risk register that captures potential consequences to health, safety and environment performance for operations.

The pre-qualification evaluation for transport carriers and suppliers requires them to demonstrate that there are processes for the assessment of risk. It also requires that a risk register is maintained to track actions and treatments.

Several of the controls identified as part of the development of the Bowtie diagrams exceed duty requirements under road transport law, and have been put in place by ERA and its suppliers as a result of the ongoing hazard identification, risk management and a continuous improvement process. These include:

- GPS-based vehicle monitoring (Control ID No. 0034) allows for real-time monitoring of vehicle location and speed and is able to detect if location-specific speed limits are being exceeded.
- A quarterly industry safety briefing (Control ID No. 0050) that allows transport carriers to continuously share information relating to identified hazards and potential risk treatments.

Additional controls associated with Hazard Identification and Risk Management are listed in Table 25.

Table 25 List of controls applicable to hazard identification and risk management

Applicable Controls	Applicable Controls
0033 - Safety communications and tool box talks	0075 - Feral animal management programs
0034 - Geo fencing (GPS-based vehicle monitoring)	0076 - Fencing
0035 - Transport KPI reporting	0077 - Yard fencing and security
0036 - Public reporting of inappropriate driving (contact information and review process)	0109 - Override device for ignition on; phone off
0038 - Journey Management Plans	0110 - CCTV of surrounding road, linked to rapid acceleration / deceleration
0050 - Industry quarterly safety briefing	0111 - Eye alert monitoring
0051 - Northern Territory road condition reports	0116 - Dedicated internal driver trainer
0052 - Internal road condition notifications	0117 - In Vehicle Monitoring System (IVMS)
0053 - Incident reporting	0120 - Monthly test weight audits
0054 - Department of Transport programmed road condition inspections	0127 - Procedure - container inspection
0057 - Communications to drivers	0128 - Procedure - pre-start check
0059 - Worksafe traffic management	0129 - Rio Tinto Policy - Freight preparation
0060 - Kakadu National Park road and access report	0141 - Back freighted
0061 - Driver hazard identification and reporting	0143 - Product loaded in front and second trailer of a B-triple road train
0062 - Bushfires NT website	0163 - Safe load passport (3 year renewal)
0066 - Road condition axle limits	0164 - DirectHaul drug and alcohol testing (random and for cause)
0067 - Glare reduction coating on cab / bonnet	0168 - Wrights drug and alcohol testing (random and for cause)
0068 - UHF communications	0170 - Driver medical assessment - breathing capacity
0069 - Daytime running lights (hardwired always on)	0171 - Quarterly operations review
0070 - Public awareness campaign	0173 - Internal valve locking mechanism - air supply dependent

6.2.5 Emergency Preparedness

An Emergency Response Plan (ERP) is designed to provide an effective response for control and recovery from incidents; and must comply with all relevant legal and regulatory requirements. This section describes the general form of emergency response as it relates to the transport of consumables. The emergency response of each contractor however, is dependent on the consumable transported, the type of incident and the range of potential impacts.

ERA itself maintains an ERP in line with the Rio Tinto HSEQ Management System Standard. This system encompasses roles and responsibilities, competency based training and required resources. In addition, ERA periodically undertake emergency exercise scenarios that validate response procedures and identify areas of improvement.

Transport carriers are required to submit an ERP for each consumable to ERA as part of pre-qualification.

An incident involving the transport of dangerous goods would trigger the ERP of the relevant contractor. A driver response procedure within the ERP provides guidance for immediate response, including securing personal and public safety, spills prevention procedures, and contacting contractor management and emergency services as

required. This contact may occur through driver communications (ID No. 0079) or a driver distress button (ID No. 0080). An exclusion zone may also be established (ID No. 0095) using on-vehicle portable warning triangles (ID No. 0117).

The drivers must report any incident involving a dangerous situation as soon as practicable to emergency services and are also required to provide any reasonable assistance required by emergency services to deal with the situation. This is specified by the Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations.

The ERPs require an Emergency Response Team to implement manage and execute the plans. If the emergency is relatively minor in nature, a technical supervisor may only be required to attend the scene. Contractors maintain on-vehicle spill response kits, emergency response kits and personal protective equipment relevant to the goods being transported. This is consistent with the requirements of ADG. Site-based emergency response equipment is also maintained by contractors across their operational areas.

Further resources include an emergency callout register of company personnel, supplier contacts, sources of neutralising and absorption agents appropriate to the consumable as well as government authorities that are responsible for specific disaster management plans that fall within their geographical zone of responsibility.

The identified controls that form part of emergency preparedness to prevent or mitigate incidents are listed in Table 26 below.

Table 26 List of controls applicable to emergency preparedness

Applicable Controls	Applicable Controls
0063 - Procedure - cyclones	0095 - Exclusion zone
0065 - Procedure - flooding	0096 - Dust suppression using water
0176 - Procedure - incident response	0097 - Spills management plan
0078 - Emergency response plan	0099 - Emergency response kits and PPE
0079 - Driver communications	0100 - Diphoterine Autonomous Portable Shower (DAP)
0080 - Driver distress button	0101 - Major hazard standard - heavy vehicles
0081 - Orica emergency response service	0122 - Internal emergency response service
0083 - Local emergency services	0124 - Site based spill response trailer
0084 - Driver remote first aid training	0125 - Fire extinguishers in accordance with ADG7 and AS/NZS 1841.5
0085 - HAZMAT signage	0126 - Driver first aid training
0086 - First aid kits and equipment	0142 - Toll emergency response service
0087 - Emergency response training	0156 - ERA emergency response services
0088 - Prowler pool spill kit	0162 - Kalari emergency response service
0089 - Emergency response training with emergency services	0177 - Risk assessed exclusion zones
0090 - On-vehicle spill response kit	0178 - Communication of Journey Management Plans to relevant authorities on the route
0091 - Safety Data Sheet (SDS) carried in cab	0180 - On-vehicle breathing apparatus
0093 - Site-based emergency response equipment	0181 - Wrights / Incitec Pivot emergency response service

6.2.6 Controls Compliance

Effective controls are able to demonstrate that each hazard and potentially hazardous event has been addressed with specific control measures.

The Bowtie diagrams for the identified hazardous events (as included in Appendix C) clearly identify the ERA controls and their role in preventing an event from occurring, or mitigating the impact once an event has occurred. These controls were identified based on the collective experience of transport carriers and consumable suppliers, informed by knowledge of the existing delivery of consumables for existing operations at the Ranger mine.

The Bowtie diagrams demonstrate that for each of the identified hazardous events there are multiple layers of protection in place, including equipment design, procedures, preventative maintenance programs and emergency response processes. The current controls comply, and in some cases, exceed legislative requirements, codes of practice, voluntary accreditation schemes and the risk management practices of transport industry.

6.2.7 Controls Reliability

The second aspect in assessing controls is that the controls in place are reliably able to perform their intended function.

Approximately 85 % of controls are under the direct influence of the transport carriers. A further 10 % are under the direct influence of government or statutory authorities. Therefore, the contractor management system is considered key to the ongoing reliability of risk management for the transport of consumables.

Using a risk management framework, controls are part of a systematic management approach. As part of pre-qualification, ERA requires contractors to have the same systematic approach across a range of specific transport related criteria in the management of HSE and risk.

The ERA pre-qualification and annual qualification review operates in conjunction with contractor risk monitoring and review, and third party auditing. This provides for comprehensive measurement and management of the reliability of controls put into place by transport carriers to manage risks to the environment, and public safety.

Therefore, the reliability of controls under the direct influence of the transport carriers is measured through this on-going management process, described in more detail in Appendix F.

7. CONCLUSION

Consistent with the NT EPA and SEWPaC guidelines for the preparation of an EIS, a comprehensive study of transport and consumables associated with the Project has been undertaken that assesses risk, impact and mitigation.

On the basis of transport of consumables associated with the current operation at Ranger mine, ERA has a comprehensive understanding of their current transport risk profile; and in collaboration with transport suppliers, applies multiple layers of controls to manage these risks effectively. ERA undertakes proactive improvement activities with their transport suppliers and NT Department of Transport. The current controls comply, and in some cases exceed, the legislative requirements, codes of practice, voluntary accreditation schemes and the risk management practices of the transport industry.

The proposed Ranger 3 Deeps project requires the same consumables that are required for existing operations, and that would be required for continued operations without the Project; although quantities of various consumables will change. The nature of these consumables is well understood, and their management is, and would continue to be, commensurate with this understanding and experience.

The cumulative traffic volume for continued operations with the project consists of 20 round trips per day, of which the Project would contribute 6 round trips. These volumes are well within the capacity of the existing road network.

The independently facilitated risk assessment process considered risks to public safety, environmental values and listed threatened and migratory species. For each consumable, a Bowtie risk analysis was undertaken to establish causal pathways and existing controls. This information, in addition to an analysis of route condition by certified traffic engineers, and quantified incident statistics, established the likelihood of an incident occurring at a particular location.

Using established flora and fauna databases, and observations by ecological specialists, areas of ecological sensitivity along the transport route were identified. Consistent with recognised risk assessment methodology, the maximum reasonable consequence was informed by the contribution of industry and ecological specialists.

In total, 246 risks for the cumulative transport activity were identified across public safety, environmental values and listed threatened and migratory species. The raw number of risks is a function of the range of consumables across multiple sections of the transport corridor. Of these risks, 4 were assessed as having a critical risk ranking, associated with public safety should an incident occur. The other risks were spread across public safety, environmental values and listed threatened and migratory species.

This study indicates that the Project does not materially alter the existing transport risk profile. Nevertheless, the current safeguards and mitigation measures that would be implemented for the Ranger 3 Deeps project either meet or exceed regulatory and industry standards.

8. LEGISLATIVE FRAMEWORK

8.1 LEGISLATION AND GUIDELINES

The NT EPA and Department of the Environment guidelines for the preparation of an EIS require information on the statutory and/or policy basis for the mitigation measures described above.

The legislative framework described below includes both statutory controls and guiding policy developed by State and Commonwealth governments in areas of road transport, dangerous goods, workplace safety and environmental protection.

Table 27 Relevant legislation and guidelines

Applicable legislation/policies/guidelines	Relevance
Northern Territory Legislation	
Control of Roads Act	The Control of Roads Act provides that, subject to the Planning Act and the Local Government Act, the control, care and management of all public roads in the Northern Territory vests with the Minister. This Act outlines the process by which public roads can be opened and closed. Any public or gazetted roads that are required to be opened or closed as a result of construction or operation of the mine would be required to follow the provisions of the Act.
Dangerous Goods Act; Dangerous Goods Regulations	The Act and its regulations are to provide for the safe storage, handling and transport of certain dangerous goods. This Act makes provision for safety in the transport of dangerous goods by road and rail as part of the system of nationally consistent road and rail transport laws.
Environmental Assessment Act	This Act provides for the assessment of the potential environmental effects of development proposals prior to the determination of project consent through the preparation and review of an environmental report.
Environmental Offences and Penalties Act	This Act establishes penalties for certain offences relating to the protection of the environment
Motor Vehicles Act; Motor Vehicles Regulations	The Act and associated regulations provide for the driver licencing and registration requirements.
Motor Vehicles (Standards) Regulations	The Act and its regulations provide for the regulation of light and heavy vehicle standards.
Radiation Protection Act	An Act about the protection of people and the environment from harmful radiation, and for related purposes.
Radioactive Ores and Concentrates (Packaging)	An Act to make provision for the packaging, storage and transport of radioactive ores and concentrates.

Applicable legislation/ policies/guidelines	Relevance
and Transport) Act	
Territory Parks And Wildlife Conservation Act Territory Parks and Wildlife Conservation Regulations	This Act provides for the establishment, study, protection, conservation and sustainable utilisation of Territory Parks and Reserves, and Northern Territory wildlife.
Traffic Act; Traffic Regulations	The objective of this Act and associated regulations is to regulate traffic, which includes provisions in relation to the erection and operation of traffic control devices. Traffic control devices refer to signals, signs or markings displayed for the purpose of regulating, warning or guiding traffic. Under the Act, consent from the applicable competent authority is required prior to the erection and operation of traffic control devices.
Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act, Transport of Dangerous Goods by Road and Rail (National Uniform legislation) Regulations	<p>This Act makes provision for safety in the transport of dangerous goods by road and rail. Involvement in the transport of dangerous goods by road or rail includes, but is not limited to, being the consignee of dangerous goods, loading or unloading dangerous goods that have been transported or the importation or arrangement to import dangerous goods.</p> <p>The Act and associated regulations regulate the transport of dangerous goods in order to promote public safety and protect property and the environment within a nationally consistent context.</p> <p>The Regulation establishes a system of standards and licensing for the transport of dangerous goods by road and rail and also applies the Australian Code for the Transport of Dangerous Goods by Road and Rail to such transport.</p>
Waste Management and Pollution Control Act	This Act protects and where practicable restores and enhances the quality of the Northern Territory environment; provides for the protection of the environment through pollution prevention and encouragement of effective waste management and facilitates the implementation of NEPMs established by the National Environment Protection Council.
Water Act Water Regulations	The Act and associated regulations are the primary legislation for the regulation and management of water resources in the Northern Territory. This Act provides for the investigation, use, control, protection, management and administration of water resources in the Northern Territory. It must be noted that the Act prohibits the release of "restricted substances" into watercourses but no such substances have yet been prescribed. Water quality standards have been declared by notice in the Gazette.
Work Health and Safety (National Uniform Legislation) Act 2011	<p>The Northern Territory Work Health and Safety (National Uniform Legislation) Act commenced on 1 March 2012, and represents a movement towards harmonising work health and safety legislation across Australia. Under the Act, approved codes of practice provide practical guidance to meeting legislative obligations.</p> <p>Of relevance to this transport assessment is the approved Northern Territory Code of Practice in Fatigue Management. It is a voluntary code of practice for fatigue</p>

Applicable legislation/ policies/guidelines	Relevance
	management for road transport with the objective to provide operators with a basic set of key principles to be applied.
Commonwealth Legislation	
Environment Protection (Alligator Rivers Region) Act 1978	An Act to provide for the appointment of a Supervising Scientist for the purpose of protecting the environment in the Alligator Rivers Region of the Northern Territory from the effects of mining operations, and for other purposes.
Environment Protection and Biodiversity Conservation Act 1999	This Act forms the national framework for environmental protection with a focus on protecting matters of national environmental significance (MNES) and conservation.
National Environment Protection Measures (Implementation) Act 1998	This Act ensures that the community has access to relevant and meaningful information about pollution.
Product Stewardship Act 2011	An Act to provide a framework for reducing the environmental and other impacts of products, and for related purposes.
Codes of Practice	
Australian Code for the Transport of Dangerous Goods by Road and Rail, Seventh Edition	The code sets out the technical requirements and guidelines for the transport of dangerous goods by road and rail.
Australian Code of Practice for the Transport of Explosives by Road and Rail, Third Edition	This code sets out the requirements which apply to the transport of Class 1 explosives subject to this code by road and rail in Australia.
Code of Practice – Safe Transport of Radioactive Material	This code establishes uniform requirements for the safe transport of radioactive material in Australia by road, rail or water ways under the jurisdictions of States and Territories in Australia. ERA is required to comply with the code as part of its obligations under the Radioactive Ores and Concentrates (Packaging and Transport) Act 1980.

9. SCOPE AND LIMITATIONS

This report has been prepared by GHD for ERA and may only be used and relied on by ERA for the purpose agreed between GHD and ERA as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than ERA arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

10. BIBLIOGRAPHY

Applegate, R., Burgess, J., Duggan, K. & Tatenko, S., (1986), *Erosion Assessment Report on Stage 1 of Kakadu National Park*, Northern Territory Conservation Commission 1986.

AS/NZS ISO 31000:2009 (2009), *Risk management – Principles and guidelines*, Standards Australia

BITRE (2012), *State and Capital City Vehicle Kilometres Travelled, 1990 – 2012*, Bureau of Infrastructure, Transport and Regional Economics, viewed 18 November 2013, <http://www.bitre.gov.au/publications/2012/files/is_044.pdf>.

Christian, C. & Aldrick, J. (1977), *Alligator Rivers Study: a review report*, Department of NT and Australian Mining Council, Australian Government Publishing Service, Canberra.

Deacon, Zegeer & Deen (1974), 'Identification of Hazardous Rural Highway Locations' in *Transportation Research Report 410*, Transportation Research Board, viewed 18 November 2013, <<http://www.ktc.uky.edu/>>.

Department of the Environment (2013a), *Australian Heritage Database*, viewed 19 November 2013, <<http://www.environment.gov.au/cgi-bin/ahdb/search.pl>>.

Department of the Environment (2013b), *Matters of National Environmental Significance Significant impact guidelines*, Environment Protection and Biodiversity Conservation Act 1999, Department of the Environment.

Department of the Environment (2013c), *Protected Matters Search Tool Results*, Department of the Environment, report created 15th November 2013, <<http://www.environment.gov.au/epbc/pmst/>>.

DLRM (2013a) Sites of Conservation significance, Department of Land Resource Management, viewed November 2013, <<http://lrm.nt.gov.au/plants-and-animals/conservation-for-land-managers/sites-of-conservation-significance/information>>.

DLRM 2013, *Fauna and flora records*, Department of Land Resource Management, 15 November 2013

DoT (2012), *Annual Traffic Report*, Northern Territory Department of Transport, viewed 18 November 2013, <<http://www.transport.nt.gov.au/publications/traffic-reports>>.

DoT (2013a), *Northern Territory Road Access Report*, Northern Territory Department of Transport unpublished report, November 2013.

DoT (2013b). *Vehicle Accident Database*, Northern Territory Department of Transport unpublished report, November 2013.

ERA (2013), *Referral for Proposed Action, Ranger 3 Deeps Underground Mine*, Pugh. L & Anderson P., January 2013, Energy Resources of Australia Ltd.

FMCSA (2001), *Comparative Risks of Hazardous Materials and Non-Hazardous Materials Truck Shipment Accidents/Incidents*, Federal Motor Carrier Safety Administration, viewed 18 November 2013, <<http://www.fmcsa.dot.gov/documents/hazmatriskfinalreport.pdf>>.

Geurts & Wets (2003), *Black Spot Analysis Methods: Literature Review*, viewed 18 November 2013, <<http://www.ctre.iastate.edu/>>.

Hauer (1996), Identification of Sites with Promise, in *Transportation Research Record 1542*, Transportation Research Board, viewed 18 November 2013, <<http://trb.metapress.com/index/64J3308L150J5122.pdf>>.

HB 158-2010 (2009), *Delivering assurance based on ISO 31000:2009 - Risk management - Principles and guidelines*, Standards Australia

HB 203:2012 Managing environment-related risk

Lynch, B.T. & Wilson, P.L., (1998), *Land Systems of Arnhem Land*, Technical Report No. R 9711, Department of Lands, Planning and Environment.

Monash University Accident Research Centre (2007), *The Influence of Trends in the Heavy Vehicle Fleet on Trauma in the Light Vehicle Fleet* (Report No. 259), viewed 18 November 2013, <<http://www.monash.edu.au/miri/research/reports/muarc259.pdf>>.

NHVR 2013, National Heavy Vehicle Regulator, *Safety, Accreditation and Compliance*, viewed 18 November 2013, <<https://www.nhvr.gov.au/safety-accreditation-compliance/nat-heavy-vehicle-accreditation-scheme/accreditation-modules>>

Nott, J., (2003), *Kakadu – Arnhem Land Region, Northern Territory*, School of Tropical Environment Studies and Geography, James Cook University.

SA/SNZ HB 436:2013, Risk management guidelines – Companion to AS/NZS ISO 31000:2009, Standards Australia.

SEWPaC (2008a), *Arnhem Plateau Bioregion*, Department of the Environment, viewed 18 November 2013, <<http://www.environment.gov.au/system/files/resources/a8015c25-4aa2-4833-ad9c-e98d09e2ab52/files/bioregion-arnhem-plateau.pdf>>.

SEWPaC (2008c), *Darwin Coastal Bioregion*, Department of the Environment, viewed 18 November 2013, <<http://www.environment.gov.au/system/files/resources/a8015c25-4aa2-4833-ad9c-e98d09e2ab52/files/bioregion-darwin-coastal.pdf>>.

SEWPaC (2008d), *Pine Creek Bioregion*, Department of the Environment, viewed 18 November 2013, <<http://www.environment.gov.au/system/files/resources/a8015c25-4aa2-4833-ad9c-e98d09e2ab52/files/bioregion-pine-creek.pdf>>.

SEWPaC (2011a), *Arnhem Plateau Sandstone Shrubland Complex Ecological Community*, Map, Department of Sustainability, Environment, Water, Populations and Communities, June 2011.

SEWPaC (2011), *Kakadu National Park, Australian Wetlands Database, Ramsar Wetlands*, Department of the Environment, viewed 19 November 2013, <<http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=2>>.

SEWPaC (2012), *The Nationally Protected Arnhem Plateau Sandstone Shrubland Complex*, Department of Sustainability, Environment, Water, Populations and Communities (now Department of the Environment), viewed 18 November 2013, <<http://www.environment.gov.au/system/files/resources/25cdd612-df01-4f66-ae52-81b591f1b3fc/files/arnhem-plateau-shrubland-complex-factsheet.pdf>>.

Woinarski, J. C. Z., Hempel, C., Cowie, I., Brennan, K., Kerrigan, R., Leach, G. & Russell-Smith, J., (2006), *Distributional pattern of plant species endemic to the Northern Territory, Australia*, *Australian Journal of Botany*, vol. 54, pp. 627–640.

Appendices

Appendix A - Likelihood of Occurrence of Threatened and Migratory Species

Likelihood of Occurrence of Threatened and Migratory Species

The likelihood of occurrence of threatened and migratory species was assessed based on the desktop searches and literature review. The results of this assessment can be seen in Table 28.

Key to Table 28

EPBC	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
TPWC	Territory Parks and Wildlife Conservation Act 2006
DLRM	Information sources from the Department of Land Resource Management (DLRM) fauna and flora records (not predictions) database
PMST	Information sourced from the EPBC Protected Matters Search Tool
CR	Critically Endangered
EN	Endangered
VU	Vulnerable
NT	Near Threatened
LC	Least Concern
NE	Not Evaluated
DD	Data Deficient
Mi	Migratory

Likelihood of occurrence of listed threatened species/community is assessed on a 3-tier scale:

Possible - Suitable habitat occurs within the study area.

Unlikely - Suitable habitat unlikely to occur within the study area, or suitable habitat substantially modified, or suitable habitat present but species not recorded for over 50 years.

Highly unlikely - No suitable habitat present within the study area and individuals not recorded within study area.

