15.1 Introduction

The Department of Planning's *Multi Level Risk Assessment Guidelines*, provide a guide to the level of hazard assessment necessary for a development being considered. In accordance with these guidelines and as part of the Environmental Assessment, a quantitative Preliminary Hazard Analysis (PHA) was prepared for the Facilities and the associated infrastructure (including the gas pipeline).

The following sections summarise the results of the PHA undertaken by Planager Risk Management Consulting. The full report for the gas pipeline is presented in **Appendix H**. The PHA for each of the Facilities and their cumulative impacts is summarised in this chapter and presented in full in each *Project Application*.

The assessment has been carried in accordance with the Department of Planning's Hazardous Industry Planning Advisory Paper (HIPAP) No 6 (*Guidelines for Hazard Analysis*) and HIPAP No 4 (*Risk Criteria for Land Use Planning*). These documents describe the methodology and the criteria to be used in PHAs for major "potentially hazardous" development.

In accordance with Department of Planning's HIPAP No. 3 *(Environmental Risk Impact Assessment Guidelines),* the safety assessment process would continue throughout the design, construction and commissioning of the Facilities to refine and update the outcome of the development approval / environmental risk process.

15.2 Methodology

The process for PHA follows a number of steps which provide assurances that risks imposed by a development upon surrounding land uses would be within acceptable limits and that this would continue to be the case throughout the life of the development.

The aims of the PHA are to:

- identify and analyse the hazards and risks associated with all processes involved with the handling and transporting of potentially hazardous material which form part of the Project;
- assess the findings against the risk criteria currently in use by Department of Planning; and
- identify opportunities for risk reduction, and make recommendations as appropriate.

The risk assessment has quantitatively determined the risk of fatality and injury to the public associated with the handling and processing of potentially hazardous material at the proposed development.

There are five stages in risk assessment, each of which is described below.

15.2.1 Stage 1 - Hazard Identification

The hazard identification includes a review of potential hazards associated with all dangerous and hazardous goods to be processed, used and handled at the power station and associated gas pipelines and facilities. The hazard identification includes a comprehensive identification of possible causes of potential incidents and their consequences to public safety and the environment, as well as an outline of the proposed operational and organisational safety controls required to mitigate the likelihood of the hazardous events from occurring.

The tasks involved in the hazard identification for the proposed Facilities included a review of all relevant data and information to highlight specific areas of potential concern and points of discussion, including drafting up of preliminary hazard identification (HAZID) word diagram. The HAZID word diagram was then reviewed and completed in a workshop which included people with operational, engineering and risk assessment expertise. The review takes into account both random and systematic errors, and gives emphasis not only to technical requirements, but also to the management of the safety activities and the competence of people involved in them.

The final hazard identification word diagram is presented in **Appendix H** for the gas pipeline and in the respective *Project Applications* for the Facilities.

15.2.2 Stage 2 - Consequence and Effect Analysis

The consequences of identified hazards are assessed using current techniques for risk assessment. Well established and recognised correlations between exposure and effect on people are used to calculate impacts.

15.2.3 Stage 3 - Frequency Analysis

For incidents with significant effects, whether on people, property or the biophysical environment, the incident frequency is estimated based on historical data. A probabilistic approach to the failure of vessels and pipes is used to develop frequency data on potentially hazardous incidents.

15.2.4 Stage 4 - Quantitative Risk Analysis

The combination of the probability of an outcome, such as injury or death, combined with the frequency of an event gives the risk from the event. In order to assess the merit of the proposal, it is necessary to calculate the risk at a number of locations so that the overall impact can be assessed. The risk for each incident is calculated according to:

Risk = Consequence x Frequency

Total risk is obtained by adding together the results from the risk calculations for each incident, i.e. the total risk is the sum of the risk calculated for each scenario.

The results of the risk analysis are presented in three forms discussed below.

