

Appendix H Preliminary Hazard Analysis



Marulan Gas Turbine Facility

Environmental Assessment

PROJECT APPLICATION

VOLUME 2

APPENDICES

August 2008

PRELIMINARY HAZARD ANALYSIS OF DELTA ELECTRICITY'S GAS TURBINE FACILITY AT MARULAN

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Document Number: URS\07-B108A
Revision C

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14 May 2008

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Preliminary Hazard Analysis of Delta Electricity's Gas Turbine Facility at Marulan

Acknowledgment

The author would like to thank the teams at Delta Electricity and URS Australia for their assistance in preparing this report.

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B	13/02/2008	Draft for comments on technical details	Karin Nilsson	Tim Jones (Worley Parsons)	Nicole Brewer (URS)
C	14/05/2008	Final Report	Karin Nilsson	Emre Cetin (Delta Electricity)	Nicole Brewer (URS)

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EXECUTIVE SUMMARY

E1 Introduction

To meet the rising demand for electricity in NSW, Delta Electricity is proposing to build and operate a Power Station at a Marulan Site approximately 12km north of the village of Marulan.

Due principally to the nature and quantities of natural gas to be utilised as fuel, the Delta Electricity Facility is classified as potentially hazardous. There are also minor quantities of lubricating & transformer oils and chemicals which are addressed in this PHA.

The objective of this PHA is to present the hazards and risks associated with the proposed Delta Electricity Facility. Through the evaluation of likelihood and consequence of the major hazards, the risks to the community associated with Delta Electricity Facility may be estimated and compared to Department of Planning risk criteria.

The aim of the PHA is to:

- Identify and analyse the acute hazards and risks associated with all processes involved with the handling and transporting of potentially hazardous material which form part of the new development;
- Assess the findings against the risk criteria currently in use by NSW Department of Planning;
- 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.

The report assesses the risks from the following facilities:

- The Delta Electricity Facility.
- The effect on risk of the Delta Electricity Facility of the proposed neighbouring EnergyAustralia Facility.

The methodology for the PHA is well established in NSW. The assessment has been carried as per the Hazardous Industry Advisory Paper (HIPAP) No 4, Risk Criteria for Land Use Planning and in accordance with HIPAP No 6, Guidelines for Hazard Analysis. These documents describe the methodology and the criteria to be used in PHAs as currently required by Planning NSW for major *potentially hazardous* development.

The risk assessment technique involves the following general steps:

- Identification of the hazards associated with the proposed project, including those which may potentially injure people off-site or damage the off-site environment;

- Identification of the proposed safeguards to mitigate the likelihood and consequences of the hazardous events;
- Estimation of the magnitude of the consequences of these incidents;
- Where the consequences may affect the land uses outside the Facility's boundary, estimation of the probability with which these incidents may occur;
- Estimation of the risk by combining the frequency of the event occurring with the probability of an undesired consequence;
- Comparison of the risk estimated with the guidelines and criteria relevant to the proposal.

E2 Results

The main hazard associated with the proposed project is associated with the handling of natural gas, which is a flammable gas held under pressure.

Hazards may arise in fixed plant, storage, and pipelines. The failure modes assessed in the PHA derived from historical failures of similar facilities and equipment. For the facilities which form part of the development, the predominant mode in which a hazardous incident may be generated is associated with a leak. 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:

- Failure must occur causing a release. There are several possible causes of failure, with the main ones being corrosion and damage to the equipment 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 material involved and how rapidly it is ignited, the results may be a localised fire (for example a so called 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.

E3 Risk Assessment and Conclusions

The qualitative and quantitative analysis showed that:

- 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 ($1 \times 10^{-6}/\text{yr}$) and remains within the Delta Electricity Facility boundaries.
- It follows that the 10×10^{-6} per year fatality risk contour (relevant for open spaces) remains well within the Delta Electricity Facility 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 Delta Electricity Facility boundaries and does not encroach into any business or industrial zones. The criterion for industrial and business zoning is therefore satisfied.
- The 50×10^{-6} per year injury and propagation risk contours remain well within the Delta Electricity Facility boundaries. The criteria for injury and propagation risks are therefore satisfied.
- The relevant risk contours from the two neighbouring power station facilities do not encroach on each other. In terms of cumulative risk, the risk associated with the one power station is not increased by having a second power station in its vicinity.

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

The risk associated with the transport of dangerous goods and potentially hazardous material to the Delta Electricity Facility is very low.

E4 Recommendations

The risk assessment carried out in this study assumed that the Delta Electricity Facility will be operated with appropriate consideration to safety and safety management at all stages.

The following recommendations emphasise the assumptions made in this risk assessment. The recommendations are listed in the order in which they were listed in the study.

- **Recommendation 1:** 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.
- **Recommendation 2:** It is recommended 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, is be conducted within the first year of operation.
- **Recommendation 3:** Leak detection equipment to be used in areas where high risk natural gas piping is used (high likelihood of leak and/or confined locations).
- **Recommendation 4:** The detailed design of the gas turbine enclosure and associated equipment should clearly outline the 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 (Reference 8) and the UK HSE PM84 (Reference 9) or other guidance / regulation of equivalent safety.

- **Recommendation 5:** Fire protection inside the gas turbine enclosure to be determined, including use of explosion panels and use of fire retardant material.
- **Recommendation 6:** 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. In this risk assessment, 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.

GLOSSARY

HAZID	Hazard Identification
HAZOP	Hazard and Operability Study
HIPAP	Hazardous Industry Planning Advisory Paper
HSE	Health and Safety Executive (UK)
IBC	Intermediate Bulk Container
LFL	Lower Flammable Limit
MAOP	Maximum Allowable Operating Pressure
MPa	Mega Pascal (unit for pressure)
MSDS	Material Safety Data Sheet
MW	Mega Watt (unit for energy output)
NG	Natural gas
NOx	Nitrogen oxides
OH&S	Occupational Health and Safety
PHA	Preliminary Hazard Analysis
SCADA	Supervisory Control and Data Acquisition
SIL	Safety Integrity Level

REPORT

1 INTRODUCTION

1.1 BACKGROUND

To meet the rising demand for electricity in NSW, Delta Electricity is proposing to build and operate a Power Station at a Marulan Site approximately 12km north of the village of Marulan.

Due to the potentially hazardous nature of hazardous materials, the Delta Electricity Facility itself is classified as potentially hazardous.

As one element of the planning approval process, the NSW Department of Planning requires a Preliminary Hazard Analysis (PHA) to be prepared in accordance with the requirements of Hazardous Industry Planning Advisory Paper ((HIPAP) No. 6: *Guidelines for Hazard Analysis* (Ref 1) and for the risk to be evaluated and compared with their risk criteria, as specified in their HIPAP No. 4: *Risk Criteria for Landuse Planning* (Ref 2).

Three separate PHAs have been prepared, as follows:

- *Preliminary Hazard Analysis of Delta Electricity's Gas Turbine Facility at Marulan*, NSW, Planager Pty Ltd, March 2008 (i.e. the present report).
- *Preliminary Hazard Analysis of EnergyAustralia's Gas Turbine Facility at Marulan*, NSW, Planager Pty Ltd, March 2008 (Ref 3).
- *Report Risk Assessment of Natural Gas Delivery Pipeline to Delta Electricity and EnergyAustralia Facilities at Marulan*, NSW, Planager Pty Ltd, March 2008 (Ref 4).

This document forms an appendix to the Environmental Assessment and provides details of the PHA undertaken for the proposed Delta Electricity Facility.

1.2 SCOPE AND AIM OF STUDY

The objective of this PHA is to present the hazards and risks associated with:

- The Delta Electricity Facility.
- Potential for domino effects between the Delta Electricity Facility and neighbouring proposed EnergyAustralia Facility.

Through the evaluation of likelihood and consequence of the major hazards, the risks to the community associated with proposed Delta Electricity Facility may be estimated and compared to Department of Planning risk criteria.