Table 28 Likelihood of occurrence and assessment of potential impact on listed threatened species and ecological communities in study area

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC - TPWC			
Listed Threatened Ecological Communities				
Arnhem Plateau Sandstone Shrubland Complex	EN		The Arnhem Shrubland Complex is mainly on the Arnhem Plateau and outliers such as Ubirr, Nawurlandja (Little Nourlangie Rock) and Burrungui (Nourlangie Rock). It is also on the Marawal Plateau. The national ecological community is mainly found on the sandstone rock pavements. It grows in cracks of rock and also in shallow sandsheets of the wardde wardde (sandstone country). The Arnhem Shrubland Complex can also grow on mudstone on the Marawal Plateau in Nitmiluk National Park.	Unlikely This community is found in rocky areas, which are unlikely to be at ground level where risk from vehicle accidents exists.
Listed Threatened Species				
Mammals				
Brush-tailed Rabbit-rat (<i>Conilurus penicillatus</i>)	VU	EN	Restricted to mixed eucalypt open forest and woodland, or on dunes with Casuarina, seeming to prefer habitats that are not burnt annually, that have an understorey of predominantly perennial grasses and a sparse-to-moderate middle storey.	Possible Habitat present within study area. There are records within study area with the most recent record being in 2009 (DLRM 2013).
Northern Quoll (<i>Dasyurus hallucatus</i>)	EN	CR	Habitat comprises rocky areas and tall open coastal eucalypt forests. Prime habitat in these northern regions is sandstone escarpment. Habitat in KNP includes open forest and woodlands on plains dominated by <i>Eucalyptus tetradonta</i> , <i>E. miniata</i> and <i>E. tectifica</i> , open woodland on low rocky hills dominated by <i>E. setosa</i> and <i>E. bleeseri</i> and riparian areas with flowing water dominated by <i>Melaleuca viridiflora</i> and <i>Pandanus spiralis</i> . Sometimes occurs around human dwellings and campgrounds.	Possible Habitat present within study area. There are records within study area with the most recent record being in 2009 (DLRM 2013).
Golden-backed Tree-rat (<i>Mesembriomys macrurus</i>)	VU	CR	Known from only three definite records in Northern Territory: "Balanbrinni" (probably Balbarini) in the upper McArthur in 1901; Nellie Creek (in the upper Mary) in 1903; and Deaf Adder Gorge in 1969. All	Unlikely Habitat present within study area, although species has not

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC - TPWC			
			<p>three records were from riverine vegetation.</p> <p>In the Kimberley, has been recorded from a broad range of vegetation types, including eucalypt open forests with tussock grass understorey, rainforest patches on a variety of landforms and soils, eucalypt woodlands with hummock grass understorey, rugged sandstone screes, beaches, and blacksoil plains with pandanus.</p>	<p>been recorded since 1903 (DLRM 2013).</p>
Northern Brush-tailed Phascogale (<i>Phascogale pirata</i>)	VU	EN	<p>Most records from tall open forests dominated by <i>Eucalyptus miniata</i> (Darwin woollybutt) and <i>E. tetradonta</i> (Darwin stringybark).</p>	<p>Possible</p> <p>Habitat occurs within area and there are previous records within study area with the most recent in 2003 (DLRM 2013).</p>
Bare-rumped Sheath-tail Bat (<i>Saccolaimus saccolaimus nudicluniatu</i> s)	CR	NT	<p>Only anecdotal information is available based on habitat around roosts or from shot specimens. Kakadu National Park specimens collected have been from open pandanus woodland fringing the sedgeland of the South Alligator River.</p> <p>May forage over habitat edges such as the edge of rainforest and in forest clearings.</p>	<p>Possible</p> <p>Possible roosting and foraging habitat in pandanus woodland present within study area. Specimens have been collected from Kakadu previously (DLRM 2013).</p>
Arnhem Leaf-nosed Bat (<i>Hipposideros inornata</i>)	-	VU	<p>Roosts in caves or abandoned mine adits in cool drafty areas, close to water. Little is known of its foraging habitat or diet, but it has been reported foraging in riparian areas and in eucalypt tall open forests.</p>	<p>Possible</p> <p>Foraging habitat present within study area. There are records within study area, most recently in 1983 (DLRM 2013).</p>
Northern Leaf-nosed Bat (<i>Hipposideros stenotis</i>)	-	EN	<p>Little is known of the ecology of this species. It is associated with rocky outcrops and roosts in shallow caves, boulder piles and disused mines. It forages in a variety of habitats from monsoon vine thickets and woodlands to open grasslands.</p>	<p>Possible</p> <p>Foraging habitat present within study area. There are records within study area, most recently in 1983 (DLRM 2013).</p>
Water Mouse (<i>Xeromys</i>)	VU	DD	<p>Habitat includes mangroves and the associated saltmarsh, sedgeland, clay pans, heathlands and</p>	<p>Possible</p>

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
<i>myoides</i>)			freshwater wetlands. Utilises both intertidal and freshwater habitats.	Habitat occurs within study area though there are no previous records.
Arnhem Rock-rat (<i>Zyomys maini</i>)	VU	VU	Occurs in rugged sandstone environments, typically where there are many caves, crevices or boulders, in association with monsoon rainforest, typically in areas which are floristically-rich.	Possible Habitat occurs within study area. There are records within study area, although the most recent was in 1990 (DLRM 2013).
Australian Snubfin Dolphin (<i>Orcaella heinsohni</i>)	Mi	DD	Within Australia, Australian Snubfin Dolphins have been recorded almost exclusively in coastal and estuarine waters. It is doubtful that they venture very far upstream in river systems, although occasional vagrants may venture upstream.	Highly unlikely It is unlikely that Snubfins will venture very far upstream in the river systems present within the study area.
Indo-Pacific Humpback Dolphin (<i>Sousa chinensis</i>)	Mi	DD	In Australia, Indo-Pacific Humpback Dolphins are known to occur along the northern coastline.	Highly unlikely It is unlikely that Humpback Dolphins will venture very far upstream in the river systems present within the study area.
Humpback Whale (<i>Megaptera novaeangliae</i>)	VU / Mi	LC	Occurs in all major oceans, mostly in coastal and continental shelf waters.	Highly unlikely Humpback Whale habitat is not present within study area.
Golden Bandicoot (<i>Isoodon auratus</i>)	VU	EN	Occurs mainly in heathland and shrubland on sandstone or sandsheets, and avoids vegetation with greater tree cover.	Unlikely Habitat present within study area. There are records within study area, though the most recent is 1967 (DLRM 2013).
Black-footed Tree-rat (<i>Mesembriomys gouldii</i>)	-	VU	Found in the Top End of the Northern Territory in tropical woodlands and open forests in coastal areas.	Possible Suitable habitat present within

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
				study area and there are records within study area as recently as 2011 (DLRM 2013).
Fawn Antechinus (<i>Antechinus bellus</i>)	-	EN	Occurs in savannah woodland and tall open forest of the Top End of the Northern Territory.	Possible Suitable habitat present within study area. There are records within study area as recently as 2010 (DLRM 2013).
Pale Field-rat (<i>Rattus tunneyi</i>)	-	VU	Occurs in dense vegetation along creeks.	Possible Suitable habitat along dense vegetation along creeks present within study area. There are numerous records within study area (DLRM 2013).
Birds				
Yellow Chat (Alligator Rivers) (<i>Epthianura crocea tunneyi</i>)	EN	EN	Occurs around channels and depressions on seasonally inundated floodplains. In the dry season, it has been observed in areas of exposed mud or clay with or without a sparse (up to 50 %) cover of grasses, sedges and forbs, such as <i>Hymenachne acutigluma</i> , <i>Ludwigia adscendens</i> , <i>Ipomoea aquatica</i> , <i>Sesbania sesban</i> and species of <i>Cyperus</i> and <i>Eleocharis</i> . Habitat preferences in the wet season are less well known, but all of the few records of nesting from Kakadu National Park have been in low mangroves on the margins of tidal channels.	Possible Suitable habitat likely to occur within study area. There are records within study area in 1992 (DLRM 2013).
Red Goshawk (<i>Erythrotriorchis radiates</i>)	VU	VU	Prefers tall open forest and woodland, or tall fringing woodlands along rivers in grasslands, shrublands, and low open woodlands. Also occurs in coastal and sub-coastal areas in wooded and forested lands of tropical and warm-temperate Australia or riverine forests. Nests in large trees, frequently the tallest and most massive in a tall stand, and nest trees are invariably within one km of permanent water.	Possible Species habitat present within study area. There are records within study area as recent as 2010 (DLRM 2013).

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EN / Mi	TPWC		
Gouldian Finch (<i>Erythrura gouldiae</i>)	EN / Mi	VU	Inhabits open woodlands that are dominated by Eucalyptus trees and support a ground cover of Sorghum and other grasses. Critical components of suitable core habitat appear to be the presence of favoured annual and perennial grasses (especially Sorghum), a nearby source of surface water and, in the breeding season, unburnt hollow-bearing Eucalyptus trees (especially <i>E. tintinnans</i> , <i>E. brevifolia</i> and <i>E. leucophloia</i>). Breeding habitat confined to ridges and rocky foothills.	Possible Suitable foraging habitat present within study area. There are records within study area, as recent as 2010 (DLRM 2013).
Crested Shrike-tit (northern) (<i>Falcunculus frontatus whitei</i>)	VU / Mi	NT	Inhabits eucalypt open woodlands, such as those dominated by Bloodwood, <i>Eucalyptus opaca</i> , Darwin Box <i>E. tectifera</i> and Roughleaf Cabbage Gum <i>E. confertiflora</i> , and less often in woodland dominated by Darwin Woollybutt <i>E. miniata</i> , Darwin Stringybark <i>E. tetradonta</i> or Smooth-stemmed Bloodwood <i>Corymbia bleeseri</i> .	Possible Suitable habitat present within study area. There are records within study area, as recent as 2009 (DLRM 2013).
Partridge Pigeon (eastern) (<i>Geophaps smithii smithii</i>)	VU	VU	Occurs in open forest and woodland dominated by Darwin Stringybark <i>E. tetradonta</i> and Darwin Woollybutt <i>E. miniata</i> that has a structurally diverse understorey. Nests on the ground, usually where there is plenty of vegetation cover. Forage where the ground layer is open, or on bare ground in recently burnt areas.	Possible Suitable habitat present within study area. There are records within study area, as recent as 2010 (DLRM 2013).
Australian Painted Snipe (<i>Rostratula australis</i>)	EN / Mi	VU	Inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. Also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Masked Owl (northern) (<i>Tyto novaehollandiae kimberli</i>)	VU	VU	Inhabits riparian forest, rainforest, open forest, Melaleuca swamps and the edges of mangroves.	Possible Suitable habitat possibly present within study area. There are records within study area (DLRM 2013).
Grey Falcon (<i>Falco hypoleucos</i>)	-	VU	Inhabits areas of lightly-timbered lowland plains, typically on inland drainage systems, where the average annual rainfall is less than 500 mm.	Possible There are previous records

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
				within study area (DLRM 2013), although suitable habitat is scarce in the study area.
White-throated Grasswren (<i>Amytornis woodwardi</i>)	-	VU	Confined to hummock grasslands sometimes with open shrubland or woodland overstorey, mixed among dense boulder fields, sandstone pavements and escarpment drainage lines. Restricted to the rugged sandstone massif of western Arnhem Land, extending south-west as far as Nitmiluk National Park and northeast as far as the Mann River.	Possible Suitable habitat may not be present within study area. There are records within study area in 1913 (DLRM 2013).
Melville Cicadabird (<i>Coracina tenuirostris melvillensis</i>)	Mi	LC	Inhabits monsoon forests and mangrove swamps in the Top End of Australia from Broome to the Macarthur River in Northern Territory and including Melville Island.	Possible Species or species habitat may occur within area
White-bellied Sea-Eagle (<i>Haliaeetus leucogaster</i>)	Mi	LC	Occurs in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands.	Possible Habitat present within study area. There are numerous records within study area (DLRM 2013).
Barn Swallow (<i>Hirundo rustica</i>)	Mi	NE	Occurs in open country in coastal lowlands, often near water, towns and cities and also in or over freshwater wetlands, paperbark Melaleuca woodland, mesophyll shrub thickets and tussock grassland. Breeds throughout the northern hemisphere in temperate and subtropical regions.	Possible Habitat present within study area.
Rainbow Bee-eater (<i>Merops ornatus</i>)	Mi	LC	Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Derby White-browed Robin (<i>Poecilodryas superciliosa cerviniventris</i>)	Mi	LC	Inhabits riparian vegetation.	Possible Habitat present within study area.

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
Rufous Fantail (<i>Rhipidura rufifrons</i>)	Mi	LC	Occur in tropical rainforest and monsoon rainforests, including semi-evergreen mesophyll vine forests, semi-deciduous vine thickets or thickets of Paperbarks (<i>Melaleuca spp.</i>).	Possible Habitat occurs within study area.
Common Sandpiper (<i>Actitis hypoleucos</i>)	Mi	LC	Occurs in a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats. Often associated with mangroves, and sometimes found in areas of mud littered with rocks or snags. Roost sites are typically on rocks or in roots or branches of vegetation, especially mangroves.	Possible Habitat occurs within study area. There are records within study area (DLRM 2013).
Cattle Egret (<i>Ardea ibis</i>)	Mi	LC	Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Oriental Plover (<i>Charadrius veredus</i>)	Mi	LC	Forages amongst short grass or on hard stony bare ground but also on mudflats or among beachcast seaweed on beaches. Roosts on soft wet mud or in shallow water of beaches and tidal mudflats and also occasionally in dry, open habitats, such as saltmarsh or paddocks.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Oriental Pratincole (<i>Glareola maldivarum</i>)	Mi	LC	Inhabits open plains, floodplains or short grassland (including farmland or airstrips), often with extensive bare areas. Often occur near terrestrial wetlands, such as billabongs, lakes or creeks, and artificial wetlands such as reservoirs, saltworks and sewage farms, especially around the margins.	Possible Habitat present within study area. There are previous records within study area (DLRM 2013).
Whimbrel (<i>Numenius phaeopus</i>)	Mi	NT	Often found on the intertidal mudflats of sheltered coasts. It is also found in harbours, lagoons, estuaries and river deltas, often those with mangroves, but also open, unvegetated mudflats. It is occasionally found on sandy or rocky beaches, on coral or rocky islets, or on intertidal reefs and platforms. Forages on intertidal mudflats, along the muddy banks of estuaries and in coastal lagoons, either in open unvegetated areas or among mangroves.	Possible Habitat present within study area. There are records within study area (DLRM 2013).

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
Grey Plover (<i>Pluvialis squatarola</i>)	Mi	NT	Occur almost entirely in coastal areas, where they usually inhabit sheltered embayments, estuaries and lagoons with mudflats and sandflats, and occasionally on rocky coasts with wave-cut platforms or reef-flats, or on reefs within muddy lagoons. They also occur around terrestrial wetlands such as near-coastal lakes and swamps, or salt-lakes.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Marsh Sandpiper (<i>Tringa stagnatilis</i>)	Mi	LC	Occupies permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, salt-pans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes. Forages in shallow water at the edge of wetlands.	Possible Habitat present within study area.
Terek Sandpiper (<i>Xenus cinereus</i>)	Mi	LC	Forages in the open, on soft wet intertidal mudflats or in sheltered estuaries, embayments, harbours or lagoons. The species has also been recorded on islets, mudbanks, sandbanks and spits, and near mangroves and occasionally in samphire (<i>Halosarcia spp.</i>). Birds are seldom near the edge of water; however birds may wade into the water.	Possible Habitat present within study area.
Bar-tailed Godwit (<i>Limosa lapponica</i>)	Mi	VU	Forages in flocks on intertidal mudflats or in shallow water in Northern Territory during austral Summer.	Possible This species is likely to be present closer to the coast than the study area. There are records within study area in 1990 (DLRM 2013).
Black-tailed Godwit (<i>Limosa limosa</i>)	Mi	NT	Commonly found in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit; occasionally recorded on rocky coasts or coral islets.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Caspian Plover (<i>Charadrius asiaticus</i>)	Mi	NE	Primarily associated with saline habitats such as salt-pans, saline soils subject to seasonal flooding, inland saltmarshes and alkali flats.	Possible Habitat present within study area. There are records within study area (DLRM 2013).

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
Caspian Tern (<i>Hydroprogne caspia</i>)	Mi	LC	Mostly found in sheltered coastal embayments (harbours, lagoons, inlets, bays, estuaries and river deltas) and those with sandy or muddy margins are preferred. Also occur on near-coastal or inland terrestrial wetlands that are either fresh or saline, especially lakes (including ephemeral lakes), waterholes, reservoirs, rivers and creeks.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Common Greenshank (<i>Tringa nebularia</i>)	Mi	LC	Inhabits a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. Habitats include embayments, harbours, river estuaries, deltas and lagoons and are recorded less often in round tidal pools, rock-flats and rock platforms.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Curlew Sandpiper (<i>Calidris ferruginea</i>)	Mi	VU	Mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Eastern Curlew (<i>Numenius madagascariensis</i>)	Mi	VU	Most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Eastern Great Egret (<i>Ardea modesta</i>)	Mi	LC	Occurs in a wide range of wetland habitats. These include swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands; reservoirs; sewage treatment ponds; drainage channels; salt pans and salt lakes; salt marshes; estuarine mudflats, tidal streams; mangrove swamps; coastal lagoons; and offshore reefs.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Eastern Osprey (<i>Pandion cristatus</i>)	Mi	LC	Occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They are mostly found in coastal areas but occasionally travel inland along major rivers, particularly in northern Australia Require extensive areas of open fresh, brackish or saline water for foraging.	Possible Habitat present within study area. There are records within study area (DLRM 2013).

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
				area (DLRM 2013).
Eastern Reef Egret (<i>Egretta sacra</i>)	Mi	LC	Occurs on beaches, rocky shores, tidal rivers and inlets, mangroves, and exposed coral reefs	Unlikely More likely to occur closer to the coast than in study area. There are records within study area (DLRM 2013).
Fork-tailed Swift (<i>Apus pacificus</i>)	Mi	LC	Almost exclusively aerial, flying from less than 1 m to at least 300 m above ground. Mostly occur over inland plains but sometimes above foothills or in coastal areas.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Garganey (<i>Anas querquedula</i>)	Mi	NE	Prefers large freshwater or occasionally brackish lakes, again with abundant floating, emergent and fringing vegetation, also shallow flood plains and shallow dams. Frequents small, shallow ponds and lakes with abundant floating, emergent and fringing vegetation in grass dominated environments, prefer swampy meadows, flooded fields and shallow freshwater marshes during breeding.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Glossy Ibis (<i>Plegadis falcinellus</i>)	Mi	LC	Occurs in fresh water marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation. Occasionally found in coastal locations such as estuaries, deltas, saltmarshes and coastal lagoons.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Greater Sand Plover (<i>Charadrius leschenaultii</i>)	Mi	VU	Has been recorded in the Northern Territory from most of the coastline.	Possible This species is likely to be present closer to the coast than the study area. There are records within study area in 1984 (DLRM 2013).
Latham's Snipe (<i>Gallinago hardwickii</i>)	Mi	DD	Occurs in permanent and ephemeral wetlands up to 2000 m above sea. They usually inhabit open, freshwater wetlands with low, dense vegetation (e.g. swamps, flooded grasslands or heathlands,	Possible Habitat present within study

Species / Community	Conservation Status EPBC - TPWC		Habitat and Resource Preference	Likelihood / Extent of Impact
			around bogs and other water bodies).	area. There are records within study area (DLRM 2013).
Lesser Sand Plover (<i>Charadrius mongolus</i>)	Mi	VU	Occurs in coastal littoral and estuarine environments. Inhabits large intertidal sandflats or mudflats in sheltered bays, harbours and estuaries, and occasionally sandy ocean beaches, coral reefs, wave-cut rock platforms and rocky outcrops. It also sometime occurs in short saltmarsh or among mangroves.	Possible This species is likely to be present closer to the coast than the study area. There are records within study area (DLRM 2013).
Little Curlew (<i>Numenius minutus</i>)	Mi	LC	Most often found feeding in short, dry grassland and sedgeland, including dry floodplains and blacksoil plains, which have scattered, shallow freshwater pools or areas seasonally inundated. When resting during the heat of day, the Little Curlew congregates around pools, river beds and water-filled tidal channels, and shallow water at edges of billabongs. The species prefers pools with bare dry mud (including mudbanks in shallow water) and they do not use pools if they are totally dry, flooded or heavily vegetated.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Little Ringed Plover (<i>Charadrius dubius</i>)	Mi	NE	Found on the margins of freshwater wetlands.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Little Stint (<i>Calidris minuta</i>)	Mi	NE	Occurs along the muddy edges of small inland lakes, reservoirs, riverbanks and seasonal pools, as well as on coastal mudflats and seashores.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Long-toed Stint (<i>Calidris subminuta</i>)	Mi	NE	Occurs in a variety of terrestrial wetlands. Prefer shallow freshwater or brackish wetlands including lakes, swamps, river floodplains, streams, lagoons and sewage ponds. The species is also fond of areas of muddy shoreline, growths of short grass, weeds, sedges, low or floating aquatic vegetation, reeds, rushes and occasionally stunted samphire.	Possible Habitat present within study area. There are records within study area (DLRM 2013).

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
Marsh Sandpiper (<i>Tringa stagnatilis</i>)	Mi	LC	Occurs in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, salt pans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks. In KNP they have been recorded more around shallow freshwater lakes than in areas influenced by tide.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Oriental Cuckoo (<i>Cuculus optatus</i>)	Mi	LC	Mainly inhabits forests, occurring in coniferous, deciduous and mixed forest.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Pacific Golden Plover (<i>Pluvialis fulva</i>)	Mi	LC	Inhabits coastal habitats, though it occasionally occurs around inland wetlands. Usually occur on beaches, mudflats and sandflats (sometimes in vegetation such as mangroves, low saltmarsh such as <i>Sarcocornia</i> , or beds of seagrass) in sheltered areas including harbours, estuaries and lagoons.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Red-necked Stint (<i>Calidris ruficollis</i>)	Mi	LC	Inhabits coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Sharp-tailed Sandpiper (<i>Calidris acuminata</i>)	Mi	LC	Found on muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, salt pans and hypersaline salt lakes inland.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Swinhoe's Snipe (<i>Gallinago megala</i>)	Mi	DD	Occurs at the edges of wetlands, such as wet paddy fields, swamps and freshwater streams. Also occurs in grasslands, drier cultivated areas (including crops of rapeseed and wheat) and market gardens. Habitat specific to Australia includes the dense clumps of grass and rushes round the edges of fresh	Possible Habitat present within study area. There are records within study

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
			and brackish wetlands.	area (DLRM 2013).
White-winged Black Tern (<i>Chlidonias leucopterus</i>)	Mi	LC	Inhabits fresh, brackish or saline, and coastal or subcoastal wetlands. Frequent tidal wetlands, such as harbours, bays, estuaries and lagoons, and their associated tidal sandflats and mudflats. Terrestrial wetlands, including swamps, lakes, billabongs, rivers, floodplains, reservoirs, saltworks, sewage ponds and outfalls are also inhabited.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Wood Sandpiper (<i>Tringa glareola</i>)	Mi	NE	Occurs in well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Reptiles				
Hawksbill Turtle (<i>Eretmochelys imbricata</i>)	VU / Mi	VU	Occurs in tropical, subtropical and temperate waters of all oceans of the world. Nest mainly on narrow beaches where they frequently go under vegetation to nest.	Highly unlikely It is unlikely that this species will swim occur upstream in the study area.
Plains Death Adder (<i>Acanthophsis hawkei</i>)	VU	VU	Occurs on the flat, treeless cracking-soil plains of northern Australia.	Possible Habitat is likely to occur in study area. Numerous records within study area (DLRM 2013).
Arnhemland Egernia (<i>Bellatorias obiri</i>)	EN	EN	Restricted to sandstone outcrops, typically with extensive fissures and cave systems.	Possible Likely to occur in study area were sandstone outcrops exist. There are records within study area (DLRM 2013).
Loggerhead Turtle (<i>Caretta caretta</i>)	EN / Mi	VU	Nests on open, sandy beaches.	Highly unlikely It is unlikely that this species will swim occur upstream in the

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
				study area.
Green Turtle (<i>Chelonia mydas</i>)	VU / Mi	NT	Nests on open, sandy beaches.	Highly unlikely It is unlikely that this species will swim occur upstream in the study area.
Leatherback Turtle (<i>Dermochelys coriacea</i>)	EN / Mi	CR	Nests on open, sandy beaches.	Highly unlikely It is unlikely that this species will swim occur upstream in the study area.
Olive Ridley Turtle (<i>Lepidochelys olivacea</i>)	EN / Mi	VU	Nests on open, sandy beaches.	Highly unlikely It is unlikely that this species will swim occur upstream in the study area.
Yellow-snouted Gecko (<i>Lucasium occultum</i>)	EN	VU	Very little is known of the ecology of the Yellow-snouted Gecko. All individuals captured to date have occurred in conjunction with well-developed leaf litter and grasses in open forests dominated by <i>E. miniata</i> and <i>E. tetradonta</i> .	Possible Habitat from previous records occurs in study area. There is one record within study area (DLRM 2013).
Flatback Turtle (<i>Natator depressus</i>)	VU / Mi	DD	Nests on open, sandy beaches.	Highly unlikely It is unlikely that this species will swim occur upstream in the study area.
Salt-water Crocodile (<i>Crocodylus porosus</i>)	Mi	LC	Mostly occurs in tidal rivers, coastal floodplains and channels, billabongs and swamps. Also found along the coast and in the ocean.	Possible Saltwater crocodiles are likely to occur in most of the study area in areas containing water bodies. There are numerous records within study area (DLRM 2013).