Individual Fatality Risk

Individual Fatality Risk is the likelihood (or frequency) of fatality to notional individuals at locations around the Facility, as a result of any of the postulated fire and explosion events. The units for individual risk are probability (of fatality) per million per year. Typically, the result of individual risk calculations is shown in the form of risk contours overlaid on a map of the development area.

Injury and irritation risk

Injury and irritation risk, i.e. the likelihood of injury to individuals at locations around the Facility as a result of the same scenarios used to calculate individual fatality risk.

Societal risk

Societal risk takes into account the number of people exposed to risk. Whereas individual risk is concerned with the risk of fatality to a (notional) person at a particular location (person 'most at risk', i.e. outdoors), societal risk considers the likelihood of actual fatalities among any of the people exposed to the hazard. Societal risk is presented as so called *f-N curves*, showing the frequency of events (f) resulting in N or more fatalities. To determine societal risk, it is necessary to quantify the population within each zone of risk surrounding the Facilities. By combining the risk results with the population data, a societal risk curve can be produced.

The risk results are then assessed against the guidelines adopted by the Department of Planning.

15.2.5 Stage 5 - Risk reduction

Where possible, risk reduction measures are identified throughout the course of the study in the form of recommendations.

15.2.6 Individual Risk Criteria

The individual fatality risk is the probability of fatality to a person or the Facilities at a particular point. It is usually expressed as chances per million per year (pmpy). It is assumed that the person will be at the point of interest 24 hours per day for the whole year. By convention in NSW, no mitigation is allowed, i.e. any possible evasive action that could be taken by a person exposed to a hazardous event, e.g. by walking out of a toxic cloud or a heat radiation. The assessment of fatality, incident propagation and injury risk would include all components contributing to the total risk, i.e. fire and explosion.

The Department of Planning uses a set of guidelines on acceptable levels or individual risk which are in line with the criteria used elsewhere in the world. These guidelines are published in the Hazardous Industry Planning Advisory Paper No. 4: *Risk Criteria for Land Use Safety Planning*.

15.2.7 Societal Risk Criteria

Societal risk is concerned with the potential for an incident to coincide in time and space with a human population. Societal risk takes into account the potential for an incident to cause multiple fatalities.

Therefore, two components are relevant, namely:

- The number of people exposed in an incident, and
- The frequency of exposing a particular number of people.

The societal risk criteria specify levels of societal risk which must not be exceeded by a particular activity. The same criteria are currently used for existing and new developments. Two societal risk criteria are used, defining acceptable and unacceptable levels of risk due to a particular activity. The criteria are represented on the societal risk (f-N) curve as two parallel lines. Three zones are thus defined:

1. Above the unacceptable/intolerable limit the societal risk is not acceptable whatever the perceived benefits of the development.
2. The area between the unacceptable and the acceptable limits is known as the ALARP (as low as reasonably possible) region. Risk reduction may be required for potential incidents in this area.
3. Below the acceptable limit, the societal risk level is negligible regardless of the perceived value of the activity.

15.3 Assessment of Potential Impacts – Common Shared Works

The hazards associated with the bulk earthworks and with the construction and operation of the access road and transmission line (s) were considered minor and would be managed in the relevant construction environmental management plans and operational environmental management plans.

15.4 Assessment of Potential Impacts – Facilities

A summary of the individual and cumulative impacts of two Facilities is presented in this section. The detailed assessments are presented in the respective Project Applications.

The qualitative and quantitative analysis for the Facilities concluded:

Individual Risk of Fatality: The risk of fatality at the nearest residential area is well below the criterion for new installations of one chance in a million per year (1×10^{-6}/yr) and remains within the site boundary.

It follows that the 10×10^{-6} per year fatality risk contour (relevant for open spaces) remains well within the site boundaries and does not encroach into any open spaces. The criterion for open spaces is therefore satisfied.

It also follows that the 50×10^{-6} per year fatality risk contour (relevant for industry and business) remains well within the site boundaries and does not encroach into any business or industrial zones. The criterion for industrial and business zoning is therefore satisfied.

Injury Risk: The 50×10^{-6} per year injury risk contour remains well within the Facility boundaries. The criterion for injury risk is therefore satisfied.