The scope of this report includes the following:

- Systematic identification and documentation of the major hazards, based on the information supplied and relevant experience with similar processes;

- Establishment of the consequence of each identified hazard and determination as to their offsite effects. This process is generally qualitative, with relevant quantitative calculations/modelling being completed where necessary;
- Where offsite effects are identified, the frequency of occurrence is estimated based on historical data. If such data is unavailable, assumptions and qualitative discussions are presented;
- Determination of the acceptability (or otherwise) risk by comparison of the qualitative or quantitative assessment of the identified risks with the criteria specified in the NSW Department of Planning HIPAP No. 4 (Ref 2); and
- Identification of risk reduction measures as deemed necessary.

At the time this PHA was conducted, design of the Delta Electricity Facility was in its preliminary stages. Detailed plant information was therefore not available for review. In situations where such information could impact on the PHA, assumptions have been made. These assumptions are intentionally conservative and have been stated in the report.

As a result of this conservatism, the results of the PHA are also inherently conservative, and this should be noted in their interpretation and application beyond the scope of this work.

2 SITE AND PROCESS DESCRIPTION

2.1 SITE LOCATION AND SURROUNDING LAND USES

The Marulan Site is located on Canyonleigh Road, Brayton, approximately 12 km northwest of Marulan.

The Marulan Site is 19.6 km from the Marulan Highway turnoff and 10.3 km from the Canyonleigh-Brayton Road turnoff.

The location of the Delta Electricity Facility within the Marulan Site would be within an envelope of approximately 27 ha. A location map is presented in Figure 1. An overview of the Marulan Site layout and the indicative layout and location of the proposed EnergyAustralia Facility in relation to the Delta Electricity Facility is presented in Figure 2 below.

The land parcels which would be affected by the development are Lot 18 DP 1056592 and Lot 2341 DP 62834. The Marulan Site comprises approximately 116 ha of pasture land and dry eucalypt forest. Overall the Marulan Site slopes gently west towards the river. In order to avoid the potential for flood impact and minimise the disturbance of archaeological deposits, the ground level of the Marulan Site would be set at 605m. This allows for the plant to be set back approximately 150m from the Wollondilly River. The Marulan Site is located in the Upper Lachlan local government area. Access to the Marulan Site would be via Canyonleigh Road.

Developments immediately surrounding the Marulan Site are predominantly rural enterprises on large and medium size holdings, and smaller rural home sites of about 10 hectares. The TransGrid switchyard is located about 800 m to the southeast of the Marulan Site.

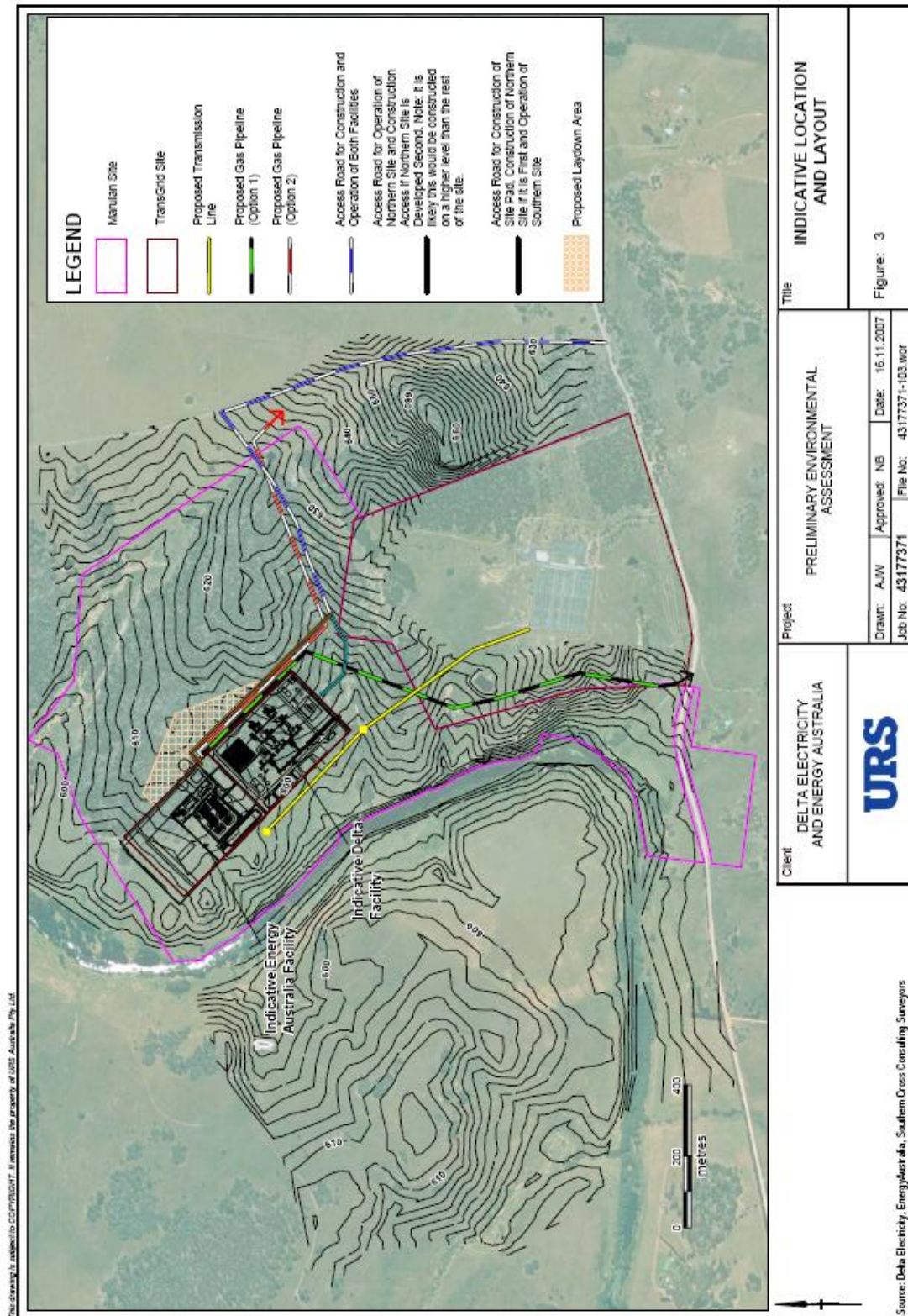
Internal roads would be constructed on the Marulan Site to facilitate the movement of construction and operation traffic to the Delta Electricity Facility.

It is understood that the Planning Certificate issued by Upper Lachlan Shire Council under Section 149(5) of the *Environmental Planning and Assessment Act 1979* for the Marulan Site (prior to its purchase and subdivision as the Marulan Site), stated that the Marulan Site was not proclaimed to be a mine subsidence district within the meaning of section 15 of the *Mine Subsidence Compensation Act 1961*.

Figure 1 – Site Location



Figure 2 – Site Location and Layout With Neighbouring Facility



2.2 POWER STATIONS - OPERATION

2.2.1 Gas Turbine Facility – General Information

Gas Turbines, or more correctly Combustion Turbines, are rotary machines that compress air, combust fuel to heat that compressed air, and then extract energy from the flow of heated air. A combustion turbine thus largely consists of an upstream air compressor coupled to a downstream turbine, and a combustion chamber in-between.

Energy is extracted in the form of mechanical power, to drive the compressor and to drive the electricity generator.

2.2.2 Gas Turbine Power Station - Delta Electricity

The implementation of the proposed Delta Electricity would be carried out in two stages:

- **Stage 1:** Two open cycle gas turbines with a total capacity in the range of 250 to 350 MW operating as a peaking plant (about 5% of the time on an annual basis). Each turbine would have a capacity in the order of 125 to 175 MW depending on final equipment selected.
- **Stage 2:** Conversion to combined cycle facility to generate electricity for intermediate/base load electricity demand, operating on a continuous basis (about 90% of the time on an annual basis). The proposed capacity of the Stage 2 combined cycle plant is in the range of 400 to 450 MW.

The gas turbines would be of proven technology, comprising small compact generators placed inside soundproof enclosures. Normal operation of the gas turbines would use natural gas for fuel. These units would be capable of being operated individually or in conjunction, providing a high level of reliability of power.

