Appendix T

Risk Assessment

URS Australia Pty Ltd

Brisbane

Gladstone Pacific Nickel Limited
Gladstone Nickel Project
Risk Assessment

ModuSpec

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Project Title	GPNL Proposed Nickel Plant Risk Assessment
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Job No.	AUS0352.3
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ABSTRACT

URS were commissioned by Gladstone Pacific (GPNL) to prepare an environmental impact statement (EIS) for the Gladstone Nickel Project, a proposed nickel refinery to be located in an industrial area of Gladstone, Queensland. URS commissioned ModuSpec Australia to undertake a risk assessment of the Gladstone Nickel Project to allow URS to address the health and safety requirements of the EIS.

The main objectives of the risk assessment were to assess the major hazards associated with the Gladstone Nickel Project in accordance with AS/NZS 4360:2004, to identify hazards that have the potential to extend offsite, and to determine if a quantitative risk assessment is necessary in accordance with the terms of reference document

This reports documents the risk assessment.

Key Words: *(e.g. Industry category, study type)*
MINE, EIS, SQRA,

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1. EXECUTIVE SUMMARY

URS were commissioned by Gladstone Pacific (GPNL) to prepare an environmental impact statement (EIS) for the Gladstone Nickel Project, a proposed nickel refinery to be located in an industrial area of Gladstone, Queensland. URS commissioned ModuSpec Australia to undertake a risk assessment of the Gladstone Nickel Project to allow URS to address the health and safety requirements of the EIS.

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The following steps were undertaken:

1. Preliminary work
2. Preliminary hazard identification (HAZID)
3. Workshop review with GPNL and URS project personnel
4. Consequence modelling
5. Finalisation of the risk assessment.

The risks associated with the Gladstone Nickel Project were assessed and found to be generally low. Notable exceptions are the risks associated with the following areas:

- Solvent extraction (organic phase fire – medium risk)
- Ammonia (ammonia release - medium risk)
- Nickel and cobalt reduction areas (ammonia release - medium risk).

Releases of ammonia from the ammonia area have the potential to cause multiple onsite fatalities. The impact of these releases could extend to nearby plant areas and, in the case of vessel failure, the store, car park, workshop and other areas likely to house personnel.

The following major hazards have the potential to extend offsite:

- Release of slurry or saline water from pipelines to/from residue storage facility at Aldoga
- Release of sulphur from sulphuric acid plant stack.
- Release of ammonia from the ammonia storage area.

Only a release of ammonia has the potential for significant offsite impact, however offsite fatalities are considered unlikely as the area is not populated. In particular, ammonia releases do not impact the Orica Yarwun site. On this basis ModuSpec believe that further analysis of the risks from the site in the form of a QRA is not warranted.

To address the potential for onsite fatalities associated with the ammonia area, GPNL should consider implementing further mitigation measures in this area.

2. ACRONYMS AND ABBREVIATIONS

HAZID	Hazard identification
HMS	High magnesium saprolite
LMS	Low magnesium saprolite
PPE	Personal protective equipment
ppm	Parts per million
SLOT DTL	Specified level of toxicity dangerous toxic load

3. INTRODUCTION

URS were commissioned by Gladstone Pacific (GPNL) to prepare an environmental impact statement (EIS) for the Gladstone Nickel Project, a proposed nickel refinery to be located in an industrial area of Gladstone, Queensland. URS commissioned ModuSpec Australia to undertake a risk assessment of the Gladstone Nickel Project to allow URS to address the health and safety requirements of the EIS.

This reports documents the risk assessment undertaken.

3.1. Objectives and Scope

The main objectives of the risk assessment were to assess the major hazards associated with the Gladstone Nickel Project in accordance with AS/NZS 4360:2004, to identify hazards that have the potential to extend offsite, and to determine if a quantitative risk assessment is necessary in accordance with the terms of reference document [1].

A major hazard was defined as a large scale situation that has the potential to have a significant impact on people, environment or property i.e. events that have the potential to lead to:

- Fatalities
- Wide spread environmental damage
- Large cost property loss.

Excluded from the assessment were localised events such as:

- Occupational health and safety events e.g. falls
- Events associated with maintenance e.g. isolation and confined space hazards.

The risk assessment only covered operation of the Gladstone Nickel Project. Further, the risk assessment only covered the following parts of the facility:

- Nickel refinery (leach)
- Nickel refinery (metal)
- Pipelines to/from the residue storage facility at Aldoga
- Residue storage facility at Aldoga
- Associated facilities.

Transfer of materials to/from the Port of Gladstone, port operations, pipelines from Marlborough, and the Marlborough Mine and Coorumburra Beneficiation Plant were not included.

Finally, all hazards were assessed qualitatively/semi-quantitatively. No quantitative risk assessment was undertaken.

4. METHODOLOGY

The methodology used has five main steps:
1. Preliminary work
2. Preliminary hazard identification (HAZID)
3. Workshop review with GPNL and URS project personnel
4. Consequence modelling
5. Finalisation of the risk assessment.

This methodology is consistent with the guidelines set out in AS/NZS 4360:2004 Risk Management. The steps are outlined below:

4.1. Preliminary work

Project information was reviewed to familiarise with the Gladstone Nickel Project. This information included:
- Process description
- Process flow diagrams
- Plant layout and location drawings
- Reagents and emissions data.

4.2. Preliminary Hazard Identification (HAZID)

Credible major hazards, causes, consequences and controls were identified using a structured review process as follows:
1. Divide the refinery into smaller areas
2. Identify significant equipment and hazardous materials handled in each area
3. Discuss the processes employed in each area
4. Brainstorm credible major hazards
5. Identify causes, consequences and existing controls for each major hazard.

The HAZID involved ModuSpec personnel experienced in nickel refinery risk assessment. The HAZID was supplemented by a review of risk assessments of similar facilities.