Propagation Risk: The 50×10^{-6} per year propagation risk contour remains well within the Facility boundaries. The criterion for propagation risk is therefore satisfied.

Cumulative Risk: The analysis showed that, in terms of cumulative risk impact, there is no increase in the risk associated with each proposed Facility (Delta Electricity and EnergyAustralia) from having two Facilities on the Marulan Site at their proposed location.

Societal Risk: As the risk of fatality does not extend anywhere outside the respective Delta Electricity and EnergyAustralia Facility site boundaries, it is considered that the proposed development does not have a significant impact on societal risk.

Transport of Dangerous Goods: The risk associated with the transport of dangerous goods and potentially hazardous material to the Facilities is very low. Even though many of the assumptions in this PHA are conservative, the results show that the risk associated with this development is very low. The most stringent risk criteria, as required by the Department of Planning, are adhered to.

15.5 Assessment of Potential Impacts – Gas Pipeline

The main hazard associated with the Gas Pipeline is related to a leak of flammable natural gas.

This would generally only have the potential to cause injury or damage if there was ignition, which resulted in a fire or explosion incident. The factors involved are:

- The pipelines, vessel or equipment must fail in a particular mode causing a release. There are several possible causes of failure, with the main ones being corrosion and damage by external agencies;
- The released material must come into contact with a source of ignition. In some cases this may be heat or sparks generated by mechanical damage while in others, the possible ignition source could include non-flame proof equipment, vehicles, or flames some distance from the release;
- Depending on the release conditions, including the mass of flammable material involved and how rapidly it ignited, the results may be a localised fire (for example a jet fire), a flash fire or an explosion of the vapour cloud formed through the release;
- Finally, for there to be a risk, people must be present within the harmful range (consequence distance) of the fire or explosion. How close the people are will determine whether any injuries or fatalities result. Environmental damage from gas fire incidents are generally associated with a failure to control the fire water used.

Natural gas is a buoyant, flammable gas which is lighter than air (relative density of 0.6). On release into the open, the non-ignited gas tends to disperse rapidly at altitude. Ignition at the point of release is possible, in which case the gas would burn as a jet (or torch) flame. On release in an enclosed area (for example within the gas turbine housing) an explosion or a flash fire is possible.

The gas is non-toxic, posing only an asphyxiation hazard. Due to its buoyancy, any release of credible proportions from operations of this scale in the open would not present an asphyxiation hazard. With standard confined space entry procedures and appropriate security arrangements to prevent unauthorised access to any of the facilities the risk associated with asphyxiation from natural gas should be minimal.

Locally, the pressure of the compressed gas may be hazardous in case of an uncontrolled release. These hazards, while of importance for people working at the Facilities, do not have implications beyond the immediate location of the release unless the released gas is ignited. Therefore, the risk associated with non-ignited compressed gas does not form part of the scope of the present risk assessment. This potential risk would however need to be closely managed through job safety analysis (JSA) and/or other risk assessment practices used by management and operators of the Facilities (in accordance with NSW Occupational Health and Safety Act and its associated legislation).

A total of six potentially hazardous scenarios were identified for the proposed gas delivery pipeline, as listed in **Table 15-1** below.

Table 15-1 Summary of Identified Hazards

Number	Hazardous Event Potential
1	Leak of natural gas from the gas supply pipeline
2	Flooding results in damage to piping and equipment
3	Land subsidence or mining activity results in pipeline damage
4	Aircraft crash results in damage to pipeline resulting in hazardous releases
5	Damage to pipeline through terrorism / vandalism
6	Neighbouring fire

Consequence Analysis

This initial outflow rates estimated for natural gas releases are shown in **Table 15-2**

Table 15-2 Release Rates

Hole Size			
Small leak (5mm)	Intermediate leak (25 mm)	Massive leak (100 mm)	Full bore (guillotine)
0.22 kg/s	5.5	88 kg/s	551 kg/s (first few seconds)

The distance from the source of the fire to the specified heat radiation for jet fire scenarios is listed in **Table 15-3** below.