The operating regime for the Delta Electricity Facility is anticipated to be as per Table 1 below:

Table 1 – Operating Regimes Delta Electricity Facility

	Stage 1 Peaking Plant	Stage 2 Combined Cycle
Typical average operating hours per annum	500 hr	7884 h
Total typical average generation per annum	150 GWh	3500 GWh
Typical maximum generation in any single year	Depends on hours of operation. Max 600 GWh	3900 GWh Depends on hours of operation. Max 8760GWh
Typical average gas consumption (in Joules)	3.6 TJ/hr (or 2PJ per annum)	115 TJ/hr (or 32PJ per annum)

	Stage 1 Peaking Plant	Stage 2 Combined Cycle
Typical average gas consumption (in tonnes)	70 tonnes/hr (or 35,000 tonnes per annum assuming 500 hour operation)	70 tonnes/hr (or 552,000 tonnes per annum assuming 7884 hour operation)
Distillate consumption (if required for emergency diesel generator) of up to	2 tonnes per annum with up to 4 tonnes of distillate at the Facility at any one time.	2 tonnes per annum with up to 4 tonnes of distillate at the Facility at any one time.

2.3 LAYOUT OF THE DELTA ELECTRICITY FACILITY

2.3.1 Gas Turbine Facility - Delta Electricity

The preliminary layout of the Delta Electricity Facility is presented in Figures 4 and 5 below. These layouts show the supply gas pipeline easement entering the Marulan Site, the location of the gas receiving facility and the main entrance to the Delta Electricity Facility itself.

The location of the EnergyAustralia Facility to the northwest of the Delta Electricity Facility is also shown on this layout diagram.

The gas main would enter the Marulan Site via the South East boundary, run through the gas receiving facility (which includes a gas heating, required due to the step down in pressure) before entering the gas turbines on their Eastern end.

As shown in the indicative layout and assumed in this assessment, the gas turbines would be aligned in parallel and located to provide close connection to the switchyard which will be on their South West side. For Stage 2, the heat recovery steam generators are assumed to extend to the North East beyond each gas turbine.

The gas turbine exhaust stacks are assumed in this assessment to be located adjacent to each turbine building. The stacks used during Stage 1 operation are assumed in this assessment to be relocated for Stage 2 and used for exhaust from the heat recovery steam generator on the North East side of the steam generators.

**Figure 3 – Indicative Layout of Delta Electricity Facility - Open Cycle
(Stage 1)**

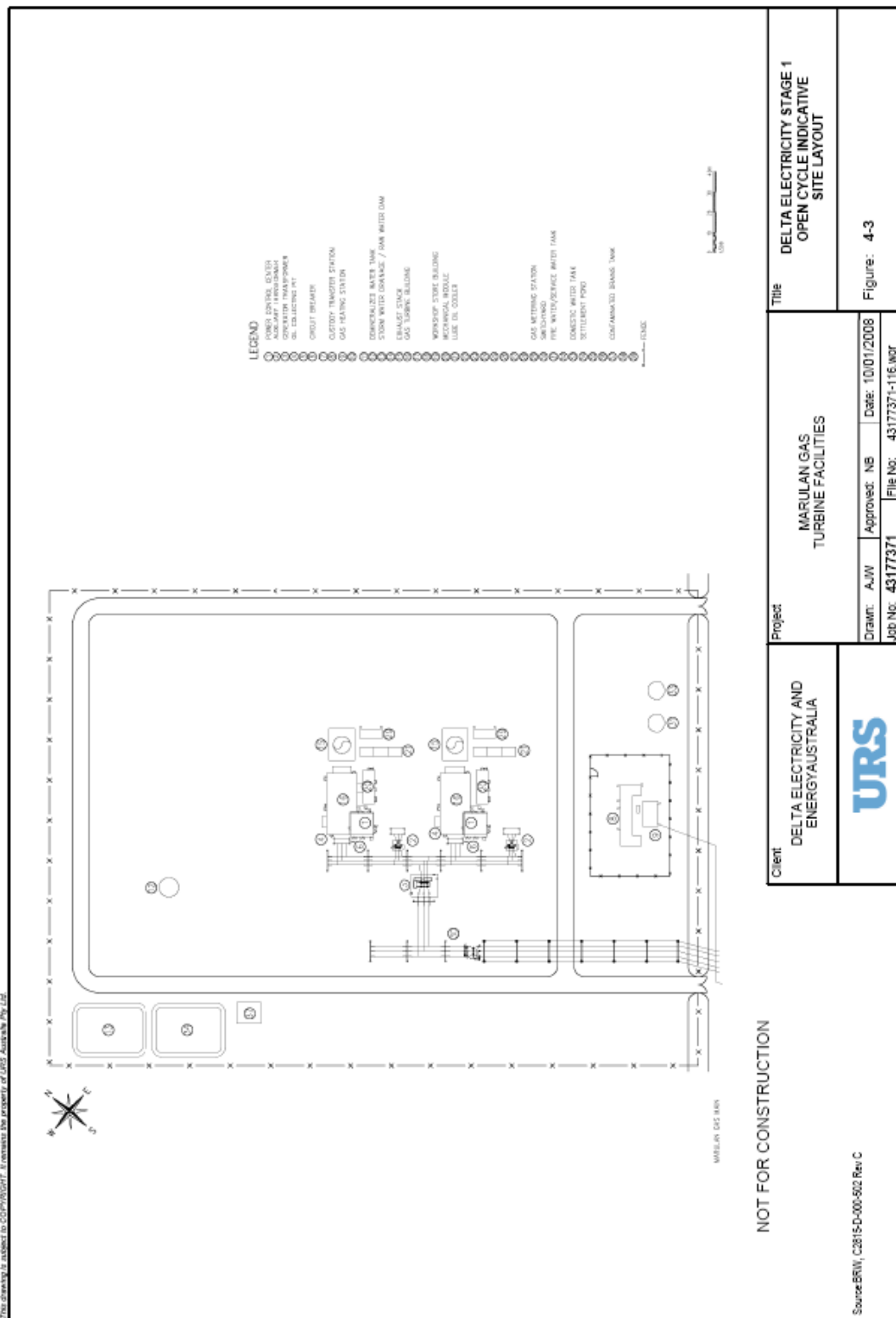
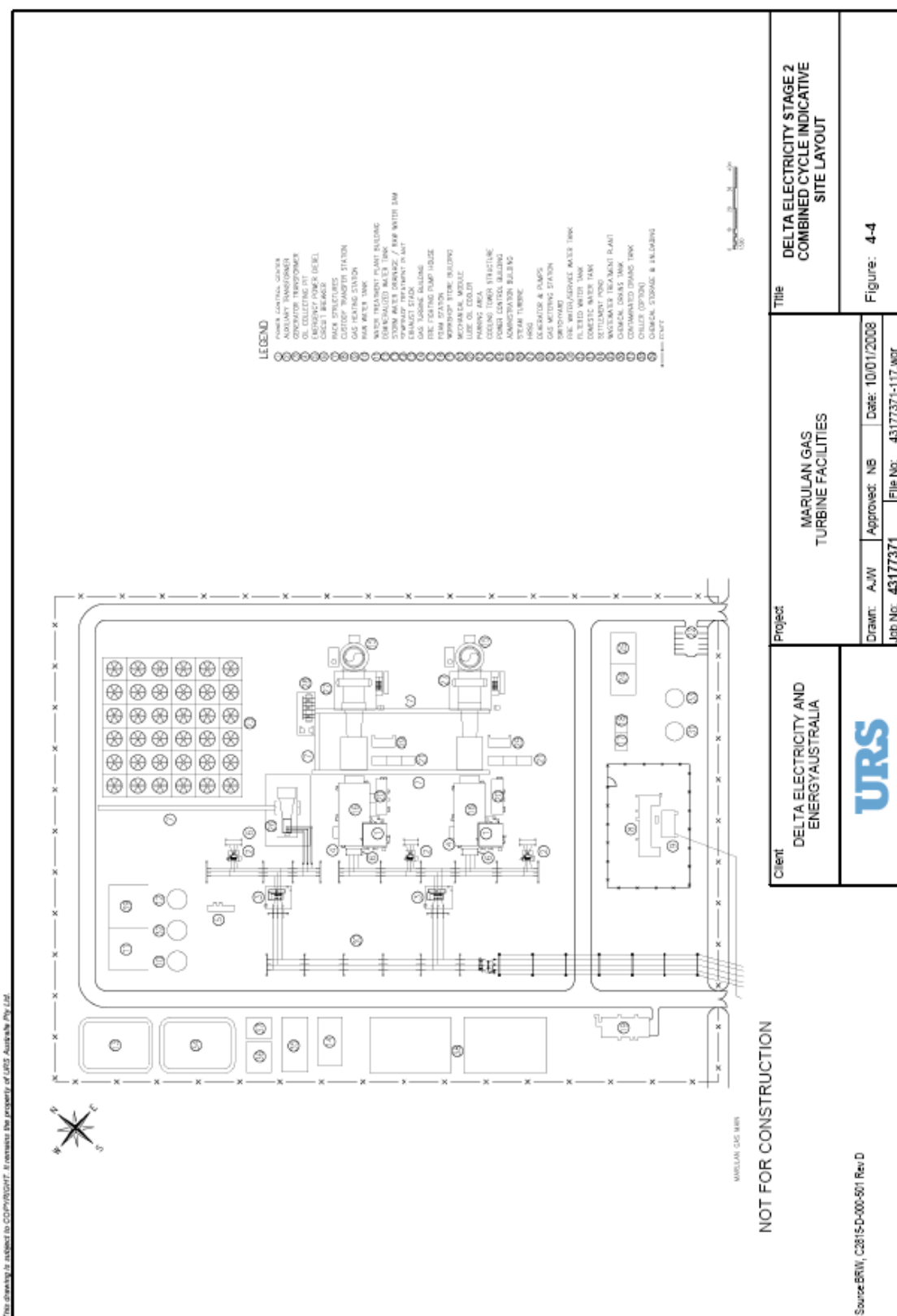