4.3. Workshop Review

The preliminary HAZID work was reviewed during a one-day workshop involving ModuSpec, GPNL and URS project personnel. Steps 2 to 5 above were repeated for each area to:
- Ensure all major hazards identified during the preliminary HAZID were relevant and correct
- Identify additional major hazards, causes, consequences and controls.

An initial risk assessment was also performed for each major hazard using a risk matrix developed from AS/NZS 4360:2004 (refer to Appendix A). A risk matrix is a tool that allows the risk associated with a hazard to be quickly approximated. This is done by:

1. Estimating how often the major hazard is expected to occur (likelihood).
2. Estimating the impact on people, environment and property when the major hazard occurs (consequence).
3. Reading the associated risk from the matrix where the likelihood row and consequence column intersect.

The matrix has been developed to ensure that major hazards that occur often and have the greatest impact are considered to be very high risk. Those that occur infrequently and have little impact are considered to be low risk. A sliding scale is applied between these two extremes. Refer to Appendix A for more information on how the risk levels were determined.

During the risk assessment, the role of existing controls was considered in determining likelihood and consequence. The most credible consequence associated with each major hazard was determined and the risk assessed based on that outcome.

4.3.1. Workshop Participants

The participants involved in the workshop are listed in Table 4-1.

Table 4-1: Workshop Participants

Name	Position	Company
Paul Doyle	Senior Environmental Engineer	URS
Lisa Park	Senior Process Engineer	GPNL
Rod Cox	Editor/Study Coordinator	GPNL
John Miller	Logistics Consultant	GPNL
Colin Moffat	Facilitator	ModuSpec Australia
Sharon Hurree	Technical Secretary	ModuSpec Australia

4.4. Consequence Modelling

To improve the estimation of consequences and to identify consequences that extend offsite, consequence modelling was conducted for each major hazard that involved significant release of vapour/gas. Representative scenarios were created from the data collected during the workshop and from subsequent data collected from project personnel.

For flammable releases, consequence modelling determined the extent of the lower flammable limit (LFL) cloud at 1 m above ground level. Fatalities are considered likely within this contour should the cloud be ignited.

For toxic releases, consequence modelling determined the extent of the specified level of toxicity dangerous toxic load (SLOT DTL) cloud at 1 m above ground level. This equates roughly to the toxic dose that will result in 1% mortality for the exposed population (i.e. LD_{01}) [2]. Fatalities are considered possible within this contour. The SLOT DTL values used are presented in Table 4-2.

Table 4-2: Toxicity Data

Material	SLOT DTL	Unit
Ammonia	3.78×10^{08}	$ppm^2.min$
Hydrogen sulphide	2.00×10^{12}	$ppm^4.min$
Sulphur trioxide	1.30×10^{04}	$ppm^2.min$

4.5. Finalisation of the Risk Assessment

The initial risk assessment made during the workshop was reviewed. The consequence modelling results were used to verify or update the assessment accordingly.

5. RESULTS

The refinery was divided into 31 areas. Twenty-seven major hazards were identified and consequence modelling completed for 15 representative scenarios.

The results are presented as follows:

- Risk assessment results for the 31 areas and 27 major hazards are summarised in Table 5-1 and detailed in Appendix B
- Consequence modelling data and assumptions for the 15 representative scenarios are presented in Appendix C
- Major hazard consequences that have the potential to extend offsite are summarised in Table 5-2. Consequence modelling results for the ammonia cases are presented in Appendix D.

Table 5-1: Results of Risk Assessment

Area No.	Area	Hazard No.	Major hazard	Consequence	Likelihood	Risk
1	Ore Receival and Slurry Storage	-	None	-	-	-
2	High Pressure Acid Leach	-	None	-	-	-
3	Saprolite Neutralisation	-	None	-	-	-
4	Counter Current Decantation	-	None	-	-	-
5	Solution Neutralisation	1	Release of hydrogen sulphide	3	E	L
6	Sulphide Precipitation	2	Release of hydrogen sulphide	3	D	L
7	Final Neutralisation	-	None	-	-	-
8	Pipelines to/from Residue Storage Facility at Aldoga	3	Release to environment	4	E	L
9	Residue Storage Facility at Aldoga	4	Release to environment	2	E	L
10	Sulphide Leach	-	None	-	-	-
11	Impurity Removal	5	Release of ammonia	2	C	L
12	Solvent extraction	6	Release of organic phase	4	D	M
		7	Mixer/settler fire	4	D	M
13	Nickel Reduction	8	Release of ammonia	3	C	M
		9	Release of hydrogen	4	E	L
14	Nickel Metal Handling	10	Furnace explosion	2	D	L
		11	Release of natural gas	1	C	L
		12	Release of hydrogen	2	C	L
15	Cobalt Reduction	13	Release of ammonia	3	C	M
		14	Release of hydrogen	4	E	L
16	Cobalt Metal Handling	15	Furnace explosion	2	D	L
		16	Release of natural gas	1	C	L
		17	Release of hydrogen	2	C	L
17	End Solution Stripping	18	Release of hydrogen sulphide	2	E	L
18	Ammonium Sulphate Plant	-	None	-	-	
19	Sulphuric Acid Plant	19	Release of sulphuric acid	2	C	L
		20	Release of sulphur, sulphur dioxide/trioxide	4	E	L

Area No.	Area	Hazard No.	Major hazard	Consequence	Likelihood	Risk
20	Hydrogen Plant	21	Release of hydrogen	4	E	L
		22	Release of natural gas	4	E	L
21	Hydrogen Sulphide Plant	23	Release of hydrogen sulphide	3	D	L
		24	Release of hydrogen	3	E	L
22	Air Separation Plant	-	None	-	-	-
23	Limestone Plant	-	None	-	-	-
24	Lime Plant	-	None	-	-	-
25	Flocculants	-	None	-	-	-
26	Filter aid	-	None	-	-	-
27	Ammonia	25	Release of ammonia	5	E	M
28	Polyacrylic Acid	-	None	-	-	-
29	Caustic Soda	--	None	-	-	-
30	Power station	26	Release of natural gas	4	E	L
		27	Gas-fired boiler explosion	4	E	L
31	Waste water treatment plant	-	None	-	-	-

Table 5-2: Major Hazard Consequences with Potential to Extend Offsite.