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
Floodplain Monitor (<i>Varanus panoptes</i>)	-	VU	Occupies a variety of habitats, including coastal beaches, floodplains, grasslands and woodlands.	Possible Habitat occurs in study area, There are records within study area (DLRM 2013).
Mertens' Water Monitor (<i>Varanus mertens</i>)	-	VU	Inhabits margins of watercourses, swamps and lagoons in Northern Australia. Has a broad geographic range, occupying coastal and inland waters across the far north of Australia.	Possible Habitat present in study area. There are records within study area as recent as 2012 (DLRM 2013).
Mitchell's Water Monitor (<i>Varanus mitchelli</i>)	-	VU	Inhabits margins of watercourses, swamps and lagoons in Northern Australia. Has a broad geographic range, occupying coastal and inland waters across the far north of Australia.	Possible Habitat present in study area. There are records within study area (DLRM 2013).
Amphibians				
Howard Springs Toadlet (<i>Uperoleia daviesae</i>)	-	VU	Confined to sandsheet heathland within the Howard and Elizabeth River Catchments close to Darwin.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
Fish				
Northern River Shark (<i>Glyphis garricki</i>)	EN	EN	Little is known of the ecology of the northern river shark but it is probably restricted to shallow, brackish reaches of large rivers. Known from few records, including Adelaide and East and South Alligator River systems.	Possible No records for study area, though habitat occurs in study area.
Speartooth Shark (<i>Glyphis glyphis</i>)	CR	VU	Inhabits tidal rivers and estuaries. Large tropical river systems appear to be the primary habitat for this shark.	Possible No records for study area, though habitat occurs in study area.

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
Dwarf Sawfish (<i>Pristis clavata</i>)	VU	VU	Inhabits shallow coastal waters and estuarine habitats and does not utilise any purely freshwater areas.	Possible No records for study area, though habitat occurs in study area.
Freshwater Sawfish (<i>Pristis microdon</i>)	VU	VU	Occur in rivers and estuaries, while large mature animals tend to occur more often in coastal and offshore waters up to 25 m depth.	Possible No records for study area, though habitat occurs in study area.
Green Sawfish (<i>Pristis zijsron</i>)	VU	VU	Inhabits muddy bottom habitats and enters estuaries.	Possible No records for study area, though habitat occurs in study area.
Plants				
<i>Goodenia quadrifida</i>	VU	DD	Occurs on the upper parts of estuarine floodplains, on poorly drained grey clays or silty soils.	Possible Habitat present in study area.
<i>Acacia praetermissa</i>	VU	VU	Grows on hillsides in rocky, skeletal, lateritic soil in eucalypt woodland.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
<i>Helicteres macrothrix</i> , <i>Helicteres sp.</i> Glenluckie Creek	EN	EN	Recorded from three populations - near Mt Bunday, Batchelor/Glenluckie Creek and Lake Bennett. There is a high degree of confidence that the species is restricted to its current general area.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
<i>Hibiscus brennanii</i>	VU	VU	Grows on sandstone cliffs, in gullies and on broken sandstone.	Possible Habitat possibly occurs in study area.
<i>Ptychosperma bleeseri</i>	EN	EN	Only found in eight small rainforest patches east of Darwin, within the Adelaide and Howard River	Possible

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
			system.	Habitat present within study area. Habitat may be present within study area.
<i>Typhonium taylori</i>	EN	EN	Grows on saturated sand sheet substrate in Melaleuca woodland with grasses and sedges, in full sun or part shade.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
<i>Acacia sp. Graveside Gorge</i>	CR	CR	Grow on west to south-west facing rocky sandstone slopes and ledges at the tops of sheer cliff lines.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
<i>Cleome insolata</i>	-	VU	Grows in inundated sedgeland on silty loam with an overlay of laterite gravel, but also on the adjoining roadside verge.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
<i>Cycas armstrongii</i>	-	VU	Occurs in open grassy woodland on yellow and red earths, limited in the area by drainage.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
<i>Habenaria rumphii</i>	-	EN	Occurs in open forest and woodland growing amongst grass. It is reported to be prominent in low-lying sites that are partially inundated during the wet season.	Possible Habitat present within study area. There are records within study area (DLRM 2013).

Species / Community	Conservation Status		Habitat and Resource Preference	Likelihood / Extent of Impact
	EPBC	TPWC		
<i>Ptychosperma macarthurii</i>	-	EN	Restricted to wet rainforest patches.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
<i>Schoutenia ovate</i>	-	VU	Grows in monsoon vine thicket on granite and limestone outcrops.	Possible Habitat present within study area. There are records within study area (DLRM 2013).
<i>Typhonium praetermissum</i>	-	VU	Grows in open woodland habitats including relatively open, unshaded situations. Has also been found growing in red-brown clay soil and in shallow or gravely lateritic soil.	Possible Habitat present within study area. There are records within study area (DLRM 2013).

Appendix B – **Workshop Participants**

Date: 05 December 2013

Location: Darwin

Scope: Ranger 3 Deeps transport risk assessment

Facilitator: GHD Pty Ltd

Name	Position / Role	Company	Area of Representation	Experience (years)
Geoff County	Manager (supply chain)	Orica Chemicals Pty Ltd	Anhydrous ammonia, sulfuric acid	2.5
Vittorio Bianco	Product specialist	Orica Chemicals Pty Ltd	Anhydrous ammonia, sulfuric acid	9
Brad McDougall	Manager (operations)	Chemtrans	Sulfuric acid	7
Garry Fischer	Manager (network operations)	Northern Territory Department of Transport	Northern Territory transport and traffic requirements	6
Shaun Stewart	Health, safety and environment advisor	Direct haul	Diesel	3.5
David van Heerden	Transport projects lead, supply and distribution	Shell Company of Australia	Diesel, ShellSol (2046)	30
David Haynes	Manager (Northern Territory / South Australian)	Kalari Pty Ltd	Quicklime	15
Neil Ketteringham	Supply coordinator	Energy Resources of Australia Ltd	Transport logistics	1.5
Steve Bartlett	Manager (commercial)	Energy Resources of Australia Ltd	Contractor management and commercial logistics	6
Glenn Woodrow	Specialist (environmental major projects)	Energy Resources of Australia Ltd	Environmental management	6
Nicole Conroy	Principal environmental scientist	GHD Pty Ltd	Environmental impact assessment	15
Helen Flynn	Principal risk consultant	GHD Pty Ltd	Risk management	7
Matthew Weir	Risk consultant	GHD Pty Ltd	Risk management	4
Alex Holmes	Senior ecologist	GHD Pty Ltd	Ecology – Matters of National Environmental Significance	12

Appendix C - **Bowtie Diagrams**

GHD SQRA® Software

SQRA Bowtie V3.4p

Table of Contents

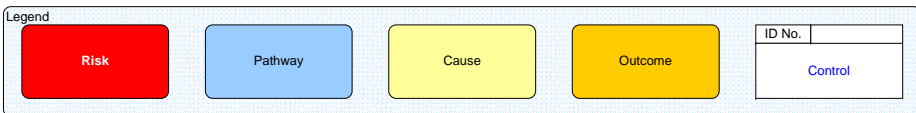
Table of Contents

Page	No	Risk
1	1	Vehicle incident involving Sulfuric acid
2	2	Vehicle incident involving Quicklime
3	3	Vehicle incident involving Ammonia anhydrous
4	4	Vehicle incident involving Diesel or ShellSol 2046
5	5	Vehicle incident involving Uranium oxide
6	6	Vehicle incident involving Pyrolusite manganese oxide (IV) powder, Alamine 336, Sodium hydroxide or Explosive (ammonium nitrate, ammonium nitrate emulsion)
7	7	Vehicle incident involving Flocculant (Magnafloc 139), Cement, Sand / aggregate or Construction materials (various)

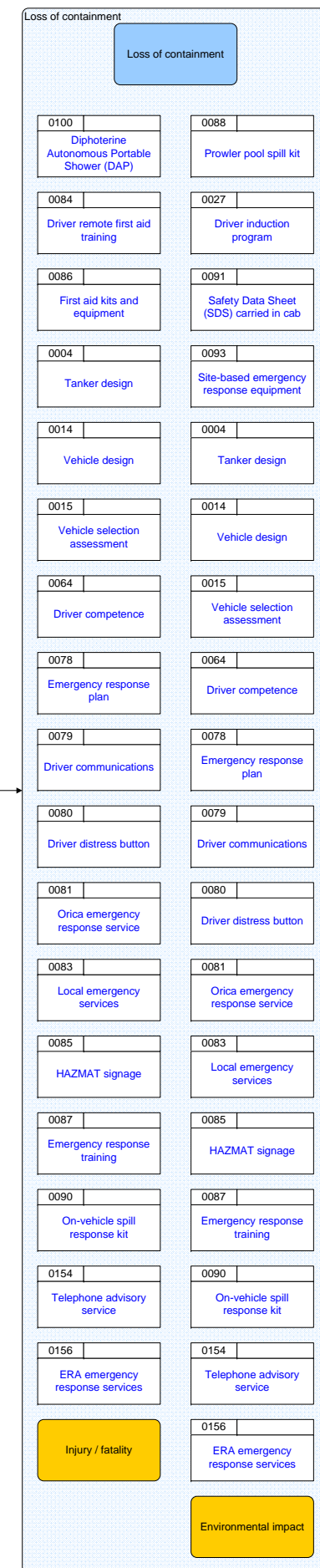
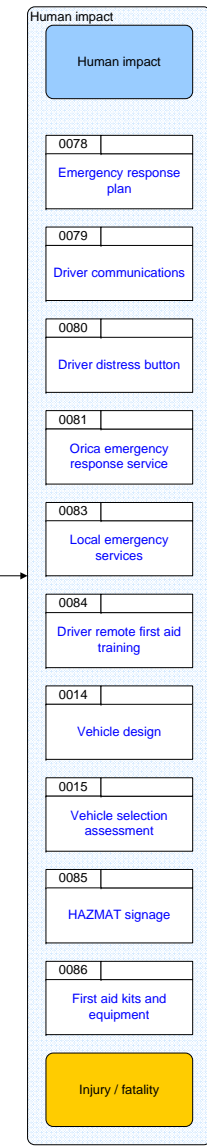
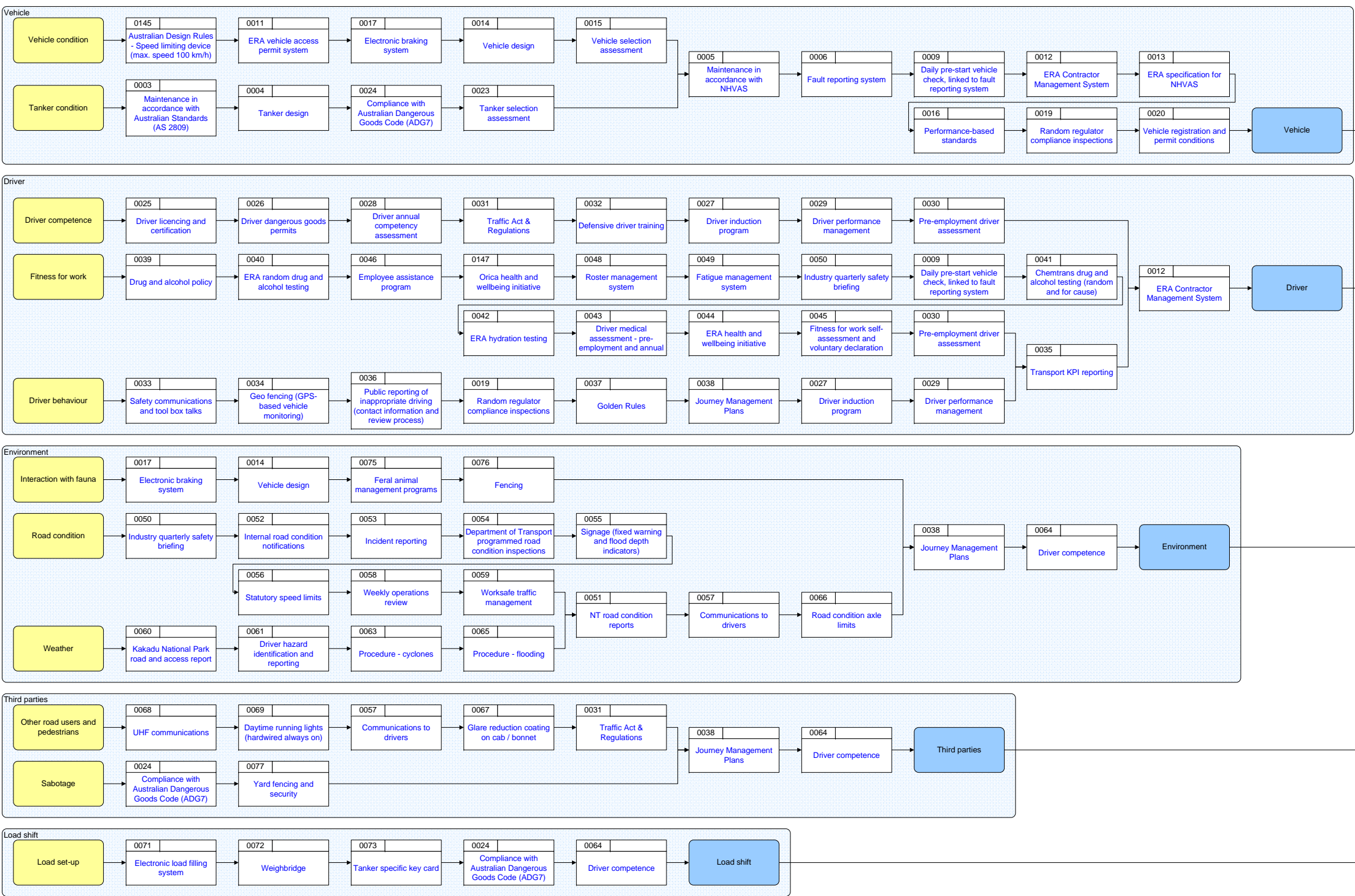


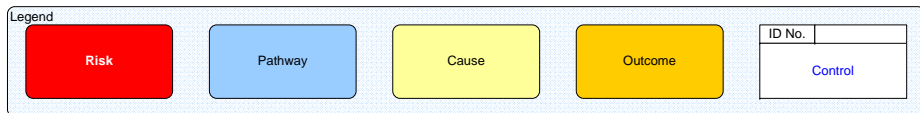
Operation	Ranger 3 Deeps
Facilitator	
Scribe	
Last saved date	6 Mar 2014
SQRA Date	5 Dec 2012
GHD Job No	

© GHD Pty Ltd 2003-2012

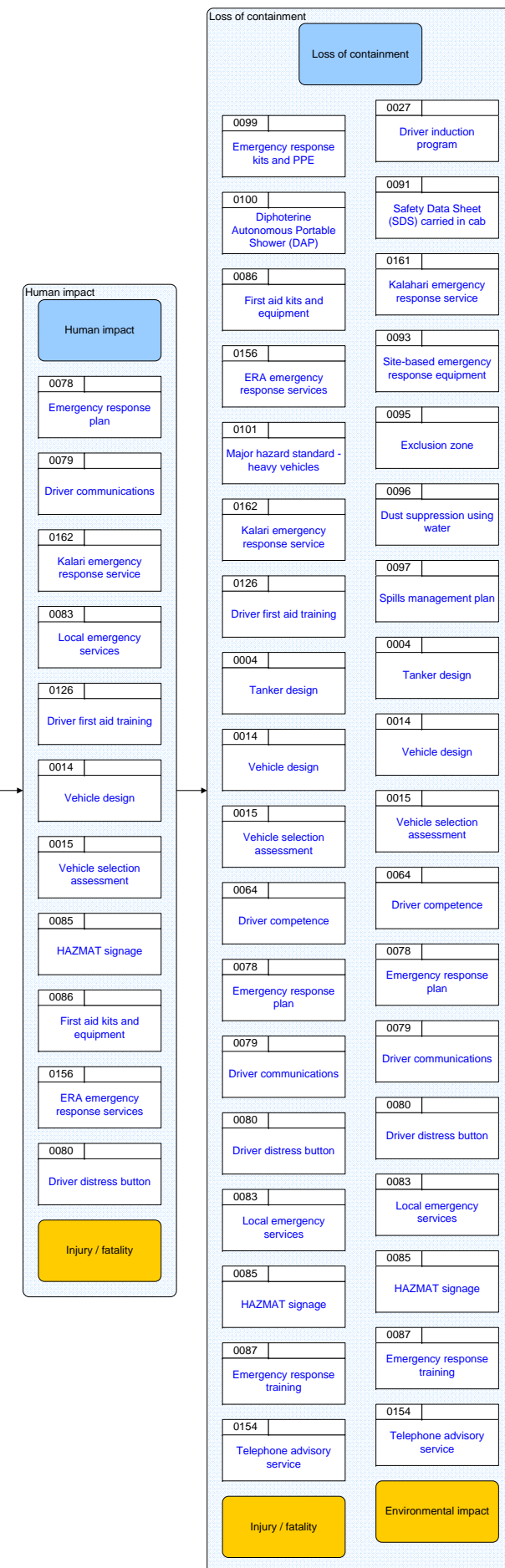
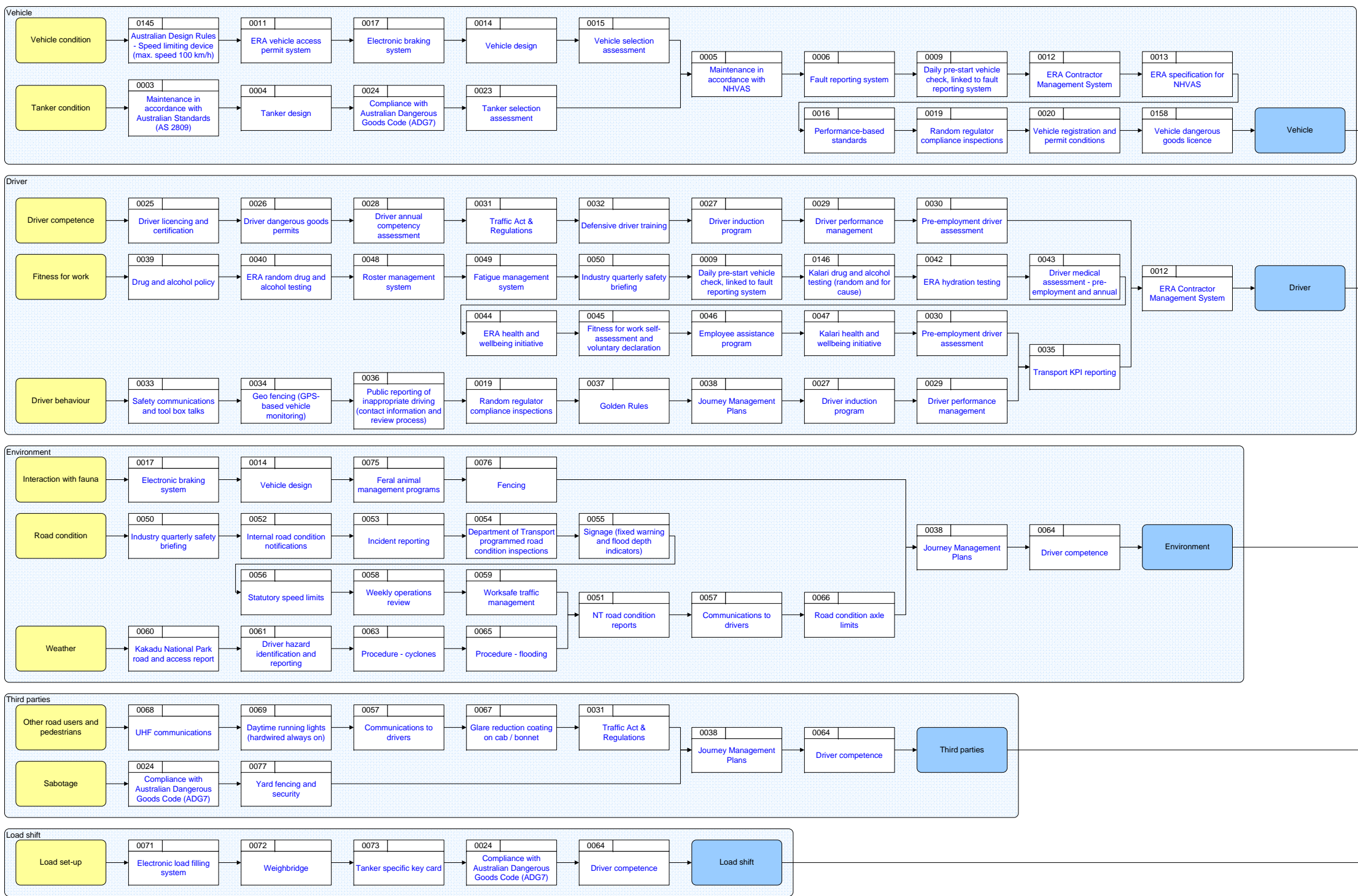


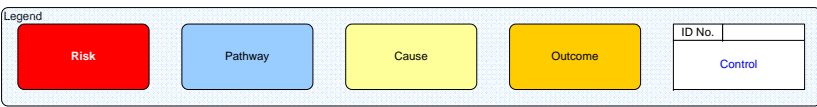
Operation	Ranger 3 Deeps
Hazard Type	
Risk No	1
Risk	Vehicle incident involving Sulfuric acid
SQRA Date	5 Dec 2012