Figure 4 – Indicative Layout of Delta Electricity Facility - Combined Cycle (Stage 2)



Following completion of construction and commissioning, the major features of the Stage 1 peaking plant will include:

- Natural gas supply pipeline with metering and regulating station;
- Two gas turbines each comprising compressor, combustion and turbine stages and including low NO_x burners, inlet air filters and exhaust stacks;
- Air cooled generators with static excitation connected to a common step-up transformer;
- Connection to the existing TransGrid switchyard via a high voltage switchyard;
- Various gas turbine auxiliary systems including fuel control and conditioning systems, lubricating and hydraulic oil systems, starting systems, control and instrumentation systems, fire protection systems, compressor water wash systems, closed cooling system with fin fan coolers, etc.
- A new 330 kV switchyard would be required at the Delta Electricity Facility. It is proposed to build the switchyard in two stages in line with the proposed two-stage construction of the power station: Stage 1 would connect the two open cycle gas turbines to the 330 kV transmission line by a generator transformer with a single transformer connecting both gas turbines. Each gas turbine is connected via its own 11 kV generator circuit breaker to enable synchronising to the network. The electrical plant for Stage 1 would consist of one 330 kV circuit breaker (along with the associated isolators and earth switches), two generator circuit breakers, one 11 kV/330 kV three windings generator step-up transformer, current and voltage transformers, four 11 kV circuit breakers, two starting transformers along with starting equipment, two 11 kV/415 V unit auxiliary transformers, two excitation transformers along with excitation equipment, 415 V unit switchgear, unit 415 V motors and two unit & common services 110 V DC system.
- The transmission line required for the Delta Electricity Facility would be approximately 1200m in length depending on the location of the plant within the footprint envelope.
- There will be diesel stored on Delta Electricity Facility for use in the emergency diesel generator. The distillate will be supplied to the Delta Electricity Facility via road tankers and unloaded and transferred to the 5 kL tank at the tanker unloading bay located with the chemical storage and unloading facility (i.e. item 39 on layout drawing). The distillate will be supplied to the emergency diesel generator via pipelines. Any spill at the tanker unloading bay or from the pipes supplying the tankers or the emergency diesel generator will run into the chemical drains system. Approximately 4 distillate tankers will access the Delta Electricity Facility each year.
- Other services such as water and wastewater treatment, storage and truck loading/unloading facilities, fire fighting systems, workshop facilities and amenities, fences, roads, etc; and

- A small workshop and stores building would be required to facilitate day-to-day maintenance with contractors to provide their own requirements for major outages.

Additional to the above, Stage 2 closed cycle Delta Electricity Facility will include the following features:

- A heat recovery steam generators installed on the exhausts of each gas turbine, recovering the heat energy previously emitted to atmosphere by the open cycle system by generating steam and producing electricity. Each steam generator would include gas ducts, pressure parts, pumps, pipework, controls and instrumentation, etc.
- One steam turbine, including steam valves receiving steam from both heat recovery steam generators;
- One air cooled generator with static excitation;
- An air cooled condenser cooling the steam exhaust from the steam turbine, including pumps and pipework to return condensate to the heat recovery steam generators;
- Various steam turbine auxiliary systems including lubricating and hydraulic oil systems, control and instrumentation systems, fire protection systems, closed cooling system with fin fan cooler; condenser air extraction plant, etc;
- High voltage switchyard would be extended to accommodate the extension of the 330kV bus to provide common connection from the steam turbine step up transformer circuit breaker to the transmission line. The network connection for Stage 2 would remain the same as for Stage 1. Spare 330 kV bays exist in the TransGrid's Marulan switchyard that would accommodate the total output of the Stage 2 plant.
- The transmission line would remain the same for Stage 2 as for Stage 1. The transmission line would have a nominal capacity of approximately 500 MVA to accommodate the output of Stage 2. A new 330 kV switchyard would be required at the Delta Electricity Facility. In line with the two-stage construction of the power station, the switchyard for Stage 2 would include a separate 11/330 kV transformer would be installed and directly connected to the transmission line and the other generator transformer. A 330 kV isolator/earth switch would be installed on the high voltage side of both generator transformers to enable work on one while the other supplies the station load.
- Extension of, or additional, services including water and wastewater treatment, storage and truck loading/unloading facilities, chemical storage and delivery facilities (for the water treatment plant), administration, workshop and stores building/s, fencing and roads, etc;
- For Stage 2 an administration building with a more extensive workshop and stores would also be constructed.

2.3.2 Natural Gas Piping Design, Both Stages 1 and 2

The design of the natural gas installation and piping is not finalised and the following piping and operational data was used to define the power station – these assumptions are believed to be conservative.

Table 2 – Piping Data QRA Assumptions

Feature	Assumption(s)
General – Overall Delta Electricity Facility	
Percent operational	While the Stage 2 plant will be operational close to 100% of the time the stage 1 peaking plant will be operational for only a fraction of the time (5% of the time). All data used in the present risk assessment are for a plant operating 100% of the time. The quantitative risk results are valid, though highly conservative, for the plant at stage 1. The results are valid for a plant operating 100% of the time.
Gas Pipelines Inside Delta Electricity Facility, including Gas Receiving Station	
Length	10m up to the pressure regulator valve, then 200m after the pressure regulator, stretching from the gas conditioning area through to each turbine
Pipe diameter	250 mm NB (nominal bore)
Number of flanges	5 flanges up to the pressure regulator valve and 90 flanges after
Pressure	6.2 MPa up to the pressure regulator, then 2.5 MPa
Temperature	25°C
Features	Gas receiving area with pressure regulator, by-pass valves, non return valves, pressure indication, flow indication and transmitter
Pipe wall thickness	Minimum 9 mm
Design Standard	As per AS2885 requirements
Gas Piping to Gas Turbine Inside Enclosure	
Length	10 metres
Pipe diameter	200 mm NB (nominal bore)
Number of flanges	200 flanges inside each housing, 90 flexible joints (as flanges)
Pressure	2.5 MPa
Temperature	25°C

2.4 GAS SUPPLY PIPELINE

The gas turbines will be fuelled by natural gas. The gas pipeline will enter the Marulan Site at the south eastern boundary. A risk evaluation of the gas pipeline is provided in Ref 4.