Area No.	Area	Hazard No.	Major hazard	Cause	Likelihood	Scenario	Consequence Description	Consequence	Risk
8	Pipelines to/from Residue Storage Facility at Aldoga	3	Release to environment	Pipe/flange failure Vehicle impact	E	-	Release of slurry/saline water into pipeline corridor/offsite, short term impact	4	L
19	Sulphuric Acid Plant	20	Release of sulphur, sulphur dioxide/ trioxide	Lose temperature in converter during start up, sublime plant leading to sulphur deposition and sulphur, sulphur dioxide/trioxide release via stack	E	-	Potential sulphur deposition offsite, short term impact on plants. Note: Sulphur dioxide/trioxide cloud does not extend offsite	4	L
27	Ammonia	25	Release of ammonia	Vessel failure (100mm)	E	15	SLOT DTL extends 800m	5	M
				Pump or unloading arm failure (80mm)	E	7	SLOT DTL extends 145m.	4	L

6. DISCUSSION

The risks associated with the Gladstone Nickel Project are generally low. All areas were assessed as having a “low” risk with the exception of the solvent extraction, nickel reduction/cobalt reduction, and ammonia areas. These were assessed as having a “medium” risk.

The risk associated with the solvent extraction area is due to the potential for significant equipment damage by fire. The following controls are important in controlling risk in this area:

- Condition monitoring
- Ignition control (anti-static clothing, diesel vehicles, hot work permits)
- Fire water/foam systems.

The risk associated with the ammonia area is driven by the large inventory of toxic liquefied gas. The following controls are important in controlling risk in this area:

- Condition monitoring
- Excess flow valves on storage vessels, road tankers and supply pipeline
- Ammonia storage area is located away from the main facility
- Supply pipeline is buried.

Driver PPE also makes a contribution.

While the risk associated with the ammonia area was assessed to be medium, it should be noted that releases of ammonia from this area have the potential to cause multiple onsite fatalities. The impact of these releases could extend to nearby plant areas and, in the case of vessel failure, the store, car park, workshop and other areas likely to house personnel.

The risks associated with the nickel and cobalt reduction areas are greater than the other areas using ammonia (i.e. impurity removal) due to larger pipe diameters from which there would be higher release rates in the case of a failure. Once again, condition monitoring is important in controlling risk in these areas.

For areas with hydrogen sulphide, the following controls are particularly important in contributing to the low risk:

- Hydrogen sulphide detectors/alarms/shutdown
- Administrative controls for personnel in the hydrogen sulphide area.

Other controls that make a contribution are:

- Man down radios
- Hydrogen sulphide PPE (personal monitor, escape respirator)
- Additional hydrogen sulphide respirators throughout the wider plant.

The results show that most major hazards do not extend offsite and, of those that do, only a release of ammonia has the potential to be significant. However offsite fatalities are considered unlikely as the surrounding area is not populated. In particular, this release does not impact the Orica Yarwun site. Further, pump or unloading arm failures only just extend offsite. Based on these results, ModuSpec believe that further analysis of the risks from the site in the form of a QRA is not warranted.

7. CONCLUSION AND RECOMMENDATIONS

The risks associated with the Gladstone Nickel Project were assessed and found to be generally low. Notable exceptions are the risks associated with the following areas:

- Solvent extraction (organic phase fire – medium risk)
- Ammonia (ammonia release - medium risk)
- Nickel and cobalt reduction areas (ammonia release - medium risk).

Releases of ammonia from the ammonia area have the potential to cause multiple onsite fatalities. The impact of these releases could extend to nearby plant areas and, in the case of vessel failure, the store, car park, workshop and other areas likely to house personnel.

The following major hazards have the potential to extend offsite:

- Release of slurry or saline water from pipelines to/from residue storage facility at Aldoga
- Release of sulphur from sulphuric acid plant stack.
- Release of ammonia from the ammonia storage area.

Only a release of ammonia has the potential for significant offsite impact, however offsite fatalities are considered unlikely as the area is not populated. In particular, ammonia releases do not impact the Orica Yarwun site. On this basis ModuSpec believe a QRA is not warranted.

To address the potential for onsite fatalities associated with the ammonia area, GPNL should consider implementing further mitigation measures in this area.

8. REFERENCES

1 Email from P. Doyle, (Senior Environmental Engineer, URS Australia Pty Ltd) to C. Moffat (Principal Risk Engineer, ModuSpec Australia Pty Ltd) "Re: Scope of work and workshop date" with attached document (pages 37 – 39 of draft terms of reference), 9th March 2006.

2 Health and Safety Executive, "Assessment of the Dangerous Toxic Load (DTL) for Specified Level of Toxicity (SLOT) and Significant Likelihood of Death (SLOD)", http://www.hse.gov.uk/hid/haztox.htm, 26th November 2003.

APPENDIX A: Risk Matrix

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1. INTRODUCTION

This appendix documents the risk matrix used during the risk assessment. The matrix was developed from HB 436:2004 [1]. This document is a companion document to AS/NZS4360:2004 and provides guidelines on determining risk matrices.

It should be noted that HB 436:2004 only provides generic guidance; matrices must be developed to suit the individual risk assessment being undertaken.

The following was considered when developing the matrix:

- 5 x 5 matrix are commonly used
- Major hazards occur infrequently so likelihood axis needs to extend well beyond "once in the life of the facility"
- Major hazards can result in significant consequences or much reduced consequences if there are sufficient controls in place. Therefore the consequence axis needs to include a full range of consequences e.g. from fatalities to no injury.
- The community is more concerned about offsite fatalities and releases to the environment than onsite fatalities and releases
- Each major hazard is area based e.g. release of hydrogen sulphide from sulphide precipitation area. Risk levels need to reflect this. Further, risk levels (L, M, H, VH) should change gradually across the matrix. Defining points include:
    - Single onsite fatality risk is considered very high (VH) if it occurs more than once every 10 years, high (H) if it occurs once in the life of the facility
    - Lowest consequence risk is considered to be low (L) in all but the most frequent of events.