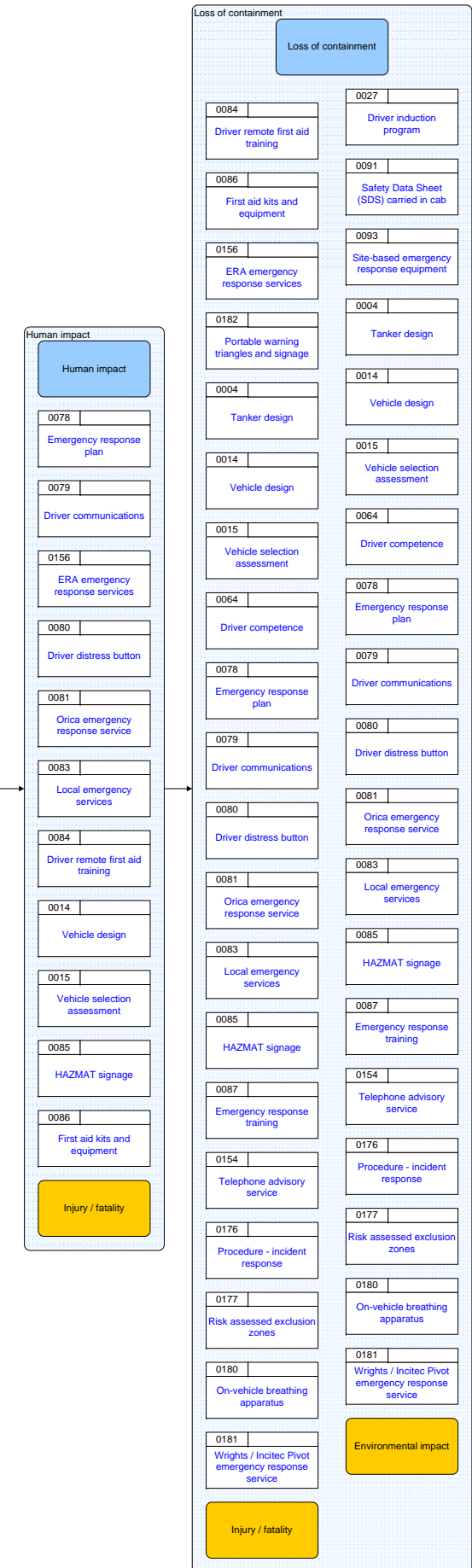
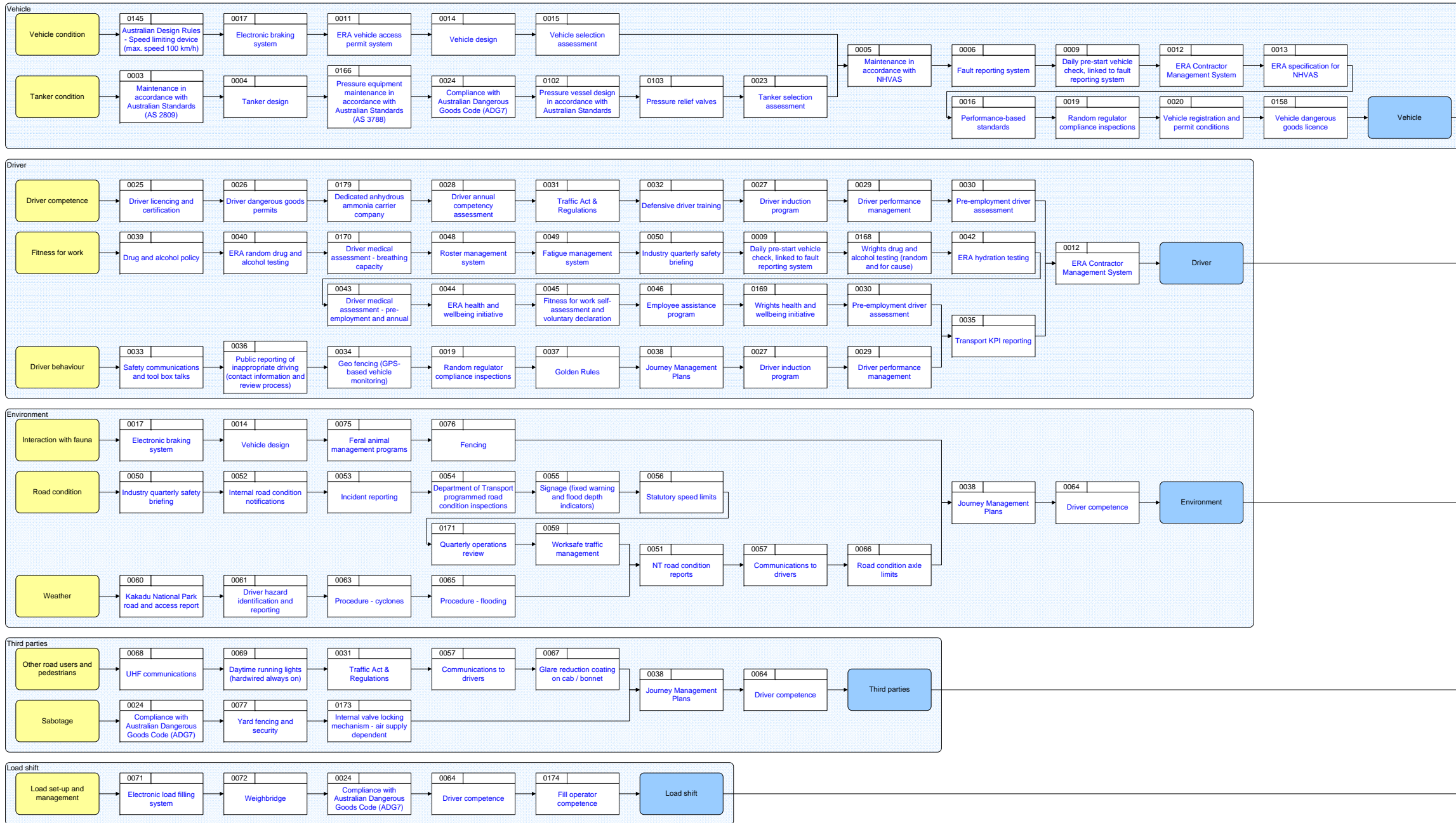


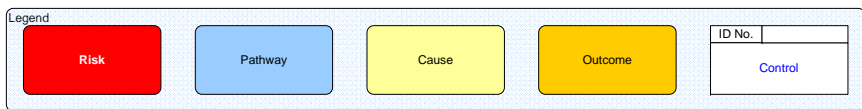
Operation	Ranger 3 Deeps
Hazard Type	
Risk No	2
Risk	Vehicle incident involving Quicklime
SQRA Date	5 Dec 2012



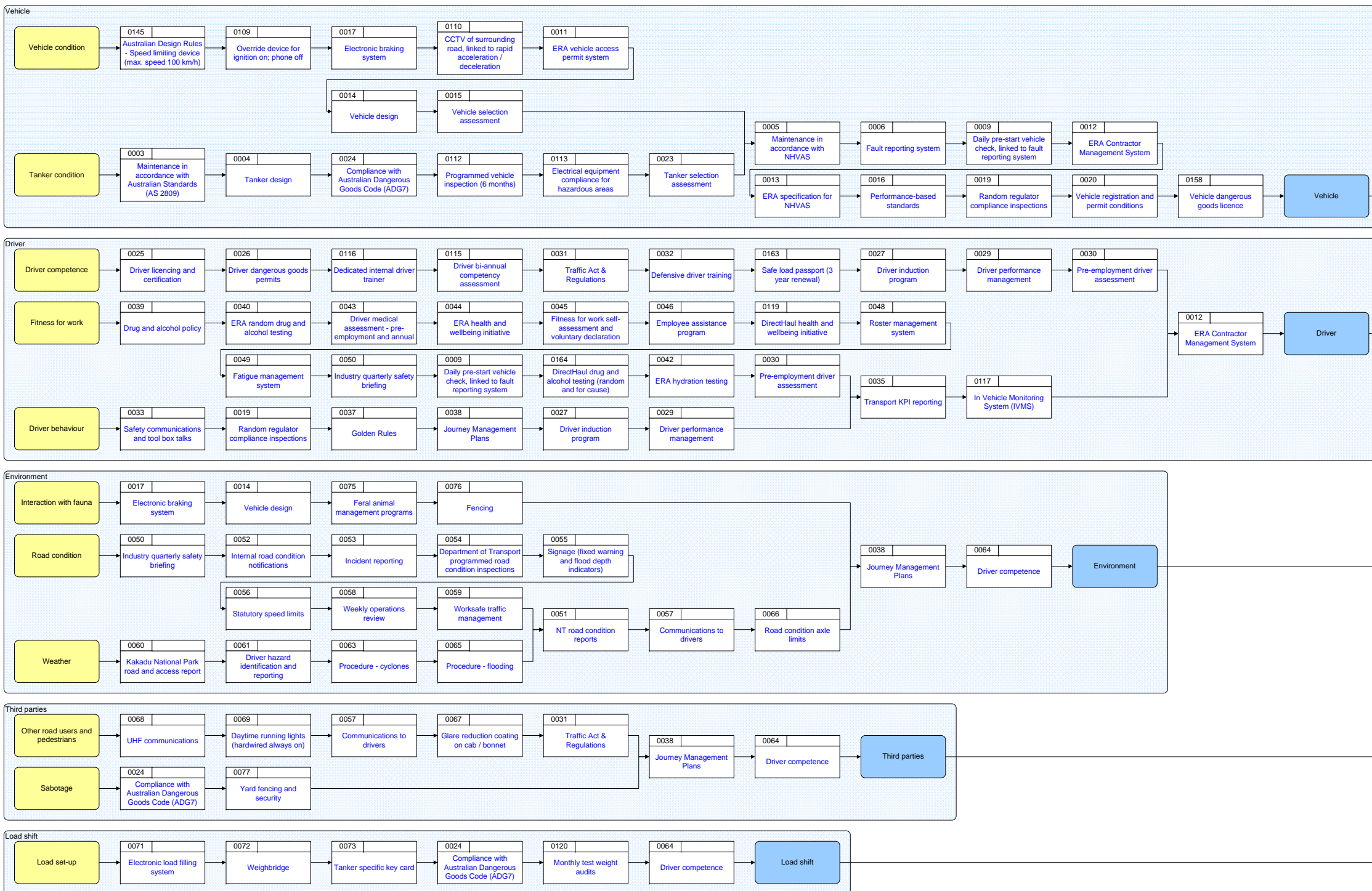


Operation	Ranger 3 Deeps
Hazard Type	
Risk No	3
Risk	Vehicle incident involving Ammonia anhydrous
SQRA Date	5 Dec 2012

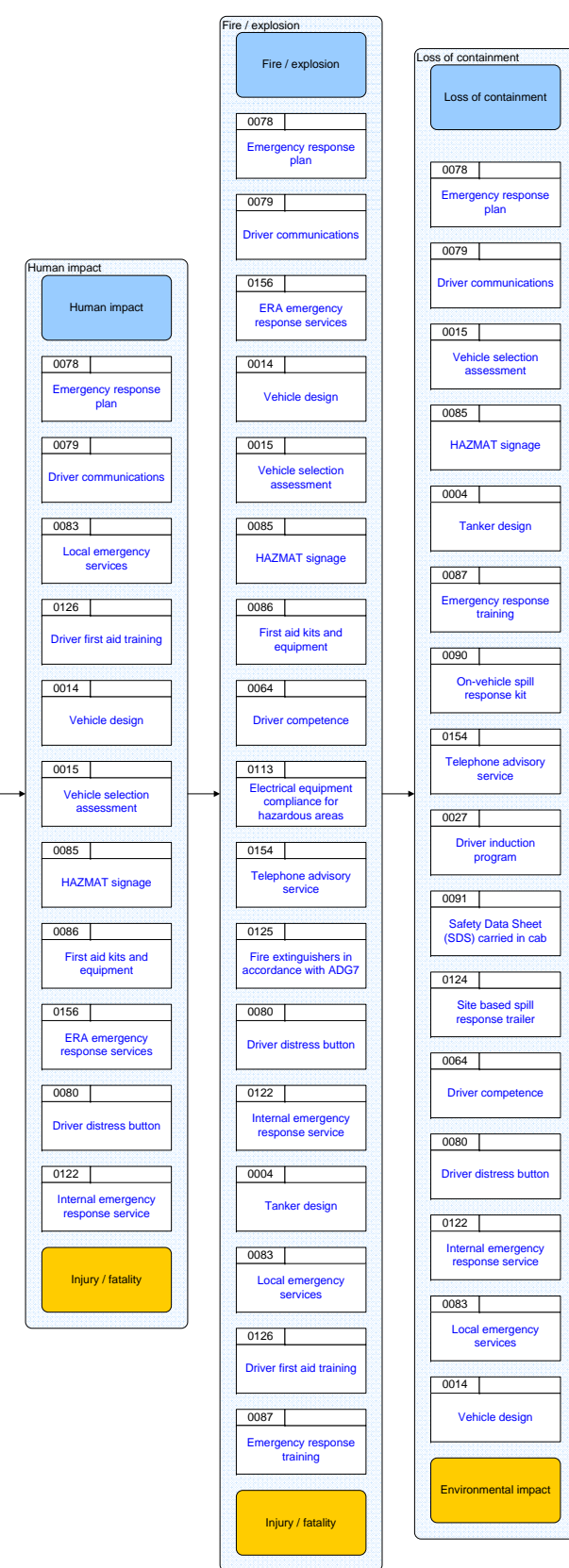


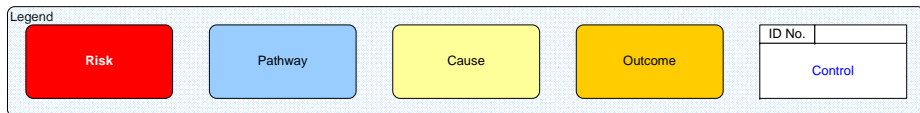


Operation	Ranger 3 Deeps
Hazard Type	
Risk No	4
Risk	Vehicle Incident Involving Diesel or ShellSol 2046
SQRA Date	5 Dec 2012

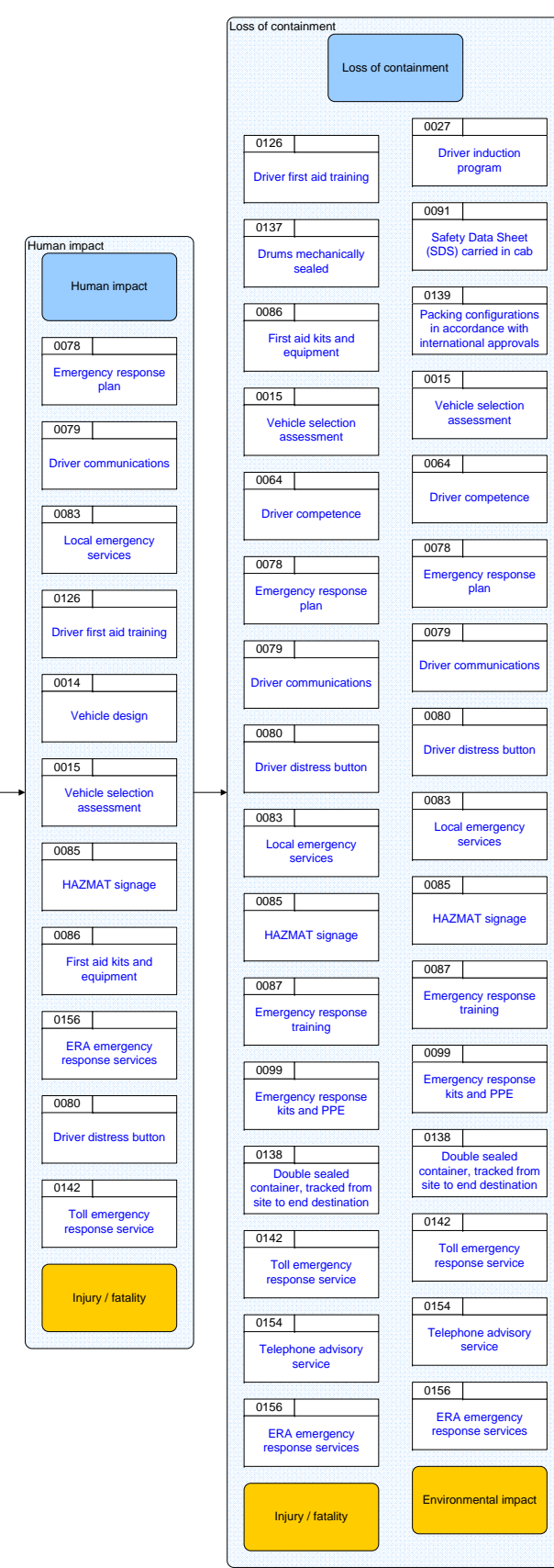
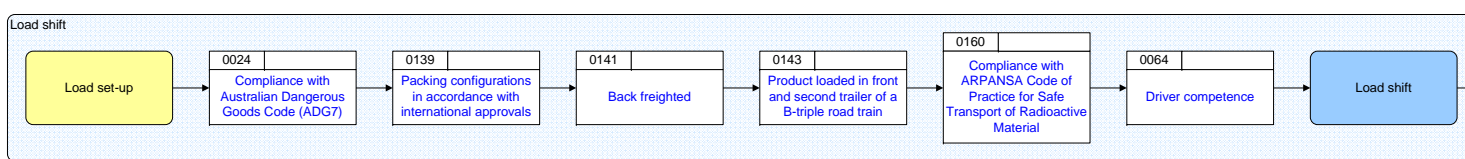
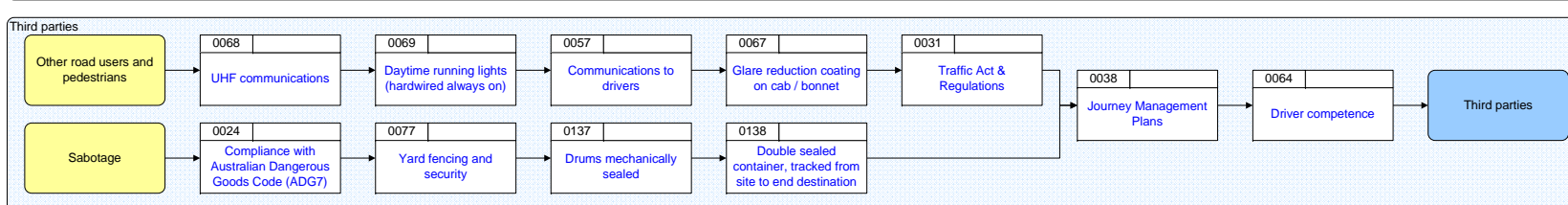
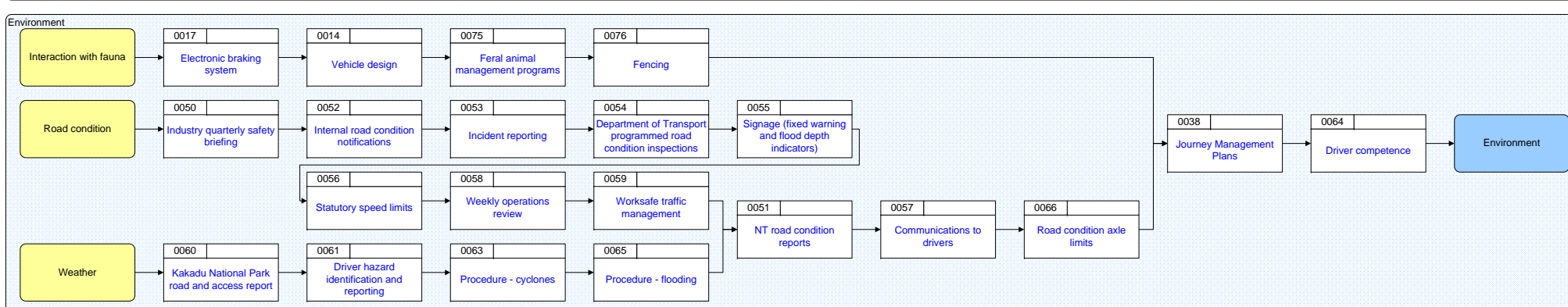
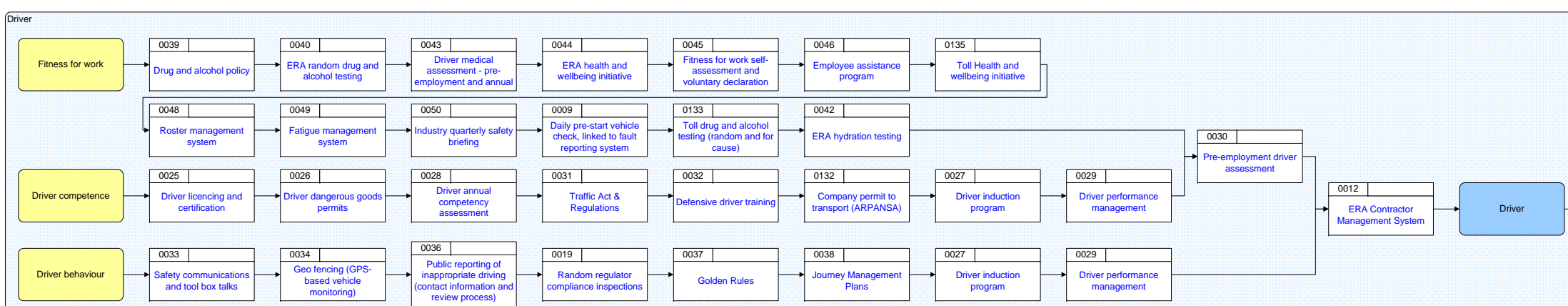
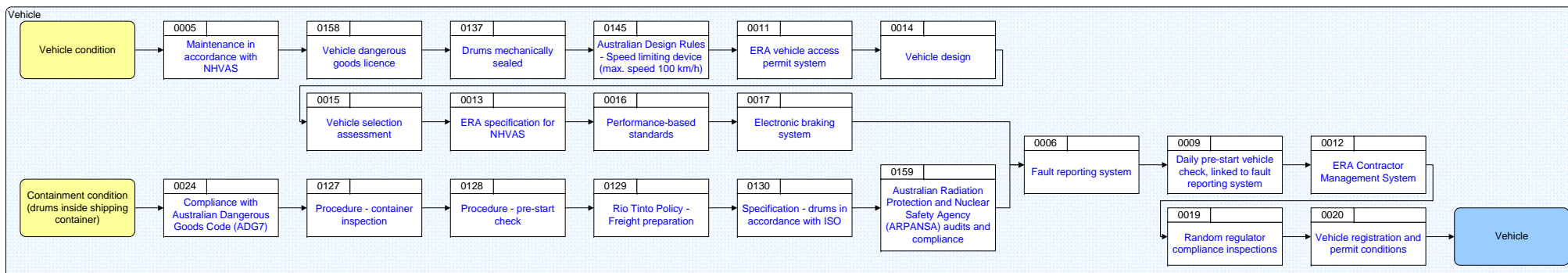


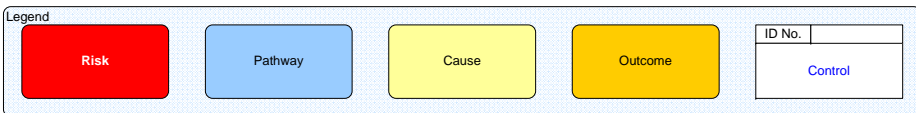
Vehicle Incident Involving Diesel or ShellSol 2046



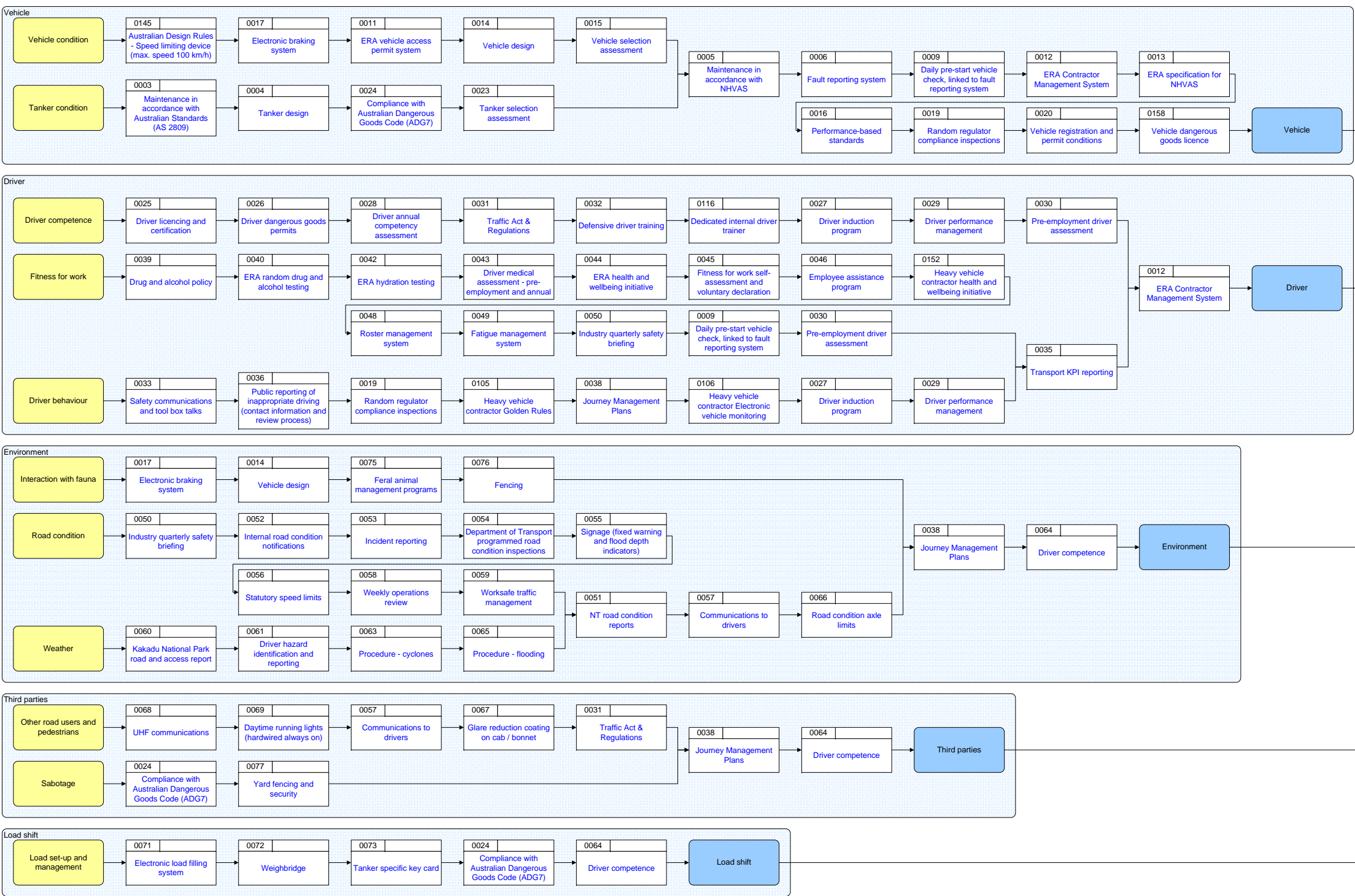


Operation	Ranger 3 Deeps
Hazard Type	
Risk No	5
Risk	Vehicle incident involving Uranium oxide
SQRA Date	5 Dec 2012