2.5 WATER TREATMENT CHEMICALS

A number of chemicals will be used to treat the water in the water treatment plant and for domestic usage, for details see Table 6 on page 21. These are mainly corrosive liquids and solids as well as some minor quantities of chlorine and anhydrous ammonia gas.

Up to 1 tonne of ammonia and 70 kg of chlorine gas would be stored at the Delta Electricity Facility at any one time. From table 3 in the Department of Planning Guidelines for applying SEPP 33 (Ref 5), these quantities are below those considered as *potentially hazardous* and will therefore not be assessed using Quantitative Risk Assessment methodologies.

The hazards associated with these gases and corrosive liquids and the risk management methodologies required to ensure safety will however be assessed qualitatively, as presented in Table 10 and in Section 5.2.5 below.

2.6 OPERATING HOURS AND STAFFING

The proposed Stage 1 peaking plant would be capable of operating for 24 hours per day. However, actual operational hours would be dependent upon periodic electricity demand and economic factors (the peaking plant would be suitable for peaking demand only).

For Stage 1, while eight full time staff would be available for operation, they would be located off-site. No permanent site staff would be required as the gas turbines control systems would provide for remote automatic starting, stopping and control and remote condition monitoring and assessment. Arrangements for routine inspections of plant would be needed.

For Stage 2, it is anticipated that 18 full time staff and contractors would be required, most located on-site.

Scheduled maintenance would require 20 to 50 contractors for a period of approximately 2 months every 2 to 3 years.

2.7 SECURITY

The Delta Electricity Facility, including the gas receiving area, will be located within a fenced off area accessed through a security gate.

3 STUDY METHODOLOGY

3.1 INTRODUCTION

The methodology for the PHA is well established in Australia. The assessment has been carried as per the Department of Planning's HIPAP No 6 (*Guidelines for Hazard Analysis*, Ref 1) and HIPAP No 4 (*Risk Criteria for Land Use Planning*, Ref 1). These documents describe the methodology and the criteria to be used in PHAs, as required by the Department of Planning for major "potentially hazardous" development.

There are five stages in risk assessment (as per Ref 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 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 of the proposed Delta Electricity Facility 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 word diagram. The hazard identification word diagram is then reviewed and complete in a workshop which included people with operational / engineering / 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 hazard identification word diagram is presented in Section 4.3.

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.

Stage 3. Frequency Analysis: For incidents with significant effects, whether on people, property or the biophysical environment, the incident frequency are 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.

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:

$$\text{Risk} = \text{Consequence} \times \text{Frequency}$$

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:

- Individual Fatality Risk, i.e. the likelihood (or frequency) of fatality to notional individuals at locations around the Marulan Site, 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, i.e. the likelihood of injury to individuals at locations around the Marulan Site as a result of the same scenarios used to calculate individual fatality 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 are 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 a facility. 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 (Ref 2).

Stage 5. Risk reduction: Where possible, risk reduction measures are identified throughout the course of the study in the form of recommendations.

3.2 RISK CRITERIA

Having determined the risk from a development, it must then be compared with accepted criteria in order to assess whether or not the risk level is tolerable. If not, specific measures must be taken to reduce the risk to a tolerable level. Where this is not possible, it must then be concluded that the proposed development is not compatible with the existing surrounding land uses.

3.2.1 Individual Risk Criteria

The individual fatality risk is the probability of fatality to a person or a facility 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 should 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* (Ref 2). The criteria for maximum tolerable individual risk from a new development are shown in Table 3 below. The criteria have been chosen so as not to impose a risk which is significant when compared to the background risk we are already exposed to. This table shows the criteria for individual risk of fatality, injury and propagation of an incident.

While the Delta Electricity Facility is located in rural areas, the more rigorous criterion for residential areas (as shown in bold in the table below) has been applied as the relevant criteria for the proposed development. Also, the EnergyAustralia plant and the TransGrid switchyard would be regarded as industrial developments and hence the risk criteria for industrial areas apply (as shown in bold in the table below).

Table 3 – Criteria for Tolerable Individual Risk From A New Development

Land Use	Maximum Tolerable Risk (pmpy ¹)
Fatality risk criteria:	
Hospitals, Schools, etc	0.5
Residential areas, hotels, etc	1
Offices, retail centres, etc	5
Open space, recreation areas etc	10
Neighbouring industrial areas	50
Overpressure for Safety Distances:	
Property damage and accident propagation 14 kPa	50 Adjacent potentially hazardous installation, land zoned to accommodate such installations, or nearest public building
Injury risk levels 7 kPa	50 At residential areas
Maximum Heat Radiation:	
Injury risk levels 4.7 kW/m ²	50 At residential areas
Property damage and accident propagation 23 kW/m ²	50 Adjacent potentially hazardous installation or land zoned to accommodate such installations

In order to put these risks into perspective, published information on the level of risk to which each of us may be exposed from day to day due to a variety of activities has been shown in Table 4 below. Some of these are voluntary, for which we may accept a higher level of risk due to a perceived benefit, while some are involuntary. Generally, we tend to expect a lower level of imposed or involuntary risk especially if we do not perceive a direct benefit.

Table 4 – Risk to Individuals

Activity / Type of Risk	Published levels of risk (pmpy ¹)
VOLUNTARY RISKS (AVERAGED OVER ACTIVE PARTICIPANTS)	
Smoking	5,000
Drinking alcohol	380
Swimming	50
Playing rugby	30
Travelling by car	145
Travelling by train	30
Travelling by aeroplane	10
INVOLUNTARY RISKS (AVERAGED OVER WHOLE POPULATION)	
Cancer	1,800
Accidents at home	110
Struck by motor vehicle	35
Fires	10
Electrocution (non industrial)	3
Falling objects	3
Storms and floods	0.2
Lightning strikes	0.1

3.2.2 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:

¹ pmpy = per million per year

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

In the absence of published criteria in HIPAP 4 (Ref 2), the criteria in the 1996 regional study of Port Botany by the Department of Planning² have been used for indicative purposes, as presented in Table 5 below.

Table 5 - Criteria for Tolerable Societal Risk

Number of fatalities (N) [-]	Acceptable limit of N or more fatalities per year	Unacceptable limit of N or more fatalities per year
1	3×10^{-5}	3×10^{-3}
10	1×10^{-6}	1×10^{-4}
100	3×10^{-8}	3×10^{-6}
1000	1×10^{-9}	1×10^{-7}

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 in Table 5 above are represented on the societal risk (f-N) curve as two parallel lines. Three zones are thus defined:

- Above the unacceptable/intolerable limit the societal risk is not acceptable whatever the perceived benefits of the development.
- 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.
- Below the acceptable limit, the societal risk level is negligible regardless of the perceived value of the activity.

3.3 RISK CALCULATIONS

In order to determine the cumulative risk from all identified hazards, the computer software tool ISORIS from the Warren Centre for Advanced Engineering (Ref 6) was used. First, base information on the incidents, including type, location, processing conditions and frequency were entered into a spreadsheet. This spreadsheet calculates the leak rate for each incident using standard orifice flow equations for vapour or liquid, as appropriate. The spreadsheet also determines the base consequences for each incident in terms of total radiant heat release rate and TNT equivalent. See Appendix 1 for a printout of the incident listing from the spreadsheet.

Information on the frequency, location and consequences of each incident was extracted from the spreadsheet and processed by the ISORIS program. This

² then the Department of Urban Affairs and Planning

program is designed to take consequence and frequency information and determine risk levels to individuals at all locations within a user-defined grid. From the output of ISORIS risk contours can be drawn and overlaid on a map of the Delta Electricity Facility.

ISORIS can determine risks to persons in the open or in buildings. For this study, risks in the open have been determined. In the case of radiation, persons are more at risk in the open due to the lack of shelter, while for explosions the risk is greater inside due to the potential for the building to collapse.

To assess injury risk and the potential for knock-on or domino incidents, ISORIS can also determine the frequency of exceeding a given level of heat radiation or explosion overpressure.