2. RISK MATRIX

	Consequence				
Likelihood	**1**	**2**	**3**	**4**	**5**
A	M	H	VH	VH	VH
B	L	M	H	VH	VH
C	L	L	M	H	VH
D	L	L	L	M	H
E	L	L	L	L	M

VH = Very high, H = High, M = Medium, L = Low

Figure 1: Risk matrix

Table 2-1: Frequency Guidelines.

Level	Frequency p.a.	Description 1	Description 2	Description 3	Description 4
A	>1	More than once per year		Highly likely	Repeated incidents
B	0.1 - 1	Once every 10 years to once per year		Likely	Isolated incidents
C	0.01 - 0.1	Once every 100 years to once every 10 years	Approx once in the life of the facility	Possible	
D	0.001 - 0.01	Once every 1000 years to once every 100 years	Approx once in the life of 10 facilities	Unlikely	
E	<0.001	Less than once every 1000 years		Rare	

Table 2-2: Consequence Guidelines.

Level	Health & Safety		Environment	Property $AUS
	Onsite	**Offsite**		
1	No treatment required	No impact	Insignificant release	<10K
2	First aid required	No treatment required but activity interrupted eg traffic congestion	Onsite release contained	10K - 100K
3	Medical treatment required, one person disabled	First aid required	Onsite release with large clean up	100K - 1M
4	Single fatality, small number of people disabled	Medical treatment required, one person disabled	Offsite release with short term impact	1M - 10M
5	Multiple fatalities, large number of people disabled	Single fatality, small number of people disabled	Offsite release with long term impact	10M+

3. REFERENCES

1 Australian standards, HB 436:2004, "Risk Management Guidelines Companion to AS/NZS 4360:2004", Standards Australia and Standards New Zealand, 2004.

APPENDIX B: Risk Assessment Results

1. INTRODUCTION

This appendix presents the results of the risk assessment. The following is presented for each plant area:

(1) Area details including:
- Equipment list
- Brief process description
- List of major hazards identified.
- Comments on other hazards discussed

(2) For each major hazard in the plant area, hazard details including:
- Possible causes
- Potential consequences
- Existing controls
- Consequence, likelihood and risk for the hazard
- Comments on the determination of consequence and likelihood.

AREA DETAILS

Area No: 1 **Date:** 27-Mar-2006
Area: Ore Receival and Slurry Storage
Equipment List: Screening and scrubbing equipment
Gravity treatment equipment
Ball milling
Thickeners
Storage tanks
Process: (1) Thickening and storage of LMS and HMS slurries from Marlborough Mine / Coorumburra Benificiation Plant
(2) Beneficiation (to produce LMS and HMS slurries), thickening and storage of imported ore

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	No hazardous material present.	0

AREA DETAILS

Area No: 2 **Date:** 27-Mar-2006
Area: High Pressure Acid Leach
Equipment List: Heater vessels
Pumps
Autoclaves
Flash vessels
Scrubbers
Process: Leach nickel and cobalt from LMS slurry using concentrated sulphuric acid at around 255°C and 4.8 MPa

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	Discussed: (1) Leak from autoclave. Considered unlikely as vessel is dual wall with leak detection in between walls. If leak did occur, not considered a major hazard. (2) Acid line failure outside autoclave. Would result in steam/acid release and depressuring of autoclave. Not considered a major hazard. (3) Acid dip tube failure inside autoclave. Considered unlikely due to tube construction. If failure did occur, would result in fresh acid layer on top of the slurry, pitting of titanium liner. If liner fails, would result in immediate leak to environment (as outside wall is carbon steel). If leak did occur, not considered a major hazard.	0

AREA DETAILS

Area No:	3	**Date:**	27-Mar-2006
Area:	Saprolite Neutralisation		
Equipment List:	Neutralisation tanks Pumps		
Process:	Leach nickel and cobalt from HMS ore slurry, neutralise most of free sulphuric acid		

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	Lined tanks, not pressurised. Vent gas is mainly steam with small amount of acidic liquor.	0

AREA DETAILS

Area No: 4 **Date:** 27-Mar-2006
Area: Counter Current Decantation
Equipment List: Thickeners
Process: Recover nickel and cobalt solution from barren leach solids

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	The thickeners are not covered, contents are mildly acidic	0

AREA DETAILS

Area No: 5 **Date:** 27-Mar-2006
Area: Solution Neutralisation
Equipment List: Pipe reactor
Neutralisation tanks
Thickeners
Cyclones
Belt filters
Repulp tanks
Process: (1) Pre-reduction of chrome 6 and ferric
(2) Neutralise residual free sulphuric acid in CCD overflow and precipitate impurities

Major Hazards Identified	Comments	Hazard Sheets
Release of hydrogen sulphide		1
No other major hazards identified	Discussed carbon dioxide leak. Could result in carbon dioxide cloud, not considered a major hazard.	0

AREA DETAILS

Area No:	6	**Date:**	27-Mar-2006
Area:	Sulphide Precipitation		
Equipment List:	Plate heaters Direct contact heater Sulphide precipitation autoclaves Flash Vessel Cyclones Thickeners Pumps Barren solution filters Belt filters Plate and frame filter Repulp tanks Bagging equipment Tower mill		
Process:	Recover nickel and cobalt as mixed sulphide solids, filter mixed sulphide and pack as required.		