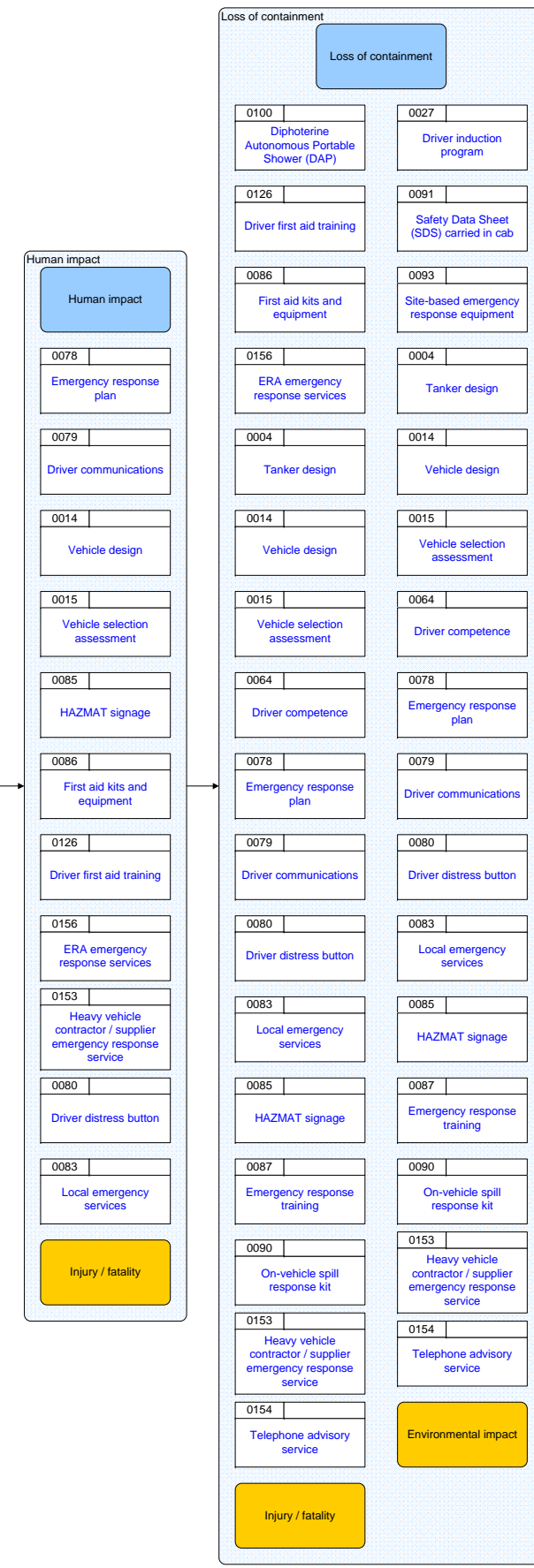


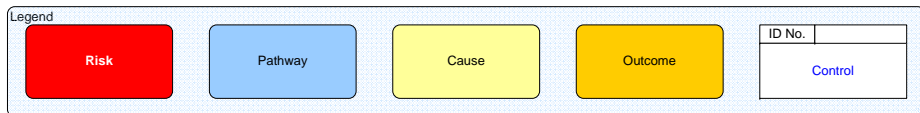


Operation	Ranger 3 Deeps
Hazard Type	
Risk No	6
Risk	Vehicle incident involving Pyrolusite manganese oxide (IV) powder, Alamine 336, Sodium hydroxide or Explosive (ammonium nitrate, ammonium nitrate emulsion)
SQRA Date	5 Dec 2012

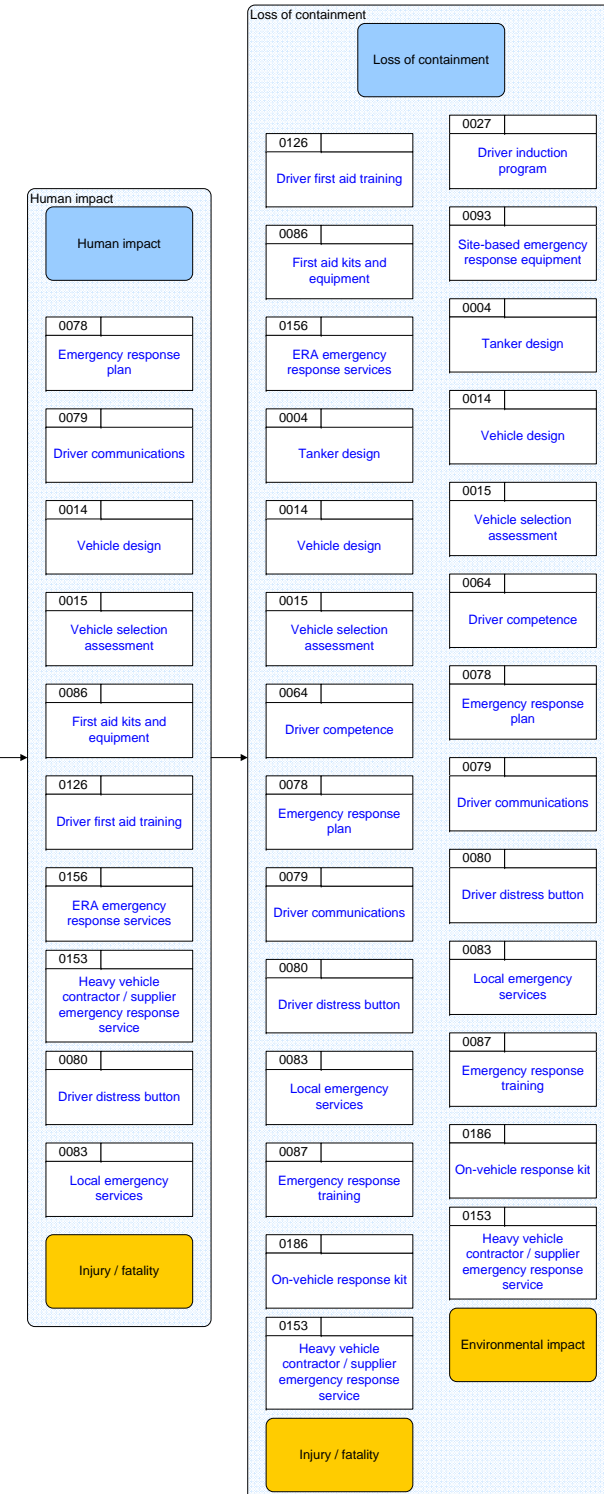
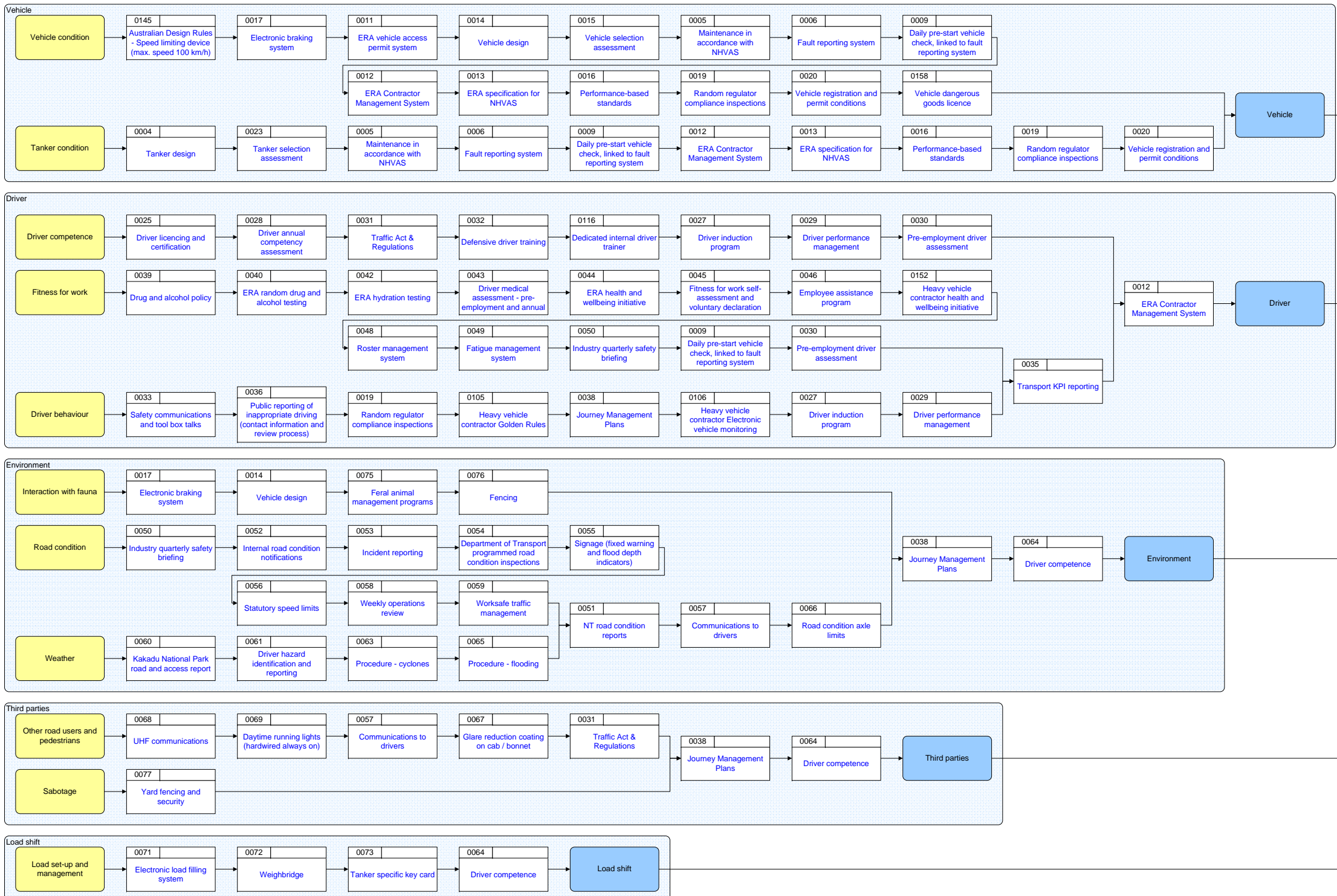


Vehicle incident involving Pyrolusite manganese oxide (IV) powder, Alamine 336, Sodium hydroxide or Explosive (ammonium nitrate, ammonium nitrate emulsion)





Operation	Ranger 3 Deeps
Hazard Type	
Risk No	7
Risk	Vehicle incident involving Flocculant (Magnafloc 139), Cement, Sand / aggregate or Construction materials (various)
SQRA Date	5 Dec 2012



Appendix D – Quantitative Likelihood Assessment

Introduction

The NT EPA and SEWPaC Guidelines for the preparation of an EIS for the project requires that sufficient quantitative analysis is provided to indicate (a) whether risks are tolerable and (b) that risk rankings assigned are fully justified.

A quantitative assessment of the likelihood uses empirical data to determine the probability of a risk scenario occurring. The calculated probability can then be aligned to the corresponding likelihood level as part of the risk rating. For example, a risk scenario with a quantified likelihood of 5 % corresponds to likelihood level of 'Possible'.

Risk scenarios have been identified as a vehicle incident involving a heavy vehicle transporting consumables for the project. Each risk scenario is specific to a particular consumable being transported and to a particular location.

For example, risk ref. 1:

- Transport of sulfuric acid – vehicle incident leading to loss of containment – Adelaide River crossing on Arnhem Highway

Therefore, the objective of the likelihood assessment is to quantify the likelihood of an incident occurring at any location (or road length) along the identified haulage routes, for each consumable. Specifically, it is the likelihood that risk scenario would result in the identified maximum reasonable 'consequence level'.

Methods

The likelihood of a crash for a heavy vehicle transporting consumable at a location (or road length) is the product of two components:

- the probability of a crash at a specific location (or road length)
- the exposure, through the frequency of trips, of the heavy vehicle to that location (or road length).

For example, if one consumable has three times the number of deliveries as another consumable along the same route then its exposure (and the likelihood of a crash at a particular location) is three times as high. The methodology to quantify these two components is separately described below.

The probability of a Crash at a Specific Location (or road length)

A leading measure of crash rate for a section of route is crashes per million vehicle kilometres travelled (VKT) (Geurts and Wets, 2003). A crash rate of 1.0 crash per million VKT means that if one million vehicles traversed a one kilometre section of road, the expectation would be for one crash to occur. It allows for comparison of the relative safety performance of different sections of road, and therefore the ability to identify areas of increased crash likelihood.

Industry practice and peer reviewed methodologies have been developed to identify crash rates. The approach adopted for this study followed guidance from the US Transportation Research Board (Hauer, 1996; Deacon, Zegeer and Deen, 1974).

Data Sources

Crash data was provided by the Northern Territory Department of Transport Vehicle Accident Database for the study area haulage routes, for the most recently available five year period (September 2008 – August 2013). The data reflects all recorded

vehicle accidents recorded by police, including property damage only (PDO) crashes. The GIS co-ordinates of the crash are recorded, as well as other accident characteristics. (DoT, 2013b)

Traffic data was sourced from the Annual Traffic Report 2012 published by the Road Network Division of the Department of Transport (DoT, 2012). Traffic volumes were recorded over the most recent 10-year period, expressed in terms of annual average daily traffic (AADT). Primary and coverage count stations are located at intervals on the haulage routes as well as on intersecting side roads. The average AADT for the five-year period corresponding to the crash data was estimated from the dataset.

Calculation of Crash Rates

To calculate the crash rate for locations, each of the roads of the haulage routes within the study areas was divided into one kilometre segments. For each individual road segment, the following was determined, based on the crash and traffic volume data:

- Average number non-intersection crashes per annum (crashes p.a.)
- Average annual traffic volumes per annum (million vehicle kilometres travelled p.a.)

Subsequently, the crash rate was calculated for each one kilometre road segment, adopting the standard formula shown below.

$$\text{Crash rate} = \frac{\text{Avg. crashes p.a.} \times 1,000,000}{\text{Avg. AADT} \times 365}$$

If an intersection was located within the road segment, intersection crash rates were calculated based on identified intersection crashes and estimated number of vehicles entering the intersection, expressed as crashes per million vehicles entering. The sum of the road length crash rate and the intersection crash rate determined the overall probability of a crash occurring within each one kilometre route segment.

Due to the potential for a location of higher crash density to occur across two road segments, the data was presented as a weighted moving average incorporating the two adjacent road segments. As a result, variations in crash rates were able to be reported, measuring the relative crash likelihood along the haulage routes.

Identifying Crash Hotspots

Locations with higher crash rates were termed crash hotspots. It is recognised that crashes can occur at random locations. For example, a crash at a location may be due to driver fatigue. It may not specifically indicate a section of road that is more likely to cause a crash.

The Rate Control Method is a peer reviewed approach to address this concern, and is commonly used by road agencies (Geurts and Wets, 2003). It uses a statistical test to determine whether a traffic accident rate at a location is abnormally high when compared with the rate for other locations with similar characteristics. It is based on the assumption that traffic crashes are uncommon events and the probability of crashes can be approximated by the Poisson distribution. The Rate Control Method test was applied to the calculated crash rates for each road to highlight locations that have a crash rate that is not due to chance. This test was applied at a 75 % degree of confidence.

Civil engineers undertook site inspections of the locations identified as statistically significant from the Rate Control Method, as well as other locations of higher crash rates. The aim of the site inspections was to confirm the findings of the desktop assessment. Observations suggested that locations of higher crash rates were

commonly located near bridges, intersections, locations with restricted sightlines or possible tourist sites. The results of the site inspections were considered to adequately confirm that the data analysis reasonably represented the variation in crash likelihood.

Heavy Vehicle Crash Rates

The crash rate calculations and identification of crash hotspots was informed by data representing all vehicle classifications, i.e. cars, campervans, buses, etc. As heavy vehicles typically account for 20 % of total traffic volumes, it was considered that using data for all vehicle classes provided a larger dataset to more accurately identify crash rate variation.

However, the purpose of the quantitative likelihood assessment is to determine the crash rates specifically for heavy vehicles. Despite the difficulty in eliminating all traffic related risks (e.g. wildlife, wandering stock, other road users), the Bowtie Diagrams in Appendix C demonstrate that ERA heavy vehicle contractors have multiple layers of protection. These significantly reduce the likelihood of a traffic incident occurring, for example:

- alcohol policy and testing
- fatigue management
- route familiarisation
- georeferencing.

Therefore, the expectation is typically a lower crash rate for heavy vehicles. This is supported by Northern Territory data over the most recently available five-year period, for which the average crash rate for all vehicles is 2.88 crashes per million VKT and the average crash rate for heavy vehicles is 0.65 crashes per million KVT (BITRE, 2012; DoT, 2013b).

Incident data relating to heavy vehicles on ERA business was provided by ERA over the most recent five year period (September 2008 – October 2013). On the basis of the consumable delivery profile of ERA over that period, the crash rate for heavy vehicles on ERA business is estimated as 0.42 crashes per million VKT. This compares to a crash rate of 0.47 crashes per million VKT for all vehicles, on the same haulage routes. This is equivalent to a reduction in the crash rate by a factor of 0.93.

To more accurately reflect the probability of crashes for heavy vehicles on ERA business, and to take into consideration the controls in place to prevent a crash from occurring, it is considered reasonable to apply the calculated reduction factor to the determined crash rate for each road segment.

As a result, the variations in crash rates along the haulage routes were determined, measuring the relative crash likelihood specifically for heavy vehicles along the haulage routes.

Heavy Vehicle Exposure to That Location (Or Road Length)

The exposure of heavy vehicles on ERA business is the second aspect. Together with the crash rate, this determines the expectation for a crash occurring. Put simply, the more driving being undertaken, the more likely a vehicle will be involved in a crash, all else being equal.

ERA estimates for Ranger mine with the Project for the period 2016 – 2020 were analysed. This was to estimate the exposure of each consumable to the crash rates at each segment of the haulage routes. Traffic generation and distribution, as detailed in Section 3.4 of this report, allows for the number of trips to be allocated. For the

quantitative likelihood assessment, the average annual trips for the Project period (2016 – 2020) have been used.

The traffic assessment has considered both the delivery trip to Ranger and the return trip back from Ranger to its point of origin (round trip). Consequently, one trip will be a loaded delivery and the return trip will be empty⁷. An example of how these trip volumes are used in the exposure assessment is provided in Table 29.

Example 1:

Table 29 lists the forecast average annual number of trips on Arnhem Hwy at Kakadu National Park gates (approximately 110 kilometres east of Stuart Hwy).

Table 29 Example, heavy vehicle exposures – Arnhem Hwy (110 kilometres east of Stuart Hwy)

	Ranger mine without Project (trips per annum)	Ranger mine with Project (trips per annum)	Change due to Project (trips per annum)
Sulfuric acid	2,167	2,876	710
Quicklime	-	-	-
Flocculant (Magnafloc 139)	144	144	0
Diesel	663	1,028	365
Pyrolusite (Manganese oxide (IV) powder)	222	222	0
Alamine 336	2	6	3
ShellSol 2046	24	33	9
Anhydrous ammonia	-	-	-
Cement	-	-	-
Sand/aggregate	-	-	-
Uranium oxide	86	205	119
Explosives (ammonium nitrate, ammonium nitrate emulsion)	-	-	-
Sodium hydroxide	3	6	3

From Table 29, under the Ranger mine with Project scenario, there are 1,028 trips per annum for heavy vehicles involved in the transport of diesel compared to 205 trips per annum for the transport of uranium oxide⁷. Vehicles transporting diesel have approximately five times the exposure to the risk at this location, and as a result have a higher likelihood of being involved in a crash.

⁷ Transport of uranium oxide has not been treated as back freighted for the quantitative likelihood assessment. This results in an overestimate of the number of empty single trailer trips, by approx. 2% of the total trips. This has no impact on the quantitative likelihood of incidents involving loaded vehicles (i.e. loss of containment; fire / explosion) and has negligible impact on overall vehicle accident likelihood rankings (A – E).

Calculation of risk scenario probability

Combining the crash rate and the exposure, the relationship is expressed as follows:

$$\text{Crash likelihood} = \text{avg. crash rate} \times \text{number of vehicles} \times \text{distance}$$

$$\text{Crashes p. a.} = \frac{\text{Avg. crashes p.a.}}{\text{million VKT p.a.}} \times \text{million vehicle p. a.} \times \text{kilometres travelled}$$

The likelihood can be calculated at any location along the haulage routes, for the transport of any consumable. The longer the length being considered, the more likely a crash will occur within that section. For instance, it would be expected that more crashes would occur within a 100 kilometre section of a road compared to a one kilometre section.

It has been assumed that all heavy vehicles on ERA business would have the same crash likelihood when exposed to a crash rate at a location.

Example 2:

As an example, the likelihood of a crash involving a heavy vehicle transporting diesel on Arnhem Hwy within 2 kilometres either side of the Kakadu National Park (KNP) gate is calculated as follows:

- Average crash rate along that section: 0.75 crashes per million VKT
- Number of forecast trips for diesel heavy vehicles on ERA business: 1,028 vehicles per annum (Table 29), equal to 1.03E-03 million VKT p.a.
- Length of road location: 4 kilometres

Table 30 Example, crash likelihood for diesel at KNP gate

Avg. crash rate (crashes per M vkt)	Number of ERA veh (M veh pa)	Distance (km)	Crash likelihood (crashes pa)
0.75	1.03E-03	4.0	3.07E-03

This is equivalent to one diesel heavy vehicle crash at the assessed location in approximately 326 years. This is rated as Unlikely in accordance with the likelihood descriptor in Section 4.2.4 of this report.

Likelihood of Escalating Event

Once a vehicle accident occurs at a location, a further escalation is required before an impact. For example, if a vehicle accident occurs, a loss of containment would be required for an environmental impact. A fire / explosion scenario for a vehicle transporting hydrocarbons would require first a vehicle incident and then a loss of containment. There are termed escalating events.

As shown in the event tree in Figure 17, the probability of a fire / explosion is the conditional probability that first a vehicle accident occurs, then a release occurs and then a fire / explosion takes place. Empirical probabilities have been applied to calculate the likelihood for risk scenarios involving escalating events.

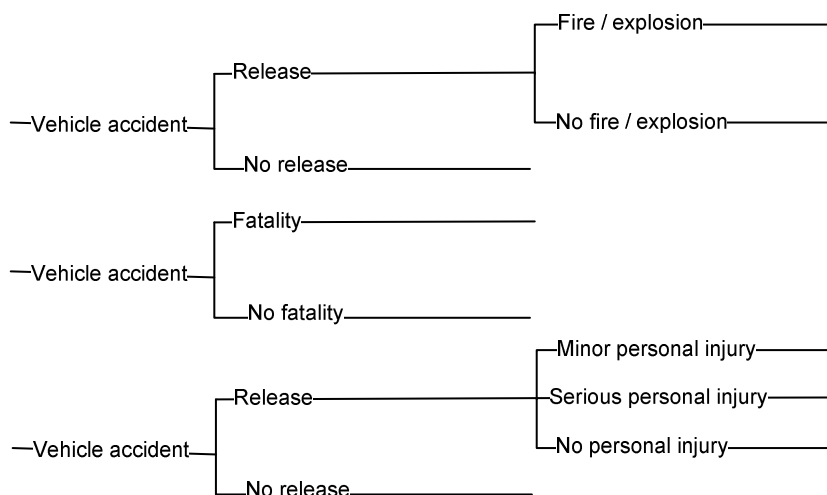


Figure 17 Event trees for escalating events

Loss of containment escalation factors

Data for rates of loss of containment has been sourced from the US Federal Motor Carrier Safety Administration (FMCSA, 2001). It is based on a national database maintained by the Office of Hazardous Materials Safety, which encompasses approximately 14,000 reported hazardous material truck incidents per year.

Table 31 is derived from that dataset. For example, if a vehicle accident occurred involving a heavy vehicle transporting diesel, there would be a 17 % chance of a loss of containment. If a loss of containment of diesel occurred there would then be a 9 % chance of it escalating to a fire or explosion. Following the event tree in Figure 17 for the example of diesel, if there is a vehicle accident involving a heavy vehicle transporting diesel, there is therefore a 2 % chance of it resulting a fire / explosion (17 % x 9 %).