3.4 SAFETY MANAGEMENT SYSTEMS

3.4.1 Safety Management in General

In quantitative risk assessments, incidents are assessed in terms of consequences and frequencies, leading to a measure of risk. Where possible, frequency data used in the analysis comes from actual experience, e.g. near misses or actual incidents. However, in many cases, the frequencies used are generic, based on historical information from a variety of plant and processes with different standards and designs.

As with any sample of a population, the quality of the management systems (referred to here as "safety software") in place in these historical plant will vary. Some will have little or no software, such as work permits, planned maintenance and modification procedures, in place. Others will have exemplary systems covering all issues of safe operation. Clearly, the generic frequencies derived from a wide sample represent the failure rates of an "average plant". This hypothetical average plant would have average hardware and software safety systems in place.

If an installation which has significantly below average safety software in place is assessed using the generic frequencies, it is likely that the risk will be underestimated. Conversely, if a plant is significantly above average, the risk will probably be overestimated. However, it is extremely difficult to quantify the effect of software on plant safety. Incorporating safety software as a means of mitigation has the potential to significantly reduce the frequency of incidents and also their consequences if rigorously developed and applied. The risk could also be underestimated if safety software is factored into the risk assessment but is not properly implemented in practice. Practical issues also arise when attempting to factor safety software into the risk assessment – applying a factor to the overall risk results could easily be misleading as in practice it may be the failure of one aspect of the safety software that causes the accident, while all other aspects are managed exemplarily.

In this study it is assumed that the generic failure frequencies used apply to installations which have safety software corresponding to accepted industry practice and that this Delta Electricity Facility has similar management practices

and systems. This assumption it is believed, will be conservative in that it will overstate the risk from well managed installations.

3.4.2 Recommendations for Safety Management System

Recommendation 1: It is recommended that an assessment is carried out of the safety management system implemented and used at the Delta Electricity Facility, specifically as it applies to the proposed hazardous materials handling, pipelining and storages within the first year of operation.

4 HAZARD IDENTIFICATION

4.1 HAZARDOUS MATERIALS

A list of the types and storage quantities of materials that are likely to be found at the proposed Delta Electricity Facility is included in the following table. Quantities are indicative only. Note that the main hazard is associated with natural gas which is a dangerous goods. However, as natural gas is not stored at the Delta Electricity Facility it does not appear in the table below.

Table 6 - Typical Chemicals Stored at the Delta Electricity Facility

Plant Area / Use	Chemical/Product	Anticipated Storage Qty
Fuel for emergency generator	Distillate (Diesel)	5kL in fixed tank
Turbines	Turbine oils (combustible oil)	2 x 15m ³ in oil tanks integral to each gas turbine and 30m ³ in steam turbine oil tank
Transformers, pumps, air compressor, lubrication, fire pump	Insulating oil (non PCB)	Three generator transformers may typically have up to 40m ³ of each, while the three auxiliary transformers will have up to 10m ³ of oil. Diesel generator, pumps and compressors have lubricating oil systems with small tanks (<300L each)
Water treatment plant and chemical dosing	Caustic soda (50%)	20m ³ in fixed tank
	Sulphuric acid (36%)	30m ³ in fixed tank
	Ferric chloride,	2m ³
	Sodium phosphate, antiscalants	1m ³
	Ammonia or aqueous ammonia	If anhydrous ammonia: 1,000kg If aqueous ammonia: 10m ³
	Chlorine gas or sodium hypochlorite	If chlorine gas: 70kg If hypo: 1m ³
Chemicals for maintenance / repair work and clean-up	Carbon dioxide	As required for fuel line purging, in cylinders
	Nitrogen	As required for gas line purging, in cylinders

Natural gas is composed predominantly of methane gas. The composition of natural gas from the Moomba to Sydney pipeline is shown in Table 7 below.

Table 7 – Composition of Natural Gas

Component	Mole %
methane	87
ethane	8.46
hydrogen	0.36
nitrogen	3.61
carbon monoxide	0.09
carbon dioxide	0.34
ethylene	0.03
Hydrogen sulphide (H ₂ S)	0.04
oxygen	0.07
TOTAL	100

The properties of methane gas are presented in Table 8 below.

Table 8 - Properties of Methane Gas

Molecular weight (g/mol)	17
Relative density of the gas (atmospheric temp. and pressure)	0.6
Heat of combustion (MJ/kg)	50
Flammable range (vol. % in air)	5 to 15
Ratio of specific heats (Cp + Cv)	1.31
Flash point	-218°C

4.2 SUMMARY OF HAZARDS IDENTIFIED

A total of 20 hazards were identified for the power station, as listed in Table 9 below.

The *Hazard Identification Word Diagram* in Table 10 details these hazards, their potential initiating events as well as their proposed controls.

Table 9 - Summary of Identified Hazards

Number	Hazardous Event Potential	Offsite Impact Potential	Assessed in Section
1	Leak of natural gas to atmosphere from gas pipes at the Delta Electricity Facility (outside the turbine enclosure)	Y	5.2.1
2	Venting of gas from process	N	-
3	Explosion within gas piping or inside a vessel	N	-
4	Leak of natural gas to inside the turbine enclosure	Y	5.2.2
5	Unburned fuel within the turbine	N	-
6	High pressure steam release	N ³	-
7	Loss of containment of distillate during unloading and storage	Y	5.2.4
8	Loss of containment of corrosive liquids.	N	5.2.5
9	Loss of containment of toxic gas	Y	5.2.5
10	Violent reaction between incompatible materials	N	5.2.5
11	Loss of containment of water treatment plant effluent	N	5.2.5
12	Fire at transformers	Y	5.2.6
13	Flooding results in process upsets and damage to plant and equipment	Y	5.2.8
14	Land subsidence, earthquake or mining activity results in plant damage	Y	5.2.8
15	Aircraft crash results in process upsets, potential damage to process / gas piping / storage facilities resulting in hazardous releases	Y	5.2.8
16	Damage to plant through terrorism / vandalism / unlawful entry to Delta Electricity Facility / sabotage	Y	5.2.8
17	Neighbouring fire (from neighbouring Delta Electricity Facility or bush / grass fire)	Y	5.2.7 and 5.2.8
18	Storm damage	Y	5.2.8
19	Incident during maintenance and repair work	Y	5.2.8
20	Transport of potentially hazardous material to and from the Delta Electricity Facility (diesel, oils, corrosives)	Y	5.2.9

The main hazard associated with the proposed development is related to a leak and ignition of flammable natural gas or, to a lesser degree, to a leak of combustible liquids (distillate), as described in Sections 4.2.1 and 4.2.2 below.

³ Off-site impact in terms of noise is expected. This is outside the scope of this PHA.

4.2.1 Flammable Natural Gas

A leak of flammable natural gas would generally only have the potential to cause injury or damage if there was ignition, which resulted in a fire or (in case of confinement) an 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 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 enclosure) 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 Delta Electricity Facility, do not have implications beyond the immediate location of the release unless the released gas is ignited. Therefore, the risk associated with of 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 Delta Electricity Facility (in accordance with NSW Occupational Health and Safety Act and its associated legislation (Ref 7)).

4.2.2 Combustible Distillate and Lubricating Oils

Other potential hazards are associated with the handling and use of distillate and other combustible liquids (i.e. the oils used for pumps, compressors, turbines etc.). These combustible materials are difficult to ignite and require heating and a significant source of energy. If ignited they would burn as a sooty pool fire.

4.2.3 Toxic Gases

The risk associated with the proposed minor storage of chlorine and anhydrous ammonia gases is related to the potential for loss of containment of a toxic gas and subsequent exposure to these gases.

The effects of exposure to toxic materials on humans can range from discomfort (eg. irritation to eyes or skin) to injury (eg. damage to lungs or respiratory system) to fatality. Effects are generally classified as chronic or acute. An acute effect is a response that rapidly follows exposure (within seconds, minutes or hours). A chronic effect can result from prolonged exposure, or from a series of exposures over a period measured in days, months or years. Only acute exposure potentials are discussed in this PHA.