Major Hazards Identified	Comments	Hazard Sheets
Release of hydrogen sulphide		1
No other major hazards identified	Discussed: (1) Leak from autoclave. Considered unlikely as vessel is lined with hard scale. (2) Leak from vent system. Hydrogen sulphide concentration 10-50 ppm, not considered a major hazard. (3) Leak of hydrogen peroxide. Will support combustion, no adjacent equipment, not considered a major hazard.	0

AREA DETAILS

Area No:	7	**Date:**	27-Mar-2006
Area:	Final Neutralisation		
Equipment List:	Neutralisation tanks Pumps		
Process:	Neutralise excess barren liquor for transfer to residue storage area		

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	No hazardous material present.	0

AREA DETAILS

Area No: 8 **Date:** 27-Mar-2006
Area: Pipelines to and from Residue Storage Facility at Aldoga
Equipment List: Pipelines (500 mm diameter, 25 km each way approx.)
Process: Transfer neutralised slurry from Yarwun refinery to residue storage facility
Transfer barren liquor from residue storage facility to Yarwun refinery
Estimated pressure at pump discharge = 2500 kPa minimum

Major Hazards Identified	Comments	Hazard Sheets
Release to environment		1
No other major hazards identified		0

AREA DETAILS

Area No: 9 **Date:** 27-Mar-2006
Area: Residue Storage Facility at Aldoga
Equipment List: Thickeners
Pumps
Residue storage area
Barren liquor tanks
Process: Slurry pumped into thickeners, underflow distributed into residue storage area feed system, overflow into barren liquor tanks. Residue storage area decant pumped into barren liquor tanks

Major Hazards Identified	Comments	Hazard Sheets
Release to environment		1
No other major hazards identified		0

AREA DETAILS

Area No:	10	**Date:**	27-Mar-2006
Area:	Sulphide Leach		
Equipment List:	Sulphide leach autoclave Flash vessel		
Process:	Re-dissolve mixed sulphide solids to produce an impure nickel/cobalt sulphate solution with low acidity and impurity content. Sulphide converted to sulphate via oxygen injection.		

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	Discussed: (1) Autoclave fire/explosion due to excess oxygen. Considered not credible. (2) Vessel corrosion due to loss of oxygen (reducing conditions). Release due to vessel corrosion not considered a major hazard.	0

AREA DETAILS

Area No: 11 **Date:** 27-Mar-2006
Area: Impurity Removal
Equipment List: Impurity removal tanks
Filters
Pumps
Process: Precipitate iron and aluminium from the sulphide leach solution by neutralising the acid with aqueous ammonia. Liquid anhydrous ammonia is supplied to this area via 1" pipe and is mixed with water to form the aqua ammonia.

Major Hazards Identified	Comments	Hazard Sheets
Release of ammonia		1
No other major hazard identified		0

AREA DETAILS

Area No: 12 **Date:** 27-Mar-2006
Area: Solvent extraction
Equipment List: Mixer/settlers
Heat exchangers
Equipment containing organic phase: pumps, tanks, activated carbon filtration vessel
Process: Remove zinc and separate the cobalt from nickel. Mixer/settlers are constructed from fibre glass lined steel and are elevated. Organic phase equipment is at ground level.

Major Hazards Identified	Comments	Hazard Sheets
Release of organic phase		1
Mixer/settler fire		1
No other major hazards identified		0

AREA DETAILS

Area No: 13 **Date:** 27-Mar-2006
Area: Nickel Reduction
Equipment List: Mixer
Heat exchanger
Autoclave
Flash vessel
Pumps
Process: Recover nickel from solution as metallic powder.

Major Hazards Identified	Comments	Hazard Sheets
Release of ammonia		1
Release of hydrogen		1
No other major hazards identified	Discussed autoclave explosion due to development of flammable mixture and ignition. Considered not credible.	0

AREA DETAILS

Area No: 14 **Date:** 27-Mar-2006
Area: Nickel Metal Handling
Equipment List: Pan filters
Dryer
Pipe chain conveyors
Bucket elevators
Hammer mill
Conveyors
Briquette machine
Sinter furnace
Dust collection system
Packaging equipment
Hoppers
Process: Form nickel powder into briquettes, treat in sinter furnace to drive off residual impurities

Major Hazards Identified	Comments	Hazard Sheets
Furnace explosion		1
Release of natural gas		1
Release of hydrogen		1
No other major hazards identified	Discussed explosion in dust collection system. Not considered a major hazard.	0

AREA DETAILS

Area No: 15 **Date:** 27-Mar-2006
Area: Cobalt Reduction
Equipment List: Mixer
Heat exchanger
Autoclave
Flash vessel
Pumps
Process: Recover cobalt from solution as metallic powder

Major Hazards Identified	Comments	Hazard Sheets
Release of ammonia		1
Release of hydrogen		1
No other major hazards identified	Discussed autoclave explosion due to development of flammable mixture and ignition. Considered not credible.	0

AREA DETAILS

Area No: 16 **Date:** 27-Mar-2006
Area: Cobalt Metal Handling
Equipment List: Pan filters
Dryer
Pipe chain conveyors
Bucket elevators
Hammer mill
Conveyors
Briquette machine
Sinter furnace
Dust collection system
Packaging equipment
Hoppers
Process: Form cobalt powder into briquettes, then treat in sinter furnace to drive off residual impurities

Major Hazards Identified	Comments	Hazard Sheets
Furnace explosion		1
Release of natural gas		1
Release of hydrogen		1
No other major hazards identified	Discussed explosion in dust collection system. Not considered a major hazard.	0

AREA DETAILS

Area No: 17 **Date:** 27-Mar-2006
Area: End Solution Stripping
Equipment List: Reaction vessel
Polishing filters
Thickener
Process: Precipitate residual nickel and cobalt from spent hydrogen reduction end solutions using hydrogen sulphide

Major Hazards Identified	Comments	Hazard Sheets
Release of hydrogen sulphide		1
No other major hazards identified		0

AREA DETAILS

Area No: 18 **Date:** 27-Mar-2006
Area: Ammonium Sulphate Plant
Equipment List: Crystallizers
Pumps
Conveyors
Storage shed
Process: Produce ammonium sulphate for refinery use and for sale as by-product

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	Vapour is predominantly water	0

AREA DETAILS

Area No: 19 **Date:** 27-Mar-2006
Area: Sulphuric Acid Plant
Equipment List: Sulphur stock pile
Conveyor
Sulphur melter
Lime silo
Pumps
Sulphur filter
Molten sulphur tank
Sulphur burner
Waste heat boilers
Converter
Packed columns
Superheaters
Economisers
Heat exchangers
Sulphuric acid storage tank
Process: Sulphur is burnt in air to form sulphur dioxide, combined with oxygen in air to form sulphur trixoide (in the presence of a catalyst) and then combined with water to form a solution containing sulphuric acid (98.5%). Other outputs are: high pressure superheated steam, low pressure saturated steam for the refinery, molten sulphur for the hydrogen sulphide plant.