Table 31 Loss of containment, escalation factors (US FMCSA 2001)

	Release (Y / N)	Branch probability (Release Y / N)	Fire / explosion (Y / N)	Branch probability (Fire / explosion Y / N)
Diesel, ShellSol 2046 (kerosene)	Y	17 %	Y	9 %
	N	83 %	N	91 %
Anhydrous ammonia	Y	4 %	Y	9 %
	N	96 %	N	91 %
Explosives (ammonium nitrate, ammonium nitrate emulsion)	Y	31 %	Y	9 %
	N	69 %	N	91 %
Sulfuric acid, Quicklime, Alamine 336, Cement, Sodium hydroxide	Y	31 %		
	N	69 %		
Sand / aggregate	Y	31 %		
	N	69 %		
Uranium oxide	Y	0.006 %		
	N	99.994 %		

Fatality escalation factors

Separately, data from the Northern Territory vehicle accident database over the five year period (2008 – 2012) indicated that 3% of crashes involving heavy vehicles resulted in a fatality (DoT, 2013b). This is listed in Table 32.

Table 32 Fatality, escalation factors (Northern Territory DoT 2013)

	Fatality (Y / N)	Branch probability (Fatality Y / N)
All consumables	Y	3 %
	N	97 %

Personal injury from loss of containment escalation factors

Similarly, Frank E Bird's empirically demonstrated industrial accident model has been applied to estimate the likelihood of a loss of containment to result in the worst credible personal injury outcome for each relevant consumable, as described in the risk register. This is a commonly adopted model for accident severity relationships. For each relevant loss of containment incident, it is estimated that 10% would result in a minor personal injury and 1% would result in a serious personal injury as a result of direct contact or interaction with the consumable. This is listed in Table 33.

Table 33 Personal injury from loss of containment, escalation factors (Frank E Bird)

	Personal injury (Y / N)	Personal injury probability (Personal injury Y / N)	Injury severity (Minor / Serious)	Branch probability (Injury severity (Minor / Serious))
Quicklime, Diesel, Anhydrous ammonia and Sodium hydroxide	Y	11%	Minor	91%
Sulfuric acid, Flocculant (Magnafloc 139), Pyrolusite (Manganese oxide (IV) powder), Alamine 336, Shellsol 2046 (kerosene), Cement, Sand/aggregate, Uranium oxide and Explosives (ammonium nitrate, ammonium nitrate emulsion)			Serious	9%
Construction materials	N	89%		

Escalating Event Likelihood

To determine the likelihood of an escalating event, the empirical factors are applied to the crash probability. As previously identified, a delivery involves two trips, with one loaded delivery and an empty return trip. Therefore, for calculating loss of containment events, only half of the accidents would involve a loaded tanker.

Combining the crash likelihood, the proportion of loaded trips and release rates, the relationship is expressed as follows:

$$\text{Release likelihood} = \text{Crash likelihood} \times \% \text{ loaded} \times \text{Escalation factor}$$

The escalation likelihood can be calculated at any location along the haulage routes, for the transport of any consumable.

Example 3:

Continuing the previous example for diesel on Arnhem Hwy within 2 kilometres either side of national park gate, the likelihood of a release is equal to the following:

- Previously determined crash likelihood for diesel at this location: 3.07E-03 (see Example 2)
- Average crash rate along that section: 0.75 crashes per million VKT
- Number of forecast trips for diesel heavy vehicles on ERA business: 1,028 vehicles per annum (Table 29)
- Length of road location: 4 kilometres
- Percentage loaded trips: 50%
- Release rate: 17% (Table 31)

Table 34 Example, loss of containment likelihood for diesel at KNP gates

Crash likelihood (crashes pa)	Loaded	Escalation factor	Release likelihood (releases pa)
3.07E-03	0.50	0.17	2.61E-04

The calculated release likelihood at this location is equivalent to one diesel release in approximately 3,837 years, which is rated as Rare in accordance with the likelihood descriptor in Section 4.2 of this report.

Results

The results for the quantitative likelihood assessment are presented in Table 35 to Table 39. The tables represent the annual probability of the event occurring at the identified location for the specific consumable.

A graded colour scale has been applied to each table to visually highlight the scenarios of higher and lower likelihood. The red cell identifies the higher value (highest likelihood scenario); the green cell identifies the lowest value (lowest likelihood scenario). Yellow coloured cells represent the midpoint values.

The quantified results can be then assigned likelihood ratings, based on the likelihood descriptors in Section 4.2.5 of this report.

Discussion

The quantitative likelihood assessment has analysed empirical data to estimate the probability of risk scenarios occurring. The calculated probability can then be aligned to the corresponding likelihood level as part of the risk rating. It provides greater confidence in the rating of likelihoods, which is required as part of the Guidelines for the preparation of an EIS for the project.

Risk scenarios have been identified as a vehicle incident involving a heavy vehicle transporting consumables for the project. Each risk scenario is specific to a particular consumable being transported and to a particular location.

Therefore, the objective of the likelihood assessment was to quantify the likelihood of a crash occurring at any location (or road length) along the identified haulage routes, for each consumable. Specifically, it refers to the likelihood that risk scenario would result in the identified maximum reasonable 'consequence level'. As a result, empirical escalation rates have been adopted to quantify the probability of a loss of containment, fire / explosion or fatality from a vehicle accident.

Table 35 Vehicle accident likelihood, by location and consumable (crashes p.a.)

Location	Scenario	Sulfuric acid	Quicklime	Flocculant (Magnafloc 139)	Diesel	Pyrolusite Manganese oxide (IV) powder	Alamine 336	ShellSol 2046	Anhydrous ammonia	Cement	Sand / aggregate	Uranium oxide	Explosive (ammonium nitrate, ammonium nitrate emulsion)	Miscellaneous	Construction materials (various)	Sodium hydroxide	Total
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	1.94E-02	-	9.68E-04	6.92E-03	1.50E-03	3.79E-05	2.24E-04	-	-	-	1.38E-03	-	6.54E-04	5.17E-04	4.32E-05	3.13E-02
	Change due to Project	4.78E-03	-	-	2.45E-03	-	2.18E-05	5.98E-05	-	-	-	7.99E-04	-	3.27E-04	5.17E-04	2.09E-05	8.66E-03
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	Ranger mine with Project	7.05E-03	-	3.52E-04	2.52E-03	5.45E-04	1.38E-05	8.17E-05	-	-	-	5.03E-04	-	2.38E-04	1.88E-04	1.57E-05	1.14E-02
	Change due to Project	1.74E-03	-	-	8.94E-04	-	7.95E-06	2.18E-05	-	-	-	2.91E-04	-	1.19E-04	1.88E-04	7.62E-06	3.15E-03
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	Ranger mine with Project	1.83E-02	-	9.13E-04	6.53E-03	1.41E-03	3.57E-05	2.12E-04	-	-	-	1.30E-03	-	6.17E-04	4.88E-04	4.07E-05	2.95E-02
	Change due to Project	4.51E-03	-	-	2.32E-03	-	2.06E-05	5.65E-05	-	-	-	7.54E-04	-	3.09E-04	4.88E-04	1.97E-05	8.18E-03
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	Ranger mine with Project	1.66E-03	9.13E-04	8.30E-05	5.94E-04	1.28E-04	3.16E-06	1.87E-05	6.23E-05	8.94E-04	7.68E-05	1.18E-04	1.45E-05	5.61E-05	4.44E-05	3.71E-06	4.65E-03
	Change due to Project	4.10E-04	2.66E-04	-	2.11E-04	-	1.82E-06	4.99E-06	3.54E-05	8.94E-04	7.68E-05	6.86E-05	1.45E-05	2.81E-05	4.44E-05	1.80E-06	2.03E-03
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	Ranger mine with Project	4.05E-04	7.73E-03	2.02E-05	1.45E-04	3.13E-05	0.00E+00	0.00E+00	5.28E-04	7.57E-03	6.51E-04	2.89E-05	1.22E-04	1.37E-05	1.08E-05	9.02E-07	1.73E-02
	Change due to Project	9.99E-05	2.25E-03	-	5.13E-05	-	0.00E+00	0.00E+00	3.00E-04	7.57E-03	6.51E-04	1.67E-05	1.22E-04	6.83E-06	1.08E-05	4.37E-07	1.11E-02
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain	Ranger mine with Project	1.62E-04	3.09E-03	8.09E-06	5.79E-05	1.25E-05	0.00E+00	0.00E+00	2.11E-04	3.03E-03	2.60E-04	1.15E-05	4.90E-05	5.47E-06	4.32E-06	3.61E-07	6.90E-03
	Change due to Project	3.99E-05	9.00E-04	-	2.05E-05	-	0.00E+00	0.00E+00	1.20E-04	3.03E-03	2.60E-04	6.68E-06	4.90E-05	2.73E-06	4.32E-06	1.75E-07	4.43E-03
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	Ranger mine with Project	4.05E-05	7.73E-04	2.02E-06	1.45E-05	3.13E-06	0.00E+00	0.00E+00	5.28E-05	7.57E-04	6.51E-05	2.89E-06	1.22E-05	1.37E-06	1.08E-06	9.02E-08	1.73E-03
	Change due to Project	9.99E-06	2.25E-04	-	5.13E-06	-	0.00E+00	0.00E+00	3.00E-05	7.57E-04	6.51E-05	1.67E-06	1.22E-05	6.83E-07	1.08E-06	4.37E-08	1.11E-03
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	Ranger mine with Project	1.01E-04	1.93E-03	5.06E-06	3.62E-05	7.82E-06	0.00E+00	0.00E+00	1.32E-04	1.89E-03	1.63E-04	7.21E-06	3.06E-05	3.42E-06	2.70E-06	2.26E-07	4.31E-03
	Change due to Project	2.50E-05	5.63E-04	-	1.28E-05	-	0.00E+00	0.00E+00	7.49E-05	1.89E-03	1.63E-04	4.18E-06	3.06E-05	1.71E-06	2.70E-06	1.09E-07	2.77E-03
Kakadu Hwy: (9) 7 km east of Mary River crossing	Ranger mine with Project	2.43E-04	4.64E-03	1.21E-05	8.68E-05	1.88E-05	0.00E+00	0.00E+00	3.17E-04	4.54E-03	3.90E-04	1.73E-05	7.35E-05	8.20E-06	6.48E-06	5.41E-07	1.04E-02
	Change due to Project	5.99E-05	1.35E-03	-	3.08E-05	-	0.00E+00	0.00E+00	1.80E-04	4.54E-03	3.90E-04	1.00E-05	7.35E-05	4.10E-06	6.48E-06	2.62E-07	6.64E-03
Stuart Hwy: (10) Pine Creek township - north of intersection of Stuart Hwy and Kakadu Hwy	Ranger mine with Project	1.08E-04	0.00E+00	5.37E-06	3.84E-05	8.31E-06	7.10E-06	4.21E-05	0.00E+00	0.00E+00	0.00E+00	7.66E-06	0.00E+00	3.63E-06	2.87E-06	2.40E-07	2.21E-04
	Change due to Project	2.65E-05	0.00E+00	-	1.36E-05	-	4.10E-06	1.12E-05	0.00E+00	0.00E+00	0.00E+00	4.44E-06	0.00E+00	1.82E-06	2.87E-06	1.16E-07	6.30E-05
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	Ranger mine with Project	2.83E-04	-	1.42E-05	1.01E-04	2.19E-05	1.87E-05	1.11E-04	-	-	-	2.02E-05	-	9.57E-06	7.57E-06	6.32E-07	5.84E-04
	Change due to Project	7.00E-05	-	-	3.59E-05	-	1.08E-05	2.96E-05	-	-	-	1.17E-05	-	4.79E-06	7.57E-06	3.06E-07	1.66E-04
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	1.87E-04	-	9.33E-06	6.68E-05	1.44E-05	1.23E-05	7.32E-05	-	-	-	1.33E-05	-	6.31E-06	4.99E-06	4.16E-07	3.85E-04
	Change due to Project	4.61E-05	-	-	2.37E-05	-	7.12E-06	1.95E-05	-	-	-	7.71E-06	-	3.15E-06	4.99E-06	2.02E-07	1.09E-04
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	Ranger mine with Project	7.83E-05	-	3.91E-06	2.80E-05	6.05E-06	5.17E-06	3.07E-05	-	-	-	5.58E-06	-	2.64E-06	2.09E-06	1.75E-07	1.61E-04
	Change due to Project	1.93E-05	-	-	9.93E-06	-	2.98E-06	8.18E-06	-	-	-	3.23E-06	-	1.32E-06	2.09E-06	8.46E-08	4.59E-05
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Study area	Ranger mine with Project	6.86E-03	-	3.43E-04	2.45E-03	5.30E-04	9.99E-07	5.93E-06	-	-	-	4.89E-04	-	2.32E-04	1.83E-04	1.53E-05	1.10E-02
	Change due to Project	1.69E-03	-	-	8.69E-04	-	5.77E-07	1.58E-06	-	-	-	2.83E-04	-	1.16E-04	1.83E-04	7.41E-06	3.04E-03
	Ranger mine with Project	3.54E-01	1.74E-01	1.77E-02	1.26E-01	2.73E-02	1.03E-03	6.10E-03	1.18E-02	1.70E-01	1.46E-02	2.52E-02	2.75E-03	1.19E-02	9.44E-03	7.88E-04	9.46E-01
Change due to Project	8.72E-02	5.05E-02	0.00E+00	4.48E-02	0.00E+00	5.94E-04	1.63E-03	6.72E-03	1.70E-01	1.46E-02	1.46E-02	2.75E-03	5.97E-03	9.44E-03	3.82E-04	4.03E-01	

Table 36 Loss of containment likelihood, by location and applicable consumable (releases p.a.)

Location	Scenario	Sulfuric acid	Quicklime	Flocculant (Magnafloc 139)	Diesel	Pyrolusite Manganese oxide (IV) powder	Alamine 336	ShellSol 2046	Anhydrous ammonia	Cement	Sand / aggregate	Uranium oxide	Explosive (ammonium nitrate, ammonium nitrate emulsion)	Sodium hydroxide
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	2.91E-03	-	1.45E-04	5.88E-04	2.25E-04	5.68E-06	1.91E-05	-	-	-	4.14E-08	-	6.48E-06
	Change due to Project	7.17E-04	-	-	2.09E-04	-	3.28E-06	5.09E-06	-	-	-	2.40E-08	-	3.14E-06
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	Ranger mine with Project	1.06E-03	-	5.28E-05	2.14E-04	8.17E-05	2.07E-06	6.95E-06	-	-	-	1.51E-08	-	2.36E-06
	Change due to Project	2.61E-04	-	-	7.60E-05	-	1.19E-06	1.85E-06	-	-	-	8.73E-09	-	1.14E-06
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	Ranger mine with Project	2.74E-03	-	1.37E-04	5.55E-04	2.12E-04	5.36E-06	1.80E-05	-	-	-	3.91E-08	-	6.11E-06
	Change due to Project	6.76E-04	-	-	1.97E-04	-	3.09E-06	4.80E-06	-	-	-	2.26E-08	-	2.96E-06
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	Ranger mine with Project	2.49E-04	1.37E-04	1.25E-05	5.05E-05	1.93E-05	4.73E-07	1.59E-06	1.25E-06	1.34E-04	1.15E-05	3.55E-09	2.17E-06	5.56E-07
	Change due to Project	6.15E-05	3.99E-05	-	1.79E-05	-	2.73E-07	4.24E-07	7.07E-07	1.34E-04	1.15E-05	2.06E-09	2.17E-06	2.69E-07
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	Ranger mine with Project	6.07E-05	1.16E-03	3.03E-06	1.23E-05	4.69E-06	0.00E+00	0.00E+00	1.06E-05	1.14E-03	9.76E-05	8.66E-10	1.84E-05	1.35E-07
	Change due to Project	1.50E-05	3.38E-04	-	4.36E-06	-	0.00E+00	0.00E+00	5.99E-06	1.14E-03	9.76E-05	5.01E-10	1.84E-05	6.56E-08
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain	Ranger mine with Project	2.43E-05	4.64E-04	1.21E-06	4.92E-06	1.88E-06	0.00E+00	0.00E+00	4.22E-06	4.54E-04	3.90E-05	3.46E-10	7.35E-06	5.41E-08
	Change due to Project	5.99E-06	1.35E-04	-	1.74E-06	-	0.00E+00	0.00E+00	2.40E-06	4.54E-04	3.90E-05	2.00E-10	7.35E-06	2.62E-08
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	Ranger mine with Project	6.07E-06	1.16E-04	3.03E-07	1.23E-06	4.69E-07	0.00E+00	0.00E+00	1.06E-06	1.14E-04	9.76E-06	8.66E-11	1.84E-06	1.35E-08
	Change due to Project	1.50E-06	3.38E-05	-	4.36E-07	-	0.00E+00	0.00E+00	5.99E-07	1.14E-04	9.76E-06	5.01E-11	1.84E-06	6.56E-09
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	Ranger mine with Project	1.52E-05	2.90E-04	7.58E-07	3.07E-06	1.17E-06	0.00E+00	0.00E+00	2.64E-06	2.84E-04	2.44E-05	2.16E-10	4.59E-06	3.38E-08
	Change due to Project	3.75E-06	8.44E-05	-	1.09E-06	-	0.00E+00	0.00E+00	1.50E-06	2.84E-04	2.44E-05	1.25E-10	4.59E-06	1.64E-08
Kakadu Hwy: (9) 7 km east of Mary River crossing	Ranger mine with Project	3.64E-05	6.96E-04	1.82E-06	7.38E-06	2.82E-06	0.00E+00	0.00E+00	6.33E-06	6.81E-04	5.86E-05	5.19E-10	1.10E-05	8.12E-08
	Change due to Project	8.99E-06	2.03E-04	-	2.62E-06	-	0.00E+00	0.00E+00	3.59E-06	6.81E-04	5.86E-05	3.01E-10	1.10E-05	3.94E-08
Stuart Hwy: (10) Pine Creek township - north of intersection of Stuart Hwy and Kakadu Hwy	Ranger mine with Project	1.61E-05	0.00E+00	8.06E-07	3.27E-06	1.25E-06	1.07E-06	3.58E-06	0.00E+00	0.00E+00	0.00E+00	2.30E-10	0.00E+00	3.59E-08
	Change due to Project	3.98E-06	0.00E+00	-	1.16E-06	-	6.15E-07	9.54E-07	0.00E+00	0.00E+00	0.00E+00	1.33E-10	0.00E+00	1.74E-08
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	Ranger mine with Project	4.25E-05	-	2.12E-06	8.61E-06	3.29E-06	2.81E-06	9.43E-06	-	-	-	6.06E-10	-	9.48E-08
	Change due to Project	1.05E-05	-	-	3.05E-06	-	1.62E-06	2.52E-06	-	-	-	3.51E-10	-	4.59E-08
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	2.80E-05	-	1.40E-06	5.68E-06	2.17E-06	1.85E-06	6.22E-06	-	-	-	4.00E-10	-	6.25E-08
	Change due to Project	6.92E-06	-	-	2.01E-06	-	1.07E-06	1.66E-06	-	-	-	2.31E-10	-	3.03E-08
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	Ranger mine with Project	1.17E-05	-	5.87E-07	2.38E-06	9.08E-07	7.76E-07	2.61E-06	-	-	-	1.67E-10	-	2.62E-08
	Change due to Project	2.90E-06	-	-	8.44E-07	-	4.48E-07	6.95E-07	-	-	-	9.70E-11	-	1.27E-08
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and	Ranger mine with Project	1.03E-03	-	5.14E-05	2.08E-04	7.95E-05	1.50E-07	5.04E-07	-	-	-	1.47E-08	-	2.29E-06
	Change due to Project	2.54E-04	-	-	7.39E-05	-	8.65E-08	1.34E-07	-	-	-	8.49E-09	-	1.11E-06
Study area	Ranger mine with Project	5.30E-02	2.60E-02	2.65E-03	1.07E-02	4.10E-03	1.54E-04	5.18E-04	2.37E-04	2.55E-02	2.19E-03	7.56E-07	4.12E-04	1.18E-04
	Change due to Project	1.31E-02	7.58E-03	0.00E+00	3.81E-03	0.00E+00	8.90E-05	1.38E-04	1.34E-04	2.55E-02	2.19E-03	4.38E-07	4.12E-04	5.73E-05

Table 37 Fire / explosion likelihood, by location and applicable consumable (fire / explosion p.a.)

Location	Scenario	Diesel	ShellSol 2046	Anhydrous ammonia	Explosive (ammonium nitrate, ammonium nitrate emulsion)
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	5.00E-05	1.62E-06	-	-
	Change due to Project	1.77E-05	4.32E-07	-	-
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	Ranger mine with Project	1.82E-05	5.90E-07	-	-
	Change due to Project	6.45E-06	1.57E-07	-	-
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	Ranger mine with Project	4.71E-05	1.53E-06	-	-
	Change due to Project	1.67E-05	4.08E-07	-	-
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	Ranger mine with Project	4.29E-06	1.35E-07	1.06E-07	1.84E-07
	Change due to Project	1.52E-06	3.60E-08	6.00E-08	1.84E-07
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	Ranger mine with Project	1.04E-06	0.00E+00	8.96E-07	1.56E-06
	Change due to Project	3.70E-07	0.00E+00	5.09E-07	1.56E-06
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain	Ranger mine with Project	4.18E-07	0.00E+00	3.58E-07	6.24E-07
	Change due to Project	1.48E-07	0.00E+00	2.03E-07	6.24E-07
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	Ranger mine with Project	1.04E-07	0.00E+00	8.96E-08	1.56E-07
	Change due to Project	3.70E-08	0.00E+00	5.09E-08	1.56E-07
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	Ranger mine with Project	2.61E-07	0.00E+00	2.24E-07	3.90E-07
	Change due to Project	9.26E-08	0.00E+00	1.27E-07	3.90E-07
Kakadu Hwy: (9) 7 km east of Mary River crossing	Ranger mine with Project	6.26E-07	0.00E+00	5.38E-07	9.36E-07
	Change due to Project	2.22E-07	0.00E+00	3.05E-07	9.36E-07
Stuart Hwy: (10) Pine Creek township - north of intersection of Stuart Hwy and Kakadu Hwy	Ranger mine with Project	2.77E-07	3.04E-07	0.00E+00	0.00E+00
	Change due to Project	9.83E-08	8.10E-08	0.00E+00	0.00E+00
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	Ranger mine with Project	7.31E-07	8.01E-07	-	-
	Change due to Project	2.59E-07	2.14E-07	-	-
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	4.82E-07	5.28E-07	-	-
	Change due to Project	1.71E-07	1.41E-07	-	-
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	Ranger mine with Project	2.02E-07	2.21E-07	-	-
	Change due to Project	7.16E-08	5.90E-08	-	-
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Study area	Ranger mine with Project	1.77E-05	4.28E-08	-	-
	Change due to Project	6.27E-06	1.14E-08	-	-
Study area	Ranger mine with Project	9.12E-04	4.40E-05	2.01E-05	3.50E-05
	Change due to Project	3.23E-04	1.17E-05	1.14E-05	3.50E-05

Table 38 Fatal vehicle incident likelihood, by location and consumable (fatalities p.a.)