The key factors which determine exposure effects are:

- Toxicity of material
- Concentration of material
- Duration of exposure
- Mode of exposure (eg. inhalation, ingestion, skin)
- Sensitivity of person exposed

Chlorine (DG Class 2.3) is a greenish-yellow gas, 2.5 times heavier than air at ambient temperature and pressure. It is highly toxic, and acts as a respiratory irritant. It has a characteristic pungent odour that can be smelt at low concentrations (that do not constitute an acute hazard). Therefore the odour can act as a hazard warning. Chlorine is non-flammable, however is an oxidising agent and therefore supports combustion.

Ammonia (DG Class 2.3, subsidiary risk Class 8) is a colourless gas with a penetrating, pungent suffocating odour detectable at low concentrations (17 ppm). As it combines with the humidity in the air upon release it acts as a heavy gas at ambient temperature and pressure. Ammonia is flammable at a concentration between 15.5% and 27%.

4.3 HAZARD IDENTIFICATION WORD DIAGRAM

The Hazard Identification Word Diagram, included in Table 10 below, provides a summary of the hazardous incidents identified for the proposed Delta Electricity Facility and their associated mitigating features. Each section of the plant and associated pipelines was reviewed in turn in a workshop, to determine the potentially hazardous scenarios relevant to that section. The sections reviewed were:

- Natural gas lateral supply pipelines within the Delta Electricity Facility's property boundary, including gas receiving station;
- Turbine enclosure and Turbine;
- Storage and Handling of combustible and flammable liquids;
- Storage and handling of water treatment chemicals;
- Electricity generation;
- Finally, potential hazards that could affect the whole Marulan Site were reviewed.

Further, the risk associated with having two facilities in close proximity to each other was evaluated in terms of their cumulative risk impact.

While the table below provides an overview of the preventative and protective features proposed and recommended for the Delta Electricity Facility, these safeguards are further detailed in 5.2 below.

Table 10 – Hazard Identification Word Diagram

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
SECTION OF PLANT: Natural Gas Receiver and Piping			
1. Leak of natural gas to atmosphere from gas pipes at the Delta Electricity Facility (outside the turbine housings).	Mechanical impact, weld failure, operational error corrosion, etc.	Release of odourised natural gas. If ignition source available (or if ignited at source), then flash fire or jet fire possible. Injury and property damage.	- Use of fully welded pipework wherever possible. Minimise pipe-runs (pipe lengths). Pipes of robust design as per AS2885 requirements. - Alarms to Gas Turbine Facility control room (local) and to remote control facility, with ability to shut down manually and vent the Delta Electricity Facility. - Emergency response plan, including call-outs to local emergency services. - Training and induction of employees and subcontractors, including emergency response training. - Preventative maintenance programs (inspection, testing and maintenance) - Compliance with AS2885 requirements for facility layout (e.g. no buildings of combustible material within 10m of regulating/metering station).
	Mechanical impact by vehicle on metering station or at the gas receiver station (within Delta Electricity Facility boundary) damages pipework, valves etc.	Release of odourised natural gas. If ignition source available (or if ignited at source), then flash fire or jet fire possible. Injury and property damage.	- Fenced area. Signage. - Visual obstruction managed. - No public roadway in the vicinity. - Bollards or other physical barriers protecting above ground pipework. - Robustness of pipework and supports. - Restrictions on speed and access. Inducted drivers only allowed at the Delta Electricity Facility. Specific green card (permits) required for truck drivers (WorkCover general induction). - Automatic isolation of valve at gas receiver station.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
Continued 1. Leak of natural gas to atmosphere from gas pipes at the Delta Electricity Facility (outside the turbine housings).	Valve gland leak or flange leak or maintenance failure at valves.	Release of natural gas. If ignition, then possibility of fire. Injury and property damage. Possibility of propagation to other parts of the plant.	- Routine inspections and servicing / maintenance of pipe and valve points. - Fire detection and protection system. - Valve stations within fenced Marulan Site. - Minimum number of flanges. Welded connections wherever possible. - Protection of nearby plant and structures from fire / heat radiation.
2. Venting of gas from process.	Maintenance work, shutdown, depressurisation of the Gas Turbine Delta Electricity Facility.	Release of flammable gas or heat to process area. Fire hazard. Potential hazard to people at the Delta Electricity Facility if venting not properly designed and managed.	- Releases to be piped to safe area and vents to be directed to elevated point. - Wind sock indicates direction of wind. - Planned venting of process piping to be managed. - Broad requirements for procedures, including inert gas purging etc., included in AS2885.
3. Explosion within piping or inside a vessel.	Failure of maintenance activities creates ingress of air into natural gas piping and vessels and subsequent start-up without adequate purging.	Possible explosion. Due to the limited quantities of gas involved the effects of the explosion would however not be expected to pose a threat to nearby businesses or to any residential areas in the vicinity.	- Piping normally operated at a positive pressure, preventing ingress of air; - Prevention of ingress of air will be considered throughout the design and operation of the Facility (for example in the preparation of start-up, shut-down and maintenance procedures). - Procedure requirements as pre AS2885.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
SECTION OF PLANT: Turbine Enclosure and Turbine			
4. Leak of natural gas inside of turbine housing.	Mechanical impact, weld failure, operational error , flange leak, corrosion, sabotage etc.	Release of odourised natural gas (NG). If ignition source available (or if ignited at source), then flash fire or jet fire possible. Personnel hazard and property damage. If confinement sufficient then an explosion is possible with overpressure effects and projectiles.	- The detailed design of the turbine housing and associated equipments need to demonstrate that explosive situations do not arise and need to clearly outline the basis of safety used to this end. Generally, the basis of safety includes a combination of well controlled ventilation flows, flammable gas detection with automatic response, explosion relief and explosion suppression. Initial design points towards a system which, in the event of fire detection, will initiate the fire protection system, which will seal the enclosure (i.e. stop and close ventilation) and release CO₂ into enclosure. - Control of ignition sources as per Australian Standard Hazardous Zone requirements. - Preventative maintenance and testing procedures and schedules to be developed. Training of operators and maintenance workers. - Fenced Marulan Site with access control. Security management plan to be put in place. Background checks and standard screening of employees prior to employment. - System put in place to ensure removal of safety critical functions is subject to careful scrutiny. - Permit to Work and operational procedures, including communication requirements. Requirements for entry into Confined Space areas. Procedures required to isolate gas supply and enter enclosure after fire event in enclosure. - Emergency procedures, drills, wind socks, exit signage - Signage with emergency numbers, direct dial to existing Delta Electricity power stations or Head Office. External agencies Police, Ambulance and Fire Brigades