Major Hazards Identified	Comments	Hazard Sheets
Release of sulphuric acid		1
Release of sulphur, sulphur dioxide / trioxide		1
No other major hazards identified	Discussed: (1) Sulphur fire. Known to occur but is localised and not considered a major hazard. (2) Sulphur dust explosion. Considered unlikely as stock pile in open area.	0

AREA DETAILS

Area No:	20	**Date:**	27-Mar-2006
Area:	Hydrogen Plant		
Equipment List:	Reformer Steam production facility Hydrogen storage		
Process:	Provide hydrogen by steam reforming natural gas		

Major Hazards Identified	Comments	Hazard Sheets
Release of hydrogen	10t hydrogen inventory	1
Release of natural gas		1
No other major hazards identified		0

AREA DETAILS

Area No:	21	**Date:**	27-Mar-2006
Area:	Hydrogen Sulphide Plant		
Equipment List:	Sulphur circulating pumps Heat exchangers Reactors (packed column with heaters) Knock-out pots (for sulphur)		
Process:	Produce hydrogen sulphide by passing hydrogen gas through molten sulphur at elevated temperature		

Major Hazards Identified	Comments	Hazard Sheets
Release of hydrogen sulphide		1
Release of hydrogen		1
No other major hazards identified	Discussed overpressure of hydrogen sulphide plant due to excessive upstream pressure, i.e. hydrogen plant. Hydrogen sulphide plant fitted with pressure safety valves, not considered an issue.	0

AREA DETAILS

Area No: 22 **Date:** 27-Mar-2006
Area: Air Separation Plant
Equipment List: Main air compressor
Molecular sieves
Distillation column
Liquid nitrogen storage
Liquid oxygen storage
Process: Cryogenic plant producing high pressure oxygen gas, plant and instrument air, high and low pressure nitrogen

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	Discussed: (1) 20t liquid oxygen inventory. Supports combustion, can saturate clothing, gas can auto-ignite debris in lines. Not considered a major hazard. (2) 10t liquid nitrogen inventory. Can be an asphyxiant. Not considered a major hazard.	0

AREA DETAILS

Area No: 23 **Date:** 27-Mar-2006
Area: Limestone Plant
Equipment List: Grinding mills
Cyclones
Thickeners
Process: Grind limestone, thicken to produce neutralisation slurry

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	No hazardous material present.	0

AREA DETAILS

Area No: 24 **Date:** 27-Mar-2006
Area: Lime Plant
Equipment List: Lime slaker
Process: Produce milk of lime neutralisation slurry

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	No hazardous material present.	0

AREA DETAILS

Area No:	25	**Date:**	27-Mar-2006
Area:	Flocculants		
Equipment List:	Storage silo Mixing vessel Distribution pumps		
Process:	Mix flocculant for use throughout refinery		

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	No hazardous material present.	0

AREA DETAILS

Area No: 26 **Date:** 27-Mar-2006
Area: Filter aid
Equipment List: Bag handling facility
Mixing vessel
Distribution pump
Process: Mix filter aid for use throughout refinery

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	No hazardous material present.	0

AREA DETAILS

Area No: 27 **Date:** 27-Mar-2006
Area: Ammonia
Equipment List: Bullets
Unloading arms
Pumps
Process: Storage of anhydrous ammonia in bullets. Ammonia is delivered by road tanker.

Major Hazards Identified	Comments	Hazard Sheets
Release of ammonia		1
No other major hazards identified		0

AREA DETAILS

Area No: 28 **Date:** 27-Mar-2006
Area: Polyacrylic Acid
Equipment List: Bag storage vessel
Pumps
Dilution tank
Process: Storage of polyacrylic acid. Acid is delivered to site by road tankers.

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified		0

AREA DETAILS

Area No: 29 **Date:** 27-Mar-2006
Area: Caustic Soda
Equipment List: Tank
Pumps
Process: Storage of caustic soda

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified		0

AREA DETAILS

Area No:	30	**Date:**	27-Mar-2006
Area:	Power station		
Equipment List:	Boilers Steam turbo-generators Pumps De-aerator		
Process:	Produce electricity from high pressure steam. Produce steam when sulphuric acid plant offline.		

Major Hazards Identified	Comments	Hazard Sheets
Release of natural gas		1
Gas-fired boiler explosion		1
No other major hazards identified		0

AREA DETAILS

Area No: 31 **Date:** 27-Mar-2006
Area: Waste water treatment plant
Equipment List: Demineralisation plant
Process: Produce filtered water and demineralised water, direct waste water to final neutralisation area

Major Hazards Identified	Comments	Hazard Sheets
No major hazards identified	No hazardous material present.	0

APPENDIX C: Consequence Modelling Data

TABLE OF CONTENTS

1. INTRODUCTION

This appendix documents the modelling data and assumptions used during the consequence modelling. Justifications and references have been included where applicable.

2. CONSEQUENCE MODELLING SCENARIOS

Table 2-1, Table 2-2 and Table 2-3 contain the modelling data used for each major hazard. This data was either collected during the workshop or received post workshop [1].