Table 15-3 Heat Radiation from Jet Fires

Hole size	Distance to Heat radiation (metres)		
	4.7 kW/m^2	12.5 kW/m^2	23.5 kW/m^2
Small leak (5mm)	5	3	3
Intermediate leak (25 mm)	25	15	12
Massive leak (100 mm)	105	65	50
Full bore (guillotine)	260	160	115

Frequency Analysis

The equipment failures and associated frequencies are presented in **Table 15-4**.

Table 15-4 Equipment Failures and Associated Frequencies

Type of Failure	Failure Rate (pmpy)
GAS SUPPLY PIPELINES (>100mm NB; 9.7 mm pipe thickness)	
<20 mm hole – steel pipeline	0.027 / m
<80 mm hole – steel pipeline	0.076 / m
Guillotine fracture (full bore) – steel pipeline	0.0007 / m

15.5.1 Summary of Impacts

The quantitative analysis for the Gas Pipeline showed that:

Individual Risk of Fatality: The risk of fatality associated with the gas delivery pipeline is well below the criterion for new installations of one chance in a million per year (1 x 10^{-6}/yr). The 1 x 10^{-6}/yr individual fatality risk for the pipeline is contained well within the pipeline easement.

It follows that the risk of fatality at the nearest open space and the nearest industrial area are also well below the criterion of ten and fifty chances per million years respectively (10 x 10^{-6}/yr and 50 x 10^{-6}/yr) and are contained within the pipeline easement.

Injury Risk: The risk of injury at the nearest residential area is well below the criterion for new installations of fifty chances per million years (50 x 10^{-6} per year).

Propagation Risk: The risk of propagation of an incident at the gas delivery pipeline does not encroach into any other industrial areas and is well below the criterion of fifty chances per million years (50 x 10^{-6} per year).

Societal Risk: The risk of fatality does not extend anywhere close to any residential area and is well within the criterion for business / industrial areas. It is therefore considered that the proposed pipeline does not have a significant impact on societal risk.

15.6 Mitigation Measures

A summary of the mitigation measures in terms of hazard is provided **Table 15-5**. The phase of implementation is indicated in the table by *Cons* – Construction *Ops* – Operation, Design and Planning.

Table 15-5 Summary of Mitigation Measures

Mitigation Measures	Implementation of mitigation measure		
	Common Shared Works	Facilities	Gas Pipeline
In accordance with Department of Planning's HIPAP No. 3 *(Environmental Risk Impact Assessment Guidelines),* the safety assessment process would continue throughout the design, construction and commissioning of the Facility to refine and update the outcome of the development approval / environmental risk process.		✓ (Design & Ops.)	
An assessment of the safety management system implemented and used at the site, specifically as it applies to the proposed hazardous materials handling, pipelining and storages, would be conducted within the first year of operation.		✓ (Ops.)	
Leak detection equipment would be used in areas where high risk natural gas piping is used (high likelihood of leak and/or confined locations).		✓ (Design & Ops.)	

Mitigation Measures	Implementation of mitigation measure		
	Common Shared Works	Facilities	Gas Pipeline
The detailed design of the turbine housing and associated equipments would clearly outline to basis of safety used to ensure that explosive situations do not arise (the risk is rendered negligible). Reference should be made to European ATEX Directive and the UK HSE PM84 or other guidance / regulation of equivalent safety.		✓ (Design)	
Fire protection inside the turbine housing would be determined, including use of explosion panels and use of fire retardant material.		✓ (Design)	
Installation of an automatic valve at site boundary which would isolate natural gas supply to the site in case of a major leak at one of the natural gas pipes on site. The reliability of this automatic valve to close on demand is set as 95% (SIL1). A major leak is regarded as one which results in a mass flow through the hole in the pipe of 5 kg/s or more.		✓ (Design)	
An assessment of the safety management system as relevant to the gas delivery pipeline would be conducted within the first year of operation.			✓ (Ops.)