Location	Scenario	Sulfuric acid	Quicklime	Flocculant (Magnafloc 139)	Diesel	Pyrolysis Manganese oxide (W) powder	Alamine 336	ShellSol 2046	Anhydrous ammonia	Cement	Sand / aggregate	Uranium oxide	Explosive (ammonium nitrate, ammonium nitrate emulsion)	Miscellaneous	Construction materials (various)	Sodium hydroxide	Total
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	5.81E-04	-	2.90E-05	2.08E-04	4.49E-05	1.14E-06	6.73E-06	-	-	-	4.14E-05	-	1.96E-05	1.55E-05	1.30E-06	9.39E-04
	Change due to Project	1.43E-04	-	-	7.36E-05	-	6.55E-07	1.80E-06	-	-	-	2.40E-05	-	9.81E-06	1.55E-05	6.28E-07	2.60E-04
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	Ranger mine with Project	2.12E-04	-	1.06E-05	7.56E-05	1.63E-05	4.13E-07	2.45E-06	-	-	-	1.51E-05	-	7.14E-06	5.65E-06	4.71E-07	3.42E-04
	Change due to Project	5.22E-05	-	-	2.68E-05	-	2.39E-07	6.54E-07	-	-	-	8.73E-06	-	3.57E-06	5.65E-06	2.29E-07	9.46E-05
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	Ranger mine with Project	5.48E-04	-	2.74E-05	1.96E-04	4.24E-05	1.07E-06	6.35E-06	-	-	-	3.91E-05	-	1.85E-05	1.46E-05	1.22E-06	8.86E-04
	Change due to Project	1.35E-04	-	-	6.95E-05	-	6.18E-07	1.69E-06	-	-	-	2.26E-05	-	9.26E-06	1.46E-05	5.92E-07	2.45E-04
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	Ranger mine with Project	4.99E-05	2.74E-05	2.49E-06	1.78E-05	3.85E-06	9.47E-08	5.61E-07	1.87E-06	2.68E-05	2.31E-06	3.55E-06	4.34E-07	1.68E-06	1.33E-06	1.11E-07	1.39E-04
	Change due to Project	1.23E-05	7.97E-06	-	6.32E-06	-	5.46E-08	1.50E-07	1.06E-06	2.68E-05	2.31E-06	2.06E-06	4.34E-07	8.42E-07	1.33E-06	5.39E-08	6.09E-05
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	Ranger mine with Project	1.21E-05	2.32E-04	6.07E-07	4.34E-06	9.38E-07	0.00E+00	0.00E+00	1.58E-05	2.27E-04	1.95E-05	8.66E-07	3.67E-06	4.10E-07	3.24E-07	2.71E-08	5.18E-04
	Change due to Project	3.00E-06	6.75E-05	-	1.54E-06	-	0.00E+00	0.00E+00	8.99E-06	2.27E-04	1.95E-05	5.01E-07	3.67E-06	2.05E-07	3.24E-07	1.31E-08	3.32E-04
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain	Ranger mine with Project	4.86E-06	9.28E-05	2.43E-07	1.74E-06	3.75E-07	0.00E+00	0.00E+00	6.33E-06	9.09E-05	7.81E-06	3.46E-07	1.47E-06	1.64E-07	1.30E-07	1.08E-08	2.07E-04
	Change due to Project	1.20E-06	2.70E-05	-	6.16E-07	-	0.00E+00	0.00E+00	3.59E-06	9.09E-05	7.81E-06	2.00E-07	1.47E-06	8.20E-08	1.30E-07	5.25E-09	1.33E-04
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	Ranger mine with Project	1.21E-06	2.32E-05	6.07E-08	4.34E-07	9.38E-08	0.00E+00	0.00E+00	1.58E-06	2.27E-05	1.95E-06	8.66E-08	3.67E-07	4.10E-08	3.24E-08	2.71E-09	5.18E-05
	Change due to Project	3.00E-07	6.75E-06	-	1.54E-07	-	0.00E+00	0.00E+00	8.99E-07	2.27E-05	1.95E-06	5.01E-08	3.67E-07	2.05E-08	3.24E-08	1.31E-09	3.32E-05
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	Ranger mine with Project	3.04E-06	5.80E-05	1.52E-07	1.08E-06	2.35E-07	0.00E+00	0.00E+00	3.96E-06	5.68E-05	4.88E-06	2.16E-07	9.19E-07	1.03E-07	8.10E-08	6.77E-09	1.29E-04
	Change due to Project	7.49E-07	1.69E-05	-	3.85E-07	-	0.00E+00	0.00E+00	2.25E-06	5.68E-05	4.88E-06	1.25E-07	9.19E-07	5.13E-08	8.10E-08	3.28E-09	8.31E-05
Kakadu Hwy: (9) 7 km east of Mary River crossing	Ranger mine with Project	7.29E-06	1.39E-04	3.64E-07	2.60E-06	5.63E-07	0.00E+00	0.00E+00	9.50E-06	1.36E-04	1.17E-05	5.19E-07	2.20E-06	2.46E-07	1.94E-07	1.62E-08	3.11E-04
	Change due to Project	1.80E-06	4.05E-05	-	9.23E-07	-	0.00E+00	0.00E+00	5.39E-06	1.36E-04	1.17E-05	3.01E-07	2.20E-06	1.23E-07	1.94E-07	7.87E-09	1.99E-04
Stuart Hwy: (10) Pine Creek township - north of intersection of Stuart Hwy and Kakadu Hwy	Ranger mine with Project	3.23E-06	0.00E+00	1.61E-07	1.15E-06	2.49E-07	2.13E-07	1.26E-06	0.00E+00	0.00E+00	0.00E+00	2.30E-07	0.00E+00	1.09E-07	8.61E-08	7.19E-09	6.64E-06
	Change due to Project	7.96E-07	0.00E+00	-	4.09E-07	-	1.23E-07	3.37E-07	0.00E+00	0.00E+00	0.00E+00	1.33E-07	0.00E+00	5.45E-08	8.61E-08	3.49E-09	1.89E-06
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	Ranger mine with Project	8.50E-06	-	4.25E-07	3.04E-06	6.57E-07	5.62E-07	3.33E-06	-	-	-	6.06E-07	-	2.87E-07	2.27E-07	1.90E-08	1.75E-05
	Change due to Project	2.10E-06	-	-	1.08E-06	-	3.24E-07	8.88E-07	-	-	-	3.51E-07	-	1.44E-07	2.27E-07	9.19E-09	4.98E-06
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	5.61E-06	-	2.80E-07	2.00E-06	4.33E-07	3.70E-07	2.19E-06	-	-	-	4.00E-07	-	1.89E-07	1.50E-07	1.25E-08	1.15E-05
	Change due to Project	1.38E-06	-	-	7.10E-07	-	2.14E-07	5.85E-07	-	-	-	2.31E-07	-	9.46E-08	1.50E-07	6.06E-09	3.28E-06
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	Ranger mine with Project	2.35E-06	-	1.17E-07	8.40E-07	1.82E-07	1.55E-07	9.20E-07	-	-	-	1.67E-07	-	7.93E-08	6.27E-08	5.24E-09	4.84E-06
	Change due to Project	5.80E-07	-	-	2.98E-07	-	8.95E-08	2.45E-07	-	-	-	9.70E-08	-	3.97E-08	6.27E-08	2.54E-09	1.38E-06
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Study area	Ranger mine with Project	2.06E-04	-	1.03E-05	7.35E-05	1.59E-05	3.00E-08	1.78E-07	-	-	-	1.47E-05	-	6.95E-06	5.49E-06	4.59E-07	3.30E-04
	Change due to Project	5.08E-05	-	-	2.61E-05	-	1.73E-08	4.74E-08	-	-	-	8.49E-06	-	3.47E-06	5.49E-06	2.22E-07	9.13E-05
	Ranger mine with Project	1.06E-02	5.21E-03	5.30E-04	3.79E-03	8.20E-04	3.09E-05	1.83E-04	3.55E-04	5.10E-03	4.38E-04	7.56E-04	8.25E-05	3.58E-04	2.83E-04	2.36E-05	2.84E-02
	Change due to Project	2.62E-03	1.52E-03	0.00E+00	1.34E-03	0.00E+00	1.78E-05	4.88E-05	2.02E-04	5.10E-03	4.38E-04	4.38E-04	8.25E-05	1.79E-04	2.83E-04	1.15E-05	1.21E-02

Table 39 Personal injury from loss of containment likelihood, by location and consumable (incidents p.a.)

Location	Scenario	Sulfuric acid	Quicklime	Flocculant (Magnafloc 139)	Diesel	Pyrolusite Manganese oxide (IV) powder	Alamine 336	ShellSol 2046	Anhydrous ammonia	Cement	Sand / aggregate	Uranium oxide	Explosive (ammonium nitrate, ammonium nitrate emulsion)	Sodium hydroxide
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	2.91E-05	-	1.45E-06	5.88E-05	2.25E-06	5.68E-08	1.91E-07	-	-	-	4.14E-10	-	6.48E-07
	Change due to Project	7.17E-06	-	-	2.09E-05	-	3.28E-08	5.09E-08	-	-	-	2.40E-10	-	3.14E-07
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	Ranger mine with Project	1.06E-05	-	5.28E-07	2.14E-05	8.17E-07	2.07E-08	6.95E-08	-	-	-	1.51E-10	-	2.36E-07
	Change due to Project	2.61E-06	-	-	7.60E-06	-	1.19E-08	1.85E-08	-	-	-	8.73E-11	-	1.14E-07
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	Ranger mine with Project	2.74E-05	-	1.37E-06	5.55E-05	2.12E-06	5.36E-08	1.80E-07	-	-	-	3.91E-10	-	6.11E-07
	Change due to Project	6.76E-06	-	-	1.97E-05	-	3.09E-08	4.80E-08	-	-	-	2.26E-10	-	2.96E-07
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	Ranger mine with Project	2.49E-06	1.37E-05	1.25E-07	5.05E-06	1.93E-07	4.73E-09	1.59E-08	1.25E-07	1.34E-06	1.15E-07	3.55E-11	2.17E-08	5.56E-08
	Change due to Project	6.15E-07	3.99E-06	-	1.79E-06	-	2.73E-09	4.24E-09	7.07E-08	1.34E-06	1.15E-07	2.06E-11	2.17E-08	2.69E-08
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	Ranger mine with Project	6.07E-07	1.16E-04	3.03E-08	1.23E-06	4.69E-08	0.00E+00	0.00E+00	1.06E-06	1.14E-05	9.76E-07	8.66E-12	1.84E-07	1.35E-08
	Change due to Project	1.50E-07	3.38E-05	-	4.36E-07	-	0.00E+00	0.00E+00	5.99E-07	1.14E-05	9.76E-07	5.01E-12	1.84E-07	6.56E-09
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain	Ranger mine with Project	2.43E-07	4.64E-05	1.21E-08	4.92E-07	1.88E-08	0.00E+00	0.00E+00	4.22E-07	4.54E-06	3.90E-07	3.46E-12	7.35E-08	5.41E-09
	Change due to Project	5.99E-08	1.35E-05	-	1.74E-07	-	0.00E+00	0.00E+00	2.40E-07	4.54E-06	3.90E-07	2.00E-12	7.35E-08	2.62E-09
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	Ranger mine with Project	6.07E-08	1.16E-05	3.03E-09	1.23E-07	4.69E-09	0.00E+00	0.00E+00	1.06E-07	1.14E-06	9.76E-08	8.66E-13	1.84E-08	1.35E-09
	Change due to Project	1.50E-08	3.38E-06	-	4.36E-08	-	0.00E+00	0.00E+00	5.99E-08	1.14E-06	9.76E-08	5.01E-13	1.84E-08	6.56E-10
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	Ranger mine with Project	1.52E-07	2.90E-05	7.58E-09	3.07E-07	1.17E-08	0.00E+00	0.00E+00	2.64E-07	2.84E-06	2.44E-07	2.16E-12	4.59E-08	3.38E-09
	Change due to Project	3.75E-08	8.44E-06	-	1.09E-07	-	0.00E+00	0.00E+00	1.50E-07	2.84E-06	2.44E-07	1.25E-12	4.59E-08	1.64E-09
Kakadu Hwy: (9) 7 km east of Mary River crossing	Ranger mine with Project	3.64E-07	6.96E-05	1.82E-08	7.38E-07	2.82E-08	0.00E+00	0.00E+00	6.33E-07	6.81E-06	5.86E-07	5.19E-12	1.10E-07	8.12E-09
	Change due to Project	8.99E-08	2.03E-05	-	2.62E-07	-	0.00E+00	0.00E+00	3.59E-07	6.81E-06	5.86E-07	3.01E-12	1.10E-07	3.94E-09
Stuart Hwy: (10) Pine Creek township - north of intersection of Stuart Hwy and Kakadu Hwy	Ranger mine with Project	1.61E-07	0.00E+00	8.06E-09	3.27E-07	1.25E-08	1.07E-08	3.58E-08	0.00E+00	0.00E+00	0.00E+00	2.30E-12	0.00E+00	3.59E-09
	Change due to Project	3.98E-08	0.00E+00	-	1.16E-07	-	6.15E-09	9.54E-09	0.00E+00	0.00E+00	0.00E+00	1.33E-12	0.00E+00	1.74E-09
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	Ranger mine with Project	4.25E-07	-	2.12E-08	8.61E-07	3.29E-08	2.81E-08	9.43E-08	-	-	-	6.06E-12	-	9.48E-09
	Change due to Project	1.05E-07	-	-	3.05E-07	-	1.62E-08	2.52E-08	-	-	-	3.51E-12	-	4.59E-09
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	Ranger mine with Project	2.80E-07	-	1.40E-08	5.68E-07	2.17E-08	1.85E-08	6.22E-08	-	-	-	4.00E-12	-	6.25E-09
	Change due to Project	6.92E-08	-	-	2.01E-07	-	1.07E-08	1.66E-08	-	-	-	2.31E-12	-	3.03E-09
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	Ranger mine with Project	1.17E-07	-	5.87E-09	2.38E-07	9.08E-09	7.76E-09	2.61E-08	-	-	-	1.67E-12	-	2.62E-09
	Change due to Project	2.90E-08	-	-	8.44E-08	-	4.48E-09	6.95E-09	-	-	-	9.70E-13	-	1.27E-09
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Study area	Ranger mine with Project	1.03E-05	-	5.14E-07	2.08E-05	7.95E-07	1.50E-09	5.04E-09	-	-	-	1.47E-10	-	2.29E-07
	Change due to Project	2.54E-06	-	-	7.39E-06	-	8.65E-10	1.34E-09	-	-	-	8.49E-11	-	1.11E-07
Study area	Ranger mine with Project	5.30E-04	2.60E-03	2.65E-05	1.07E-03	4.10E-05	1.54E-06	5.18E-06	2.37E-05	2.55E-04	2.19E-05	7.56E-09	4.12E-06	1.18E-05
	Change due to Project	1.31E-04	7.58E-04	0.00E+00	3.81E-04	0.00E+00	8.90E-07	1.38E-06	1.34E-05	2.55E-04	2.19E-05	4.38E-09	4.12E-06	5.73E-06

Appendix E – Risk Register

	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Total risks	147	68	14	13	4

Sulfuric acid	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	1				
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	1				
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	1	1			
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	1				
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	1				
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	1				
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Study area	1		1	1	

Diesel	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	1				
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	1				
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	1	1			
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	1				
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	1				
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	1				
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Study area	1		1	1	1

Sodium hydroxide	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	1				
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	1				
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	1	1			
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	1				
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	1				

Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	1				
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy	1				
Study area			1	1	

Uranium oxide	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	1				
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	1				
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	1	1			
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	1				
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	1				
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	1				
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy	1				
Study area			1	1	

ShellSol 2046	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	1				
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	1				
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	1	1			
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	1				
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	1				
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	1				
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy	1				
Study area			1	1	1

Quicklime	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain					
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains					
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains					
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			

Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek					
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain					
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining					
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy					
Study area			1	1	

Sand / aggregate	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain					
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains					
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains					
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1				
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1				
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1				
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1				
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1				
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek					
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain					
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining					
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy					
Study area			1	1	

Cement	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain					
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains					
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains					
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek					
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain					
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining					
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy					
Study area			1	1	

Anhydrous ammonia	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain					
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains					
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains					
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			

Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek					
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain					
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining					
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy					
Study area			1	1	1

Alamine 336	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	1				
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	1				
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	1	1			
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	1				
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	1				
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	1				
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy	1				
Study area			1	1	

Flocculant (Magnafloc 139)	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	1				
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	1				
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	1	1			
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	1				
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	1				
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	1				
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy	1				
Study area			1	1	

Pyrolusite Manganese oxide (IV) powder	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain	1				

Arnhem Hwy: (2) Mary River crossing and surrounding floodplains	1				
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains	1	1			
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek	1				
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain	1				
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining	1				
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy	1				
Study area			1	1	

Explosives (ammonium nitrate, ammonium nitrate emulsion)	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain					
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains					
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains					
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine	1	1			
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain	1	1			
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)	1	1			
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain	1	1			
Kakadu Hwy: (9) 7 km east of Mary River crossing	1				
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy	1				
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek					
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain					
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining					
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy					
Study area			1	1	1

Construction materials	Listed threatened migratory species	Environmental values	Public safety - vehicle incident	Public safety - LOC	Public safety - fire / explosion
Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain					
Arnhem Hwy: (2) Mary River crossing and surrounding floodplains					
Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains					
Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine					
Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain					
Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity)					
Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain					
Kakadu Hwy: (8) Mary River crossing and surrounding floodplain					
Kakadu Hwy: (9) 7 km east of Mary River crossing					
Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy					
Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek					
Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain					
Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining					
Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy					
Study area			1		