Table 2-1: Modelling Data

No.	Scenario	Material	Temp. (°C)	Pressure (kPa)	Release elevation (m)	Pipe length (m)	Hole size (mm)	Type	Detect & isolate time (s)	Max Release (kg/s)	Hazard No.
1	Release from pipework	H_2S	110	300	2	150	25	Leak	300	1.62	1
							80	Rupture	120		
2	Release from pipework	H_2S	110	800	10	150	25	Leak	300	1.62	2, 23
							100	Rupture	120		
3	Release from pipework	H_2S	110	800	7	300	25	Leak	300	1.62	18
							40	Rupture	120		
4	Release from pipework	NH_3	50	2100	7	150	25	Leak	300		5
							40	Rupture	300		
5	Release from pipework	NH_3	50	2100	7	100	25	Leak	300		8, 13
							50	Rupture	300		
6	Release from pipework	NH_3	50	2100	7	100	25	Leak	300		25
							80	Rupture	300		
7	Release from pump/unloading arm	NH_3	50	2100	1	20	25	Leak	120		25
							80	Rupture	20		
8	Release from supply pipeline	NH_3	30	1600	1	1500	25	Leak	300		25
							80	Rupture	20		
9	Release from pipework	H_2	80	5000	7	500	25	Leak	300	0.25	9, 14, 21
							100	Rupture	300		
10	Release from pipework	H_2	80	900	7	400	25	Leak	120	0.25	24
							50	Rupture	120		
11	Release from pipework	CH_4	30	4000	7	600	25	Leak	300		22, 26
							100	Rupture	300		

Table 2-2: Modelling Data for Release of Sulphur Dioxide / Trioxide

No.	Scenario	Material	Temp. (^oC)	Pressure (KPa)	Release elevation (m)	Pipe length (m)	Hole size (mm)	Type	Time to stop flow (min)	Hazard No
12	Release from reactor	H_2S	140	900	20	N/A	100	Leak	2	23
13	Release from ductwork	10% SO_3 90% N_2	300	20	15	N/A	100	Leak	10	20
14	Release from stack	10% SO_3 90% N_2	75	10	80	80	2000	Rupture	10	20

Table 2-3: Modelling Data for Release of Ammonia from Bullet

No	Scenario	Material	Temp. (^oC)	Pressure (KPa)	Release elevation (m)	Inventory (tonnes)	Hole size (mm)	Type	Hazard No
15	Release from vessel	NH_3	50	2100	1.5	80	25	Leak	25
							100	Rupture	

3. WEATHER DATA

Consolidated weather data used in the modelling was supplied by URS [2]. The data was consolidated to provide average weather conditions for the consequence modelling and are presented in Table 3-1. The relative humidity was taken from the Bureau of Meteorology and averaged at 0.67 [3].

Table 3-1: Weather Details

Stability	Average wind speed (m/s)	Average temperature (°C)
B	2.17	26
C	2.65	24
D	3.36	24
F	1.39	20

Solar flux values were estimated and are presented in Table 3-2.

Table 3-2: Solar Flux

Stability	Solar flux (kW/m^2)
B	1
C	0.6
D	0.3
F	0

4. ASSUMPTIONS

The following general assumptions were made for the consequence modelling:

1. Release rate was assumed to be constant throughout the duration of the release.
2. Release rates were reduced where applicable to account for pipe friction.
3. The inventory between isolation valves and the release point was ignored when less than 10% of the total release mass before isolation.
4. The surface roughness was assumed to be 1 m.

5. REFERENCES

1 Various emails:

- Email from Lisa J Park (Senior Process Engineer, GPNL) to Colin Moffat (Principal Risk Engineer, Moduspec Australia Pty Ltd), "Re: H_2S leak at solution neutralisation", 11 April 2006.
- Email from Lisa J Park (Senior Process Engineer, GPNL) to Colin Moffat (Principal Risk Engineer, Moduspec Australia Pty Ltd), "Re: Additional modelling data", 11 April 2006.
- Email from Lisa J Park (Senior Process Engineer, GPNL) to Colin Moffat (Principal Risk Engineer, Moduspec Australia Pty Ltd), "Fw: Consequence modelling data", 9 April 2006.
- Email from Paul Doyle (Senior Environmental Engineer, URS Australia Pty Ltd) to Colin Moffat (Principal Risk Engineer, Moduspec Australia Pty Ltd), "Re: Consequence modelling data ", 8 April 2006.

2 Email from Abbie Brooke (Senior Environmental Engineer, URS Australia Pty Ltd) to Colin Moffat (Principal Risk Engineer, Moduspec Australia Pty Ltd), "Fw: GPNL Weather Information ", 18 April 2006.

3 Bureau of Meteorology, "Averages for Gladstone Post Office", http://www.bom.gov.au/climate/averages/tables/cw_039041.shtml, 19th April 2004.

APPENDIX D: Selected Consequence Modelling Results

TABLE OF CONTENTS

1. INTRODUCTION

This appendix presents the consequence modelling results for ammonia releases that have the potential to extend offsite.

2. CONSEQUENCE MODELLING RESULTS

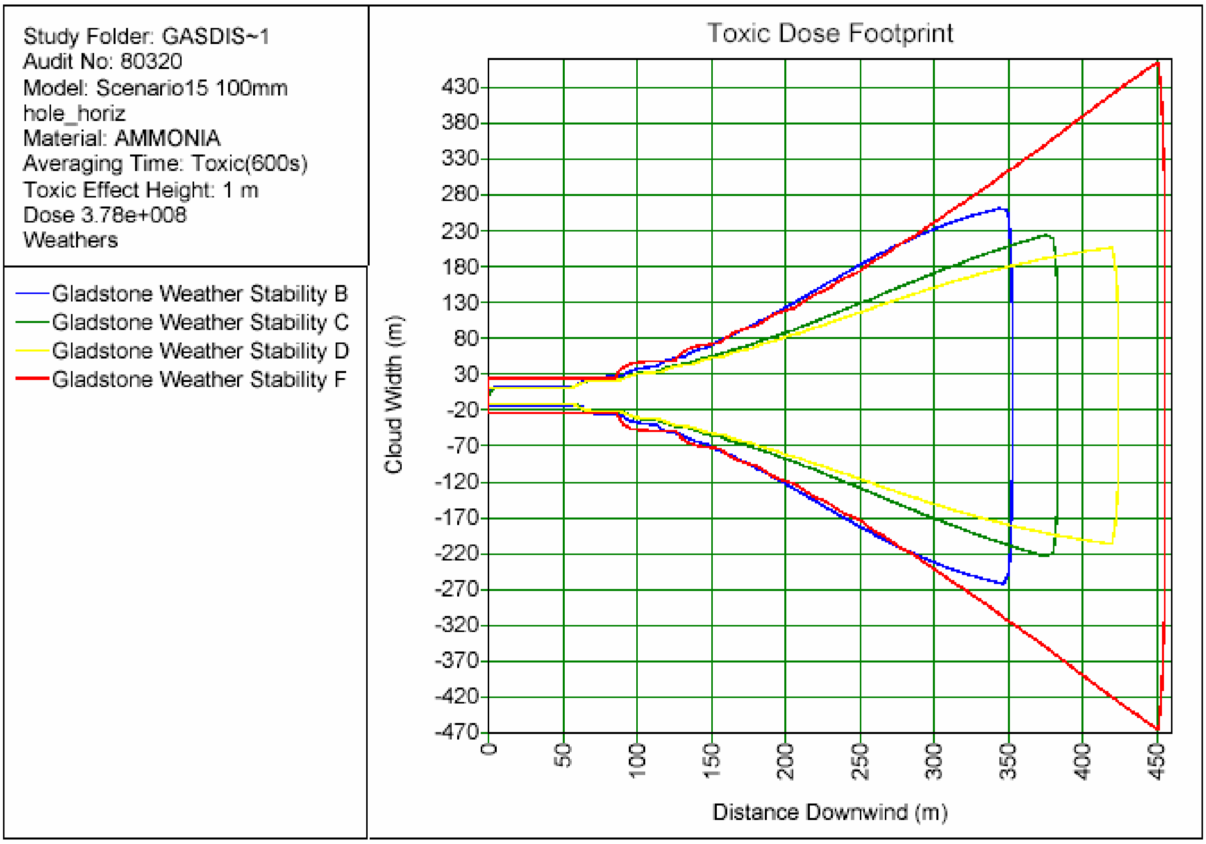

Figure 1: Scenario 15 Ammonia Vessel Failure (100mm) SLOT DTL Contours.

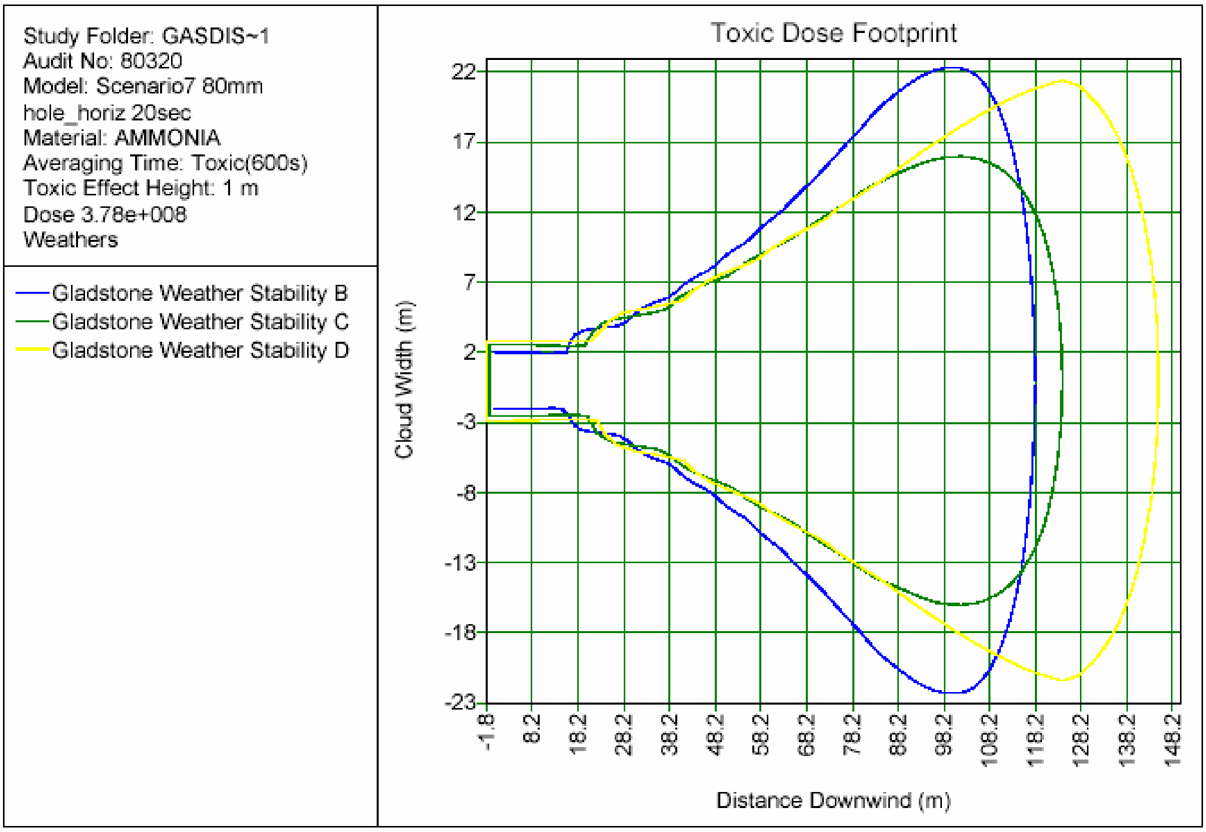

Figure 2: Scenario 7 Ammonia Pump/Unloading Arm Failure (80mm) SLOT DTL Contours.