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
1	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain (9 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	D	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Plains Death Adder, Gouldian Finch, Northern Quoll	C3
2	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Arnhem Hwy: (2) Mary River crossing and surrounding floodplains (8 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	D	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Gouldian Finch, Northern Quoll, Partridge Pigeon	C3
3	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	D	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Yellow Chat, Red Goshawk, Plains Death Adder, Masked Owl	C3
4	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
5	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
6	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
7	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
8	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
9	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
10	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
11	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Partridge Pigeon and location of NT threatened <i>Acacia praetermissa</i> (numerous records)	C3
12	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain (7 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
13	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	No nearby threatened species records but habitat likely used by migratory species and possibly Gouldian Finch and Partridge Pigeon	C3
14	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulfuric acid is harmful to aquatic life in very low concentrations and causes corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	D	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk, Australian Painted Snipe, Yellow Chat,	C3
15	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain (9 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Plains Death Adder, Gouldian Finch, Northern Quoll	C3
16	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Arnhem Hwy: (2) Mary River crossing and surrounding floodplains (8 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon	C3
17	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Yellow Chat, Red Goshawk, Plains Death Adder, Masked Owl	C3
18	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
19	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
20	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
21	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
22	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
23	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
24	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
25	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Partridge Pigeon and location of NT threatened <i>Acacia praetermissa</i> (numerous records)	C3
26	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain (7 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk	C3
27	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	No nearby threatened species records but habitat likely used by migratory species and possibly Gouldian Finch and Partridge Pigeon	C3
28	Transport of Diesel	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk, Australian Painted Snipe, Yellow Chat,	C3
29	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain (9 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Plains Death Adder, Gouldian Finch, Northern Quoll	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
30	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Arnhem Hwy: (2) Mary River crossing and surrounding floodplains (8 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon	C3
31	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Yellow Chat, Red Goshawk, Plains Death Adder, Masked Owl	C3
32	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
33	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
34	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
35	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
36	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
37	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
38	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
39	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon and location of NT threatened species <i>Acacia praetermissa</i> (numerous records)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
40	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain (7 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk	C3
41	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	No nearby threatened species records but habitat likely used by migratory species and possibly Gouldian Finch and Partridge Pigeon	C3
42	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk, Australian Painted Snipe, Yellow Chat,	C3
43	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain (9 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Plains Death Adder, Gouldian Finch, Northern Quoll	C3
44	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Arnhem Hwy: (2) Mary River crossing and surrounding floodplains (8 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Gouldian Finch, Northern Quoll, Partridge Pigeon	C3
45	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Yellow Chat, Red Goshawk, Plains Death Adder, Masked Owl	C3
46	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
47	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
48	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
49	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
50	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
51	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
52	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
53	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Partridge Pigeon and location of NT threatened <i>Acacia praetermissa</i> (numerous records)	C3
54	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain (7 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk	C3
55	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	No nearby threatened species records but habitat likely used by migratory species and possibly Gouldian Finch and Partridge Pigeon	C3
56	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	1	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk, Australian Painted Snipe, Yellow Chat,	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
57	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain (9 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Plains Death Adder, Gouldian Finch, Northern Quoll	C3
58	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Arnhem Hwy: (2) Mary River crossing and surrounding floodplains (8 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon	C3
59	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Yellow Chat, Red Goshawk, Plains Death Adder, Masked Owl	C3
60	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
61	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
62	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
63	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
64	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
65	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. <i>Adsorbs to soil and has low mobility. Floats on water.</i>	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
66	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. <i>Adsorbs to soil and has low mobility. Floats on water.</i>	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
67	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. <i>Adsorbs to soil and has low mobility. Floats on water.</i>	Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Partridge Pigeon and location of NT threatened <i>Acacia praetermissa</i> (numerous records)	C3
68	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. <i>Adsorbs to soil and has low mobility. Floats on water.</i>	Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain (7 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk	C3
69	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. <i>Adsorbs to soil and has low mobility. Floats on water.</i>	Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	No nearby threatened species records but habitat likely used by migratory species and possibly Gouldian Finch and Partridge Pigeon	C3
70	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. <i>Adsorbs to soil and has low mobility. Floats on water.</i>	Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk, Australian Painted Snipe, Yellow Chat,	C3
71	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment	Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain (9 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Plains Death Adder, Gouldian Finch, Northern Quoll	C3
72	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment	Arnhem Hwy: (2) Mary River crossing and surrounding floodplains (8 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
73	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Yellow Chat, Red Goshawk, Plains Death Adder, Masked Owl	C3
74	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
75	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
76	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
77	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
78	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
79	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
80	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
81	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon and location of NT threatened <i>Acacia praetermissa</i> (numerous records)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
82	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain (7 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk	C3
83	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	No nearby threatened species records but habitat likely used by migratory species and possibly Gouldian Finch and Partridge Pigeon	C3
84	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk, Australian Painted Snipe, Yellow Chat,	C3
85	Transport of Quicklime	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	The products high pH (12.6) has the potential to be toxic to aquatic life and plants if concentrations were sufficient to result in an acute pH shift.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
86	Transport of Quicklime	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	The products high pH (12.6) has the potential to be toxic to aquatic life and plants if concentrations were sufficient to result in an acute pH shift.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	D	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
87	Transport of Quicklime	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	The products high pH (12.6) has the potential to be toxic to aquatic life and plants if concentrations were sufficient to result in an acute pH shift.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
88	Transport of Quicklime	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	The products high pH (12.6) has the potential to be toxic to aquatic life and plants if concentrations were sufficient to result in an acute pH shift.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
89	Transport of Quicklime	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	The products high pH (12.6) has the potential to be toxic to aquatic life and plants if concentrations were sufficient to result in an acute pH shift.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
90	Transport of Quicklime	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	The products high pH (12.6) has the potential to be toxic to aquatic life and plants if concentrations were sufficient to result in an acute pH shift.	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
91	Transport of Quicklime	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	The products high pH (12.6) has the potential to be toxic to aquatic life and plants if concentrations were sufficient to result in an acute pH shift.	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
92	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Ammonia is readily oxidised to nitrite which is also toxic to fish. Expected to be harmful to terrestrial species. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a large plume that, dependant on wind velocity would spread. exothermic reaction	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
93	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Ammonia is readily oxidised to nitrite which is also toxic to fish. Expected to be harmful to terrestrial species. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a large plume that, dependant on wind velocity would spread. exothermic reaction	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
94	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Ammonia is readily oxidised to nitrite which is also toxic to fish. Expected to be harmful to terrestrial species. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a large plume that, dependant on wind velocity would spread. exothermic reaction.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
95	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Ammonia is readily oxidised to nitrite which is also toxic to fish. Expected to be harmful to terrestrial species. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a large plume that, dependant on wind velocity would spread. exothermic reaction.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
96	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Ammonia is readily oxidised to nitrite which is also toxic to fish. Expected to be harmful to terrestrial species. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a large plume that, dependant on wind velocity would spread. exothermic reaction.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
97	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Ammonia is readily oxidised to nitrite which is also toxic to fish. Expected to be harmful to terrestrial species. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a large plume that, dependant on wind velocity would spread. exothermic reaction.	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
98	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Ammonia is readily oxidised to nitrite which is also toxic to fish. Expected to be harmful to terrestrial species. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a large plume that, dependant on wind velocity would spread. exothermic reaction.	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
99	Transport of Cement	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Due to its high pH, 11 to 13, this substance can be toxic to aquatic life and plants due to acute pH shift.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
100	Transport of Cement	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Due to its high pH, 11 to 13, this substance can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	D	L	Assessment basis is a worst credible loss of 10 tonnes.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
101	Transport of Cement	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Due to its high pH, 11 to 13, this substance can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
102	Transport of Cement	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Due to its high pH, 11 to 13, this substance can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
103	Transport of Cement	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Due to its high pH, 11 to 13, this substance can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
104	Transport of Cement	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Due to its high pH, 11 to 13, this substance can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
105	Transport of Cement	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Due to its high pH, 11 to 13, this substance can be toxic to aquatic life and plants due to acute pH shift.	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
106	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
107	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
108	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
109	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
110	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
111	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
112	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
113	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain (9 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Plains Death Adder, Gouldian Finch, Northern Quoll	C3
114	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Arnhem Hwy: (2) Mary River crossing and surrounding floodplains (8 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon	C3
115	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Yellow Chat, Red Goshawk, Plains Death Adder, Masked Owl	C3
116	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
117	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
118	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
119	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
120	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
121	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
122	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
123	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon and location of NT threatened <i>Acacia praetermissa</i> (numerous records)	C3
124	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain (7 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk	C3
125	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	No nearby threatened species records but habitat likely used by migratory species and possibly Gouldian Finch and Partridge Pigeon	C3
126	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk, Australian Painted Snipe, Yellow Chat.	C3
127	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Arnhem Hwy: (1) Adelaide River crossing and surrounding floodplain (9 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Plains Death Adder, Gouldian Finch, Northern Quoll	C3
128	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Arnhem Hwy: (2) Mary River crossing and surrounding floodplains (8 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon	C3
129	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Yellow Chat, Red Goshawk, Plains Death Adder, Masked Owl	C3
130	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
131	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
132	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
133	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
134	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
135	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
136	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3
137	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Stuart Hwy: (11) eastern roadside area - approximately 60 km north of Pine Creek (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Partridge Pigeon and location of NT threatened <i>Acacia praetermissa</i> (numerous records)	C3
138	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Stuart Hwy: (12) Adelaide River crossing and surrounding floodplain (7 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk	C3
139	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Stuart Hwy: (13) 134 km Bridge crossing over creekline, riparian woodland adjoining (5 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	No nearby threatened species records but habitat likely used by migratory species and possibly Gouldian Finch and Partridge Pigeon	C3
140	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Stuart Hwy: (14) Greater Darwin region and broader area surrounding the intersection of Arnhem Hwy and Stuart Hwy (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	Gouldian Finch, Northern Quoll, Partridge Pigeon, Red Goshawk, Australian Painted Snipe, Yellow Chat,	C3
141	Transport of Sand / aggregate	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	No potential impact to listed threatened or migratory species	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	1	E	L	Assessment basis is a worst credible loss of 6 t.	Gouldian Finch, Partridge Pigeon, Northern Quoll	C3
142	Transport of Sand / aggregate	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	No potential impact to listed threatened or migratory species	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	1	E	L	Assessment basis is a worst credible loss of 6 t.	Gouldian Finch, Partridge Pigeon, Northern Quoll, Arnhem Rock-rat, Crested Shrike-tit.	C3
143	Transport of Sand / aggregate	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	No potential impact to listed threatened or migratory species	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	1	E	L	Assessment basis is a worst credible loss of 6 t.	Partridge Pigeon, Red Goshawk, Brush-tailed Rabbit-rat, Northern Quoll, Australian Painted Snipe, Gouldian Finch.	C3
144	Transport of Sand / aggregate	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	No potential impact to listed threatened or migratory species	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	1	E	L	Assessment basis is a worst credible loss of 6 t.	Gouldian Finch, Northern Quoll, Partridge Pigeon.	C3
145	Transport of Sand / aggregate	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	No potential impact to listed threatened or migratory species	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	1	E	L	Assessment basis is a worst credible loss of 6 t.	Partridge Pigeon, Red Goshawk, Northern Quoll, Arnhemland Egernia	C3
146	Transport of Sand / aggregate	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	No potential impact to listed threatened or migratory species	Kakadu Hwy: (9) 7 km east of Mary River crossing (6 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	1	E	L	Assessment basis is a worst credible loss of 6 t.	Arnhemland Egernia (endangered species with localised population) susceptible to localised impacts	C3
147	Transport of Sand / aggregate	Vehicle incident leading to loss of containment.	Listed threatened and migratory species	No potential impact to listed threatened or migratory species	Stuart Hwy: (10) Pine Creek township - intersection of Stuart Hwy and Kakadu Hwy (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	1	E	L	Assessment basis is a worst credible loss of 6 t.	Partridge Pigeon, Northern Quoll, Gouldian Finch	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
148	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Environmental values	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulphuric acid is harmful to aquatic life in very low concentrations and cause corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	D	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
149	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Environmental values	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulphuric acid is harmful to aquatic life in very low concentrations and cause corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
150	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Environmental values	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulphuric acid is harmful to aquatic life in very low concentrations and cause corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
151	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Environmental values	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulphuric acid is harmful to aquatic life in very low concentrations and cause corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
152	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Environmental values	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulphuric acid is harmful to aquatic life in very low concentrations and cause corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
153	Transport of Sulfuric acid	Vehicle incident leading to loss of containment.	Environmental values	Sulfuric acid is miscible with water and its dilution will increase the velocity of downward movement in the soil where it may dissolve the soil material. Sulphuric acid is harmful to aquatic life in very low concentrations and cause corrosion and deterioration of many common materials found in the environment (e.g. steel, limestone). Localised, temporary reduction in soil quality and minor impact to terrestrial flora/ fauna. Temporary but potentially widespread reduction in water quality and moderate acute toxicity to aquatic flora and fauna. Temporary reduction in air quality	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
154	Transport of Diesel	Vehicle incident leading to loss of containment.	Environmental values	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
155	Transport of Diesel	Vehicle incident leading to loss of containment.	Environmental values	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
156	Transport of Diesel	Vehicle incident leading to loss of containment.	Environmental values	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
157	Transport of Diesel	Vehicle incident leading to loss of containment.	Environmental values	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
158	Transport of Diesel	Vehicle incident leading to loss of containment.	Environmental values	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
159	Transport of Diesel	Vehicle incident leading to loss of containment.	Environmental values	If released to soil, Diesel fuel will strongly adsorb. It may biodegrade in water and soil or volatilise from water (half-life of ~5 hrs) and moist soil surfaces. In water adsorption to sediment should be important. If released to the atmosphere, will degrade in vapour phase by reaction with hydroxyl radicals (half-life ~1 day). Toxic to most fish at 2-100 ppm. May be toxic to aquatic organisms and has potential to cause long-term adverse effects in the aquatic environment. Expected to be inherently biodegradable. Low solubility and i.e. expected to migrate from water to the land. Expected to partition to sediment and wastewater solids. Volatile component will partition rapidly to air.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	4	E	H	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
160	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Environmental values	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
161	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Environmental values	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
162	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Environmental values	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
163	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Environmental values	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
164	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Environmental values	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
165	Transport of Sodium hydroxide	Vehicle incident leading to loss of containment.	Environmental values	If released to waterways, alkaline products may change the pH of the waterway. Fish will die if the pH reaches 10-11 (goldfish 10.9, bluegill 10.5). May leach to groundwater with toxic effects on aquatic life as above. Atmosphere - Not expected to reside in the atmosphere. Drops or particles released to atmosphere should be removed by gravity and/or be rained out.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
166	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Environmental values	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10 ⁹ years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution)	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	2	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
167	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Environmental values	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	2	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
168	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Environmental values	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	2	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
169	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Environmental values	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	2	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
170	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Environmental values	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	2	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
171	Transport of Uranium oxide	Vehicle incident leading to loss of containment.	Environmental values	This product is considered harmful to aquatic organisms, and has the potential to cause long-term adverse effects in the aquatic environment. The half-life of uranium-238 is 4.51x 10(9) years. Water - uranium, thorium, radium, radon, lead, and polonium radionuclide concentrations in ground waters have indicated that uranium, thorium, and radium are highly sorbed (i.e. they will adhere to particulate matter and will not be very mobile in solution).	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	2	E	L	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
172	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Environmental values	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
173	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Environmental values	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
174	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Environmental values	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
175	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Environmental values	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
176	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Environmental values	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
177	Transport of ShellSol 2046	Vehicle incident leading to loss of containment.	Environmental values	Shellsol is an aliphatic hydrocarbon, meaning they behave differently in the environment depending on their size. Light aliphatics volatilise rapidly from water (half life - few hours). Bioconcentration should not be significant. Light aliphatics also biodegrade quickly in soil and water, heavy aliphatics biodegrade very slowly. Vapour-phase aliphatics will degrade by reaction with hydroxyl radicals. Expected to be readily biodegradable. Adsorbs to soil and has low mobility. Floats on water.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable during the wet season.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
178	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Environmental values	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
179	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Environmental values	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
180	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Environmental values	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
181	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Environmental values	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
182	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Environmental values	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
183	Transport of Alamine 336	Vehicle incident leading to loss of containment.	Environmental values	Combustible - May evolve toxic gases (carbon/ nitrogen oxides, hydrocarbons) when heated to decomposition. Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment. Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
184	Transport of Quicklime	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 12.6, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
185	Transport of Quicklime	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 12.6, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	D	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
186	Transport of Quicklime	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 12.6, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
187	Transport of Quicklime	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 12.6, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
188	Transport of Quicklime	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 12.6, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
189	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Environmental values	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a big plume, exothermic reaction.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
190	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Environmental values	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a big plume, exothermic reaction.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
191	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Environmental values	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a big plume, exothermic reaction.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
192	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Environmental values	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a big plume, exothermic reaction.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
193	Transport of Ammonia anhydrous	Vehicle incident leading to loss of containment.	Environmental values	Environment - May cause pH changes in aqueous ecological systems. Very toxic to aquatic organisms. Biodegradable, with low mobility in soil, boil off in moisture. Impact would be a 1 - 4% contamination in water. Highly localised impact. A land spill evaporates slowly. In wet season, would result in a big plume, exothermic reaction.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	4	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
194	Transport of Cement	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 11 to 13, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
195	Transport of Cement	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 11 to 13, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	D	L	Assessment basis is a worst credible loss of 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
196	Transport of Cement	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 11 to 13, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
197	Transport of Cement	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 11 to 13, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
198	Transport of Cement	Vehicle incident leading to loss of containment.	Environmental values	Due to its high pH, 11 to 13, a large concentration of this material occurred from improper handling or disposal can be toxic to aquatic life and plants due to acute pH shift.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
199	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Environmental values	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
200	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Environmental values	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
201	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Environmental values	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
202	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Environmental values	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
203	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to loss of containment.	Environmental values	Ammonium nitrate is a plant nutrient and large contamination may result in a loss of vegetation. Ammonium nitrate is of low toxicity to aquatic life and may cause algal blooms in static waters. When released into the soil, ammonium nitrate is not expected to evaporate significantly, but has the potential to leach into ground water	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
204	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Environmental values	Lethal concentration (LC): fish toxicity (357 mg/l); aquatic invertebrates (212 mg/l); aquatic plants (>1.000 mg/l). No data available on bioaccumulation.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
205	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Environmental values	Lethal concentration (LC): fish toxicity (357 mg/l); aquatic invertebrates (212 mg/l); aquatic plants (>1.000 mg/l). No data available on bioaccumulation.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
206	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Environmental values	Lethal concentration (LC): fish toxicity (357 mg/l); aquatic invertebrates (212 mg/l); aquatic plants (>1.000 mg/l). No data available on bioaccumulation.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
207	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Environmental values	Lethal concentration (LC): fish toxicity (357 mg/l); aquatic invertebrates (212 mg/l); aquatic plants (>1.000 mg/l). No data available on bioaccumulation.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
208	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Environmental values	Lethal concentration (LC): fish toxicity (357 mg/l); aquatic invertebrates (212 mg/l); aquatic plants (>1.000 mg/l). No data available on bioaccumulation.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
209	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to loss of containment.	Environmental values	Lethal concentration (LC): fish toxicity (357 mg/l); aquatic invertebrates (212 mg/l); aquatic plants (>1.000 mg/l). No data available on bioaccumulation.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
210	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Environmental values	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Arnhem Hwy: (3) South Alligator River crossing and surrounding floodplains (14 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
211	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Environmental values	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Arnhem Hwy: (4) Wetland areas between Jabiru and Ranger Mine (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
212	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Environmental values	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (5) Nourlangie Creek crossing and surrounding floodplain (10 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
213	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Environmental values	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (6) Jim Jim Creek/Jim Jim Billabong crossing and surrounding floodplain (Yellow Water Wetlands also in vicinity) (4 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
214	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Environmental values	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (7) South Alligator River crossing and surrounding floodplain (1 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
215	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to loss of containment.	Environmental values	In flowing waters, depending on the mixture, there may be a moderate to high toxic effect although data on the ecological effect is not currently available. Immiscible or insoluble in water.	Kakadu Hwy: (8) Mary River crossing and surrounding floodplain (3 km)	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.	World Heritage and National Heritage Properties (Kakadu NP) and Wetlands of International Importance (Kakadu Ramsar site)	C3
216	Transport of Sulfuric acid	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	5	C	C	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
217	Transport of Diesel	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	5	D	C	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
218	Transport of Sodium hydroxide	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
219	Transport of Uranium oxide	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
220	Transport of ShellSol 2046	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
221	Transport of Alamine 336	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
222	Transport of Quicklime	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	5	D	C	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
223	Transport of Ammonia anhydrous	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
224	Transport of Cement	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Cement	5	D	C	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
225	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
226	Transport of Flocculant (Magnafloc 139)	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
227	Transport of Pyrolusite (Manganese oxide (IV) powder)	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
228	Transport of Sand / aggregate	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
229	Transport of Construction materials (various)	Vehicle incident leading to injury / fatality.	Public health and safety	Injury/ loss of life due to traffic accident on public roads	Study area	Refer to Appendix D, for the bowties for the control of Transport of overall Construction materials (various)	5	E	H	Assessment based on worst credible of a fatality event, where 3% of vehicle accidents result in a fatality (based on NT data)		C3
230	Transport of Sulfuric acid	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	Contact with skin will result in severe irritation, or skin burns. Breathing in mists or aerosols may produce respiratory irritation.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Sulfuric acid	3	E	M	Assessment basis is a worst credible scenario equal to loss of 18 kL at any time during the year.		C3
231	Transport of Diesel	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	Slightly irritating to the respiratory system. Breathing of high vapour concentrations may cause central nervous system depression resulting in dizziness, headache and nausea. May cause moderate irritation to the skin.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	2	D	L	Assessment basis of worst credible scenario equal to loss of 36 kL of consumable during the wet season.		C3
232	Transport of ShellSol 2046	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	May cause lung damage if swallowed. Repeated direct exposure may cause skin dryness or cracking.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	2	E	L	Assessment basis of worst credible scenario equal to loss of 9 kL of consumable.		C3
233	Transport of Quicklime	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	Irritating to eyes, respiratory system and skin.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Quicklime	2	D	L	Assessment basis is a worst credible loss of 5 - 10 tonnes.		C3
234	Transport of Ammonia anhydrous	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	Toxic if inhaled. Causes severe skin burns and eye damage. May cause respiratory irritation.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	5	E	H	Assessment basis is a worst credible loss of 23 tonnes as gas.		C3
235	Transport of Alamine 336	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	Direct contact causes skin irritation. Causes serious eye irritation. Rinse cautiously with water for several minutes.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Alamine 336	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.		C3
236	Transport of Cement	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	Irritating to eyes, respiratory system and skin.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Cement	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.		C3
237	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	May evolve toxic gases when heated to decomposition. Oxidising agent supports combustion.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	2	E	L	Assessment basis is a worst credible loss of 10 tonnes.		C3
238	Transport of Flocculant (Magnafloc 139)	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	This product contains no substances classified as hazardous to health or the environment in concentrations which should be taken into account.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Flocculant (Magnafloc 139)	1	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.		C3

Ref. #	Risk source		Environmental Factor (Receptor)	Potential Impact (Change / Effect)	Applicable Location(s)	Current Controls	Current Risk Rating			Assumptions / Comments	Specific Receptors at Applicable Location(s)	Certainty
	Hazard	Event					Consequence	Likelihood	Current Risk			
239	Transport of Pyrolusite (Manganese oxide (IV) powder)	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	No evidence of carcinogenic, mutagenic properties or reproductive effects. Dust inhalation may produce tissue damage, pneumonia. Manganese compounds are generally only slightly absorbed by the gastrointestinal tract.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Pyrolusite (Manganese oxide (IV) powder)	2	E	L	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.		C3
240	Transport of Uranium oxide	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	Radioactive - harmful, absorption of radioactive materials may result in chronic sterility, cancers, teratogenic/mutagenic effects, kidney/liver and blood damage.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Uranium oxide	3	E	M	Assessment basis is an extreme worst credible loss of a single drum of Uranium oxide.		C3
241	Transport of Sodium hydroxide	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	Highly corrosive, has the potential to cause serious adverse health effects.	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Sodium hydroxide	3	E	M	Assessment basis is a worst credible loss of one IBC, equal to 1,000 L.		C3
242	Transport of Sand / aggregate	Injury / fatality from loss of containment associated with a vehicle incident.	Public health and safety	No known direct impact to human health and safety from direct contact with consumable	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Sand / aggregate	1	E	L	Assessment basis is a worst credible loss of 6 t.		C3
243	Transport of Diesel	Fire / explosion from loss of containment associated with a vehicle incident.	Public health and safety	Thermal radiation, blast injury (e.g. ear drum rupture) or indirect effects (injury due to flying debris).	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Diesel	5	E	H	Assessment basis is worst credible of a fatality event as an escalation of a loss of containment (based on FMCSA data).		C3
244	Transport of ShellSol 2046	Fire / explosion from loss of containment associated with a vehicle incident.	Public health and safety	Thermal radiation, blast injury (e.g. ear drum rupture) or indirect effects (injury due to flying debris).	Study area	Refer to Appendix D, for the bowtie for the control of Transport of ShellSol 2046	5	E	H	Assessment basis is worst credible of a fatality event as an escalation of a loss of containment (based on FMCSA data).		C3
245	Transport of Ammonia anhydrous	Fire / explosion from loss of containment associated with a vehicle incident.	Public health and safety	Thermal radiation, blast injury (e.g. ear drum rupture) or indirect effects (injury due to flying debris).	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Ammonia anhydrous	5	E	H	Assessment basis is worst credible of a fatality event as an escalation of a loss of containment (based on FMCSA data).		C3
246	Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	Fire / explosion from loss of containment associated with a vehicle incident.	Public health and safety	Thermal radiation, blast injury (e.g. ear drum rupture) or indirect effects (injury due to flying debris).	Study area	Refer to Appendix D, for the bowtie for the control of Transport of Explosives (ammonium nitrate, ammonium nitrate emulsion)	5	E	H	Assessment basis is worst credible of a fatality event as an escalation of a loss of containment (based on FMCSA data).		C3

Appendix F – Controls Assessment

Management Systems

Contractors engaged in transport of consumables for ERA maintain common systems such as performance, monitoring and auditing systems to provide ongoing assurance that the controls are functioning reliably.

These are typical elements of a comprehensive and integrated management system consistent with recognised systems such as AS 4804 – Occupational Health and Safety Management Systems and ISO 9000 – Quality Management Systems. This is also aligned with AS/NZS ISO 31000 – Risk Management, which outlines that many components of a risk management framework are not unique to risk management activities.

Monitoring and Review

In line with AS/NZ ISO 31000, monitoring and review is conducted to ensure that controls are effective and efficient. As presented in Figure 18, monitoring and review refers to activities that are both frequent and periodic.

Under a risk management framework, the day-to-day processes such as a pre-start check linked to a fault reporting system (ID No. 0009) or GPS based vehicle monitoring (ID No. 0034) involve the greatest level of activity and are intended to provide the most powerful level of assurance.

Periodic review (including post-incident analysis) provides an opportunity to review risks and controls in a manner that facilitates continuous improvement of risk management. Incident data from the ERA SafeSite HSE database reviewed over the most recent 5-year period indicates that a range of actions have been taken by transport carriers to improve risk management. This has included improvements to GPS based vehicle monitoring (ID No. 0034), the driver distress button (ID No. 0080), and site-based emergency response equipment (ID No. 0093).

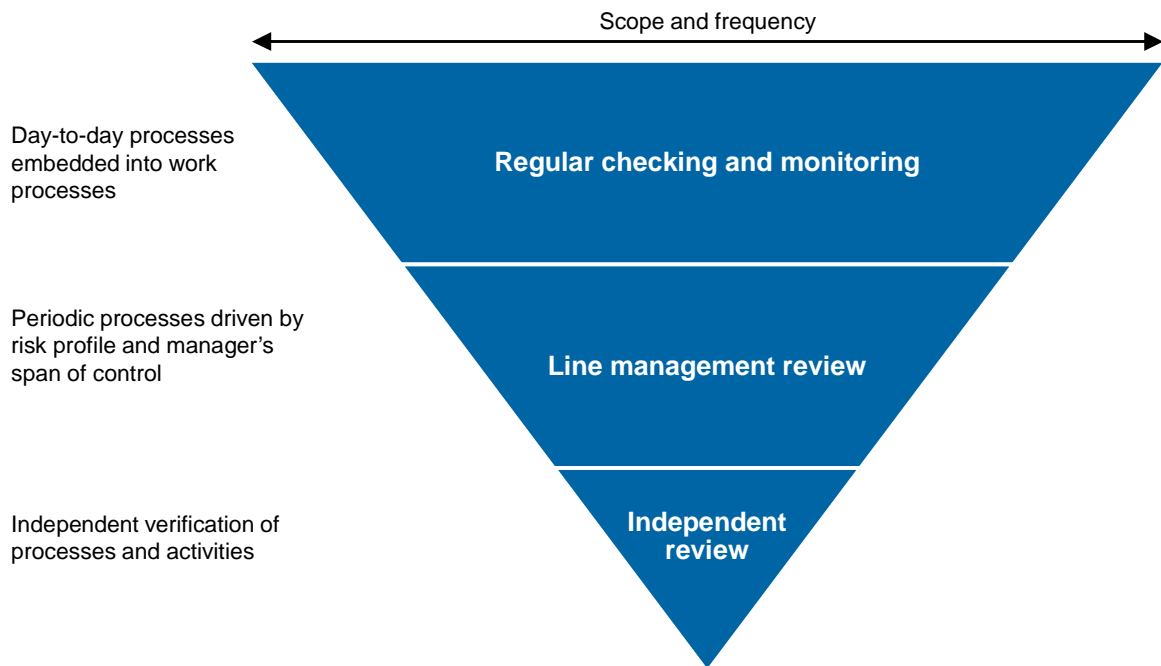


Figure 18 Hierarchy of monitor and review activities (SA/SNZ HB 436)

ERA Pre-qualification

Contractors undertaking transport of consumables for ERA have been subject to pre-qualification evaluations and annual qualification review.

Within the past five years, ERA has declined to engage transport contractors that have been found not to meet required ERA HSE management standards through the pre-qualification evaluation. In the event that a transport contractor does not meet the requirements of the periodic review, the contractor must implement corrective action.

GHD

Level 5, 66 Smith Street Darwin NT 0800

GPO Box 351 Darwin NT 0801

T: (08) 8982 0100 F: (08) 8981 1075 E: drwmail@ghd.com.au

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

G:\43\22105\WP\Rev 5\34447_12May2014.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	C Hall, M Wier & A Holmes	N Conroy	<i>N Conroy</i>	D Clark	<i>D Clark</i>	14/12/13
1	C Hall, M Wier & A Holmes	N Conroy	<i>N Conroy</i>	D Clark	<i>D Clark</i>	04/02/14
2	C Hall, M Wier & A Holmes	N Conroy	<i>N Conroy</i>	D Clark	<i>D Clark</i>	10/03/14
3	C Hall, M Wier & A Holmes	N Conroy	<i>N Conroy</i>	D Clark	<i>D Clark</i>	04/04/2014
4	C Hall, M Wier & A Holmes	N Conroy	<i>N Conroy</i>	D Clark	<i>D Clark</i>	17/04/2014
5	C Hall, M Wier & A Holmes	N Conroy	<i>N Conroy</i>	D Clark	<i>D Clark</i>	12/05/2014

www.ghd.com