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
Continued 4. Leak of natural gas to inside of turbine housing.	Violent mechanical failure of rotating machine (compressor, turbine) or heat recovery steam generator & pressure vessels.	Projectile may be ejected with high energy. Personnel hazard if person in the vicinity. If a gas pipe is hit by the projectile or associated equipment / instrumentation then it may fail, causing gas release and fire / explosion if ignition source. Fire risks and injury potential.	- Preventative maintenance of rotating machines and pressure plant. - Condition monitoring. - Use of proven technology in the choice of turbine. - Pipelines as far as possible not in probable line of projectile, people separated etc. - Buried pipeline is not at risk from such projectiles. - Plant and equipment to be designed to relevant Australian and International Standards.
5. Unburned fuel within the turbine.	Valve error / leak coupled with failure to purge prior to start-up of turbine. Sequence error.	Fuel remaining in the air and exhaust gas path of the out of service machine may ignite when the machine is started. Localised explosion. Damage to turbine and nearby structures. Personnel hazard for people within the Delta Electricity Facility.	- Maintenance and routing inspections of valving (condition monitoring) prevents valve leak. - Performance guarantees and tuning during commissioning - Automated purge cycle of turbine. - Combustion tuning. - Training and inductions of employees and subcontractors.
6. High pressure steam release.	Faulty design / preventative maintenance	High noise levels.	- Design of steam plant. - Hearing protection for people working at the Delta Electricity Facility, as required. - Preventative maintenance. - Buffer zones.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
SECTION OF PLANT: Storage and Handling of Combustible and Flammable Liquids			
7. Loss of containment of flammable or combustible liquid.	Loss of containment during unloading from truck to the emergency diesel generator tank. Mechanical failure, damage to tank etc. Overfilling of tank.	Loss of containment of diesel from tank (up to 1,200 L) or lube oil (up to 100 litres). Environmental damage if spill is not contained on site. If ignition source nearby, risk of fire. Personnel hazard and damage to property.	- Storages classified as <i>Minor Storage</i> as per AS1940 classification, implying low risk. - Spill containment as per AS1940 for Minor Storages. - Protection of storages from mechanical damage. - Inspection. - Any spill outside contained areas would be captured in the settlement pond. - Emergency response plan and spill protection as per AS1940. People trained in emergency response. - Emergency services call-out as required. - Fire protection (fire extinguishers, separation distances etc.) as per AS1940. - Valving and piping associated with the storage as per AS1940 Section 7. - Control of ignition sources as per AS1940 requirements.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
SECTION OF PLANT: Water Treatment Plant			
8. Loss of containment of corrosive liquids.	Mechanical failure, damage to packaging / vessel etc. Loss of containment during unloading from tanker to the storage tank due to line failure, valve failure, operational error, drive away. Loss of containment during transfer from storage to water treatment. Human error. Overfill of tank(s).	Loss of containment of corrosive liquid to ground (10kL of Sulphuric Acid and 14kL of Caustic Soda (Sodium Hydroxide) or small quantities of ferric chloride, sodium phosphate, antiscalant). Possible danger of exposure to people in the vicinity. Environmental hazard if not contained on site.	- Fixed storage tank, bunded as per AS3870 requirements. If spill into bund, spill is transferred to chemical drain recovery system and neutralised and recycled. - Material Safety Data Sheets available. - Unloading bay, with any spill captured as per AS3780 requirements. - Water treatment will be located within the same bund as the corrosives and brine storage tanks, minimising risk of loss of containment outside bunded areas. - Routine inspection and training. Maintenance of plant and equipment. - Tanker drivers trained as per DG Code requirements and inducted to the Delta Electricity Facility, hold green cards. - Emergency response plan. - Level indication and alarm prevents overfilling. Operator attendance during unloading. - Emergency shower and eye wash station at unloading bay. - Personal Protective Equipment (PPE) requirements as per MSDS specifications.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
9. Loss of containment of toxic gas	Mechanical failure, damage etc. to chlorine or ammonia cylinder or drum. Loss of containment during transfer from container (drum/cylinder) to water treatment.	Loss of containment of up to 70kg of chlorine or up to 1,000kg of ammonia gas. Possible danger of exposure to people in the vicinity.	- Chlorine and ammonia drums and cylinders to comply with stringent requirements in terms of construction. - Regular and standardised preventative maintenance programs for cylinders and drums. - Piping from cylinders and drums to water treatment to be hard-piped with minimal use of flexible connections. Minimise lengths of piping between container and point of use. - No use of forklifts to directly transport drums. - Tanker drivers trained as per DG Code requirements and inducted to the Delta Electricity Facility, hold green cards. - Emergency response plan.
10. Violent reaction between incompatible materials.	Incompatible materials contact due to operational error (acid into caustic or caustic into acid).	Violent exothermic reaction. Possible damage to tank fittings leading to loss of containment. Personal injury hazard.	- Clear labelling of unloading points. - Operator attendance during unloading operation. - Induction of tanker driver and training of operator.
11. Loss of containment of water treatment plant effluent	Mechanical failure, damage, corrosion of piping, valves or storage, operator error, overfill of storage.	Environmental hazard if not contained on site.	- Bunded brine storage and handling. Water treatment will be located within the same bund as the corrosives and brine storage tanks, minimising risk of loss of containment outside bunded areas. - Number of valves, flanges and lengths of pipes minimised. - Loss of containment at external (unbunded) areas would be captured in the chemical drains. - Routine inspection and training. Maintenance of plant and equipment. - Inductions, green cards etc. - Emergency response plan. - Level monitoring in brine storage reduces risk of overfill.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
Electricity Generation			
12. Fire at transformers	Faulty connection, internal fault in transformer.	Fire in switchyard. Material damage. Potential for propagation to bush / brush outside Marulan Site boundaries. Personnel injury potential.	- Gravel around switchyard provides separation distance from neighbouring combustible material (grass, bush, etc.) and ensures any oil spill seeps into the gravel and does not pool. - Fire remains localised to switchyard. - Fire protection system available at the Delta Electricity Facility to minimise damage from fire. - Asset protection zone. - Emergency response plan, mustering point for evacuation. Emergency services contacted as required. Signage for emergency services.
SECTION OF PLANT: Whole Marulan Site			
13. Flooding results in process upsets and damage to plant and equipment.	Uncontrolled flooding of Marulan Site	Potential for damage to process / storage facilities resulting in release of hazardous material (particularly natural gas and corrosive liquids and oils)	- Marulan Site elevation and siting to ensure potential for flooding from the river is minimised. - Control of erosion and Marulan Site layout through Civil Engineering design. - Risk associated with flooding of Marulan Site minimised through design.
14. Land subsidence or mining activity results in plant damage.	Land subsiding due to mining activities in area or earthquake creates failure of pipelines resulting in potential for rupture or massive leak.	Release of natural gas. If ignition, then possibility of flash or jet fire. Injury and property damage.	- Marulan Site is not affected by mine subsidence. - Pipe to be designed to Australian Standard requirements in terms of strength of material and design. - Structure designed to relevant earthquake codes.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
15. Aircraft crash results in process upsets, potential damage to process / piping / storage facilities resulting in hazardous releases.	Aircraft crash	Potential damage to process / storage facilities resulting in hazardous releases, fire / explosion. Relatively small quantities of gas held within the Power Station and very large site – effect unlikely to go off-site.	- Occupied site relatively small – aircraft crash unlikely. - Buried pipelines unlikely to be susceptible to aircraft crash. - Civil aviation safety authority (CASA) will be informed about the Marulan Site and potential aviation hazards. Aviation safety standards to apply.
16. Damage to plant and pipeline through terrorism / vandalism / unlawful entry to Delta Electricity Facility / sabotage.	Malicious damage.	Massive release of natural gas. If ignition, then possibility of flash or jet fire.	- Buried pipelines. No valve points at public areas. - Fenced Marulan Site with access control. - Security management plan to be put in place.
17. Neighbouring fire , including bush/grass fire	Fire outside Marulan Site boundaries affects site. Fire or explosion at EnergyAustralia affects the Delta Electricity Facility. Fire / gas release propagates to outside site boundary.	Possible damage to plant and equipment. Release of hazardous materials. If gas piping damaged, then fire risk.	- Bush /brush fire asset protection zone as per rural fire services guidelines. - Emergency response plan and communication to rural fire brigades. - Notice issued to local staff during high risk bush fire times. - Control of vegetation in easement. - Separation distances between Delta Electricity and EnergyAustralia facilities.
18. Storm damage	High winds or neighbouring structures or trees affecting the Delta Electricity Facility. Projectile from equipment / structures at the Delta Electricity Facility causes off-site damage.	Damage to plant and equipment. Release of hazardous materials (corrosives, flammable gases, oils). Hazard to neighbouring areas, people etc.	- Engineering design standards to cope with winds and storms as per building codes.

Event	Cause/Comments	Possible Consequences	Prevention/ Protection
19. Incident at workshop	Faulty equipment / error of operation.	Fire, personnel injury. Potential propagation of fire to nearby structures. Plant damage.	- Trained staff. - Equipment used in workshop are checked and maintained. - Fire extinguishers available in workshop - Building designed to Building Code requirements. - Dedicated hazardous material storage. - Gas cylinders (oxyacetylene) stored in accordance with standards.
TRANSPORT RISKS			
20. Transport of potentially hazardous material to and from the Delta Electricity Facility (diesel, oils, corrosives, brine)	Transport accident causes release to the environment	Release of hazardous material onto the roadways and into the environment causing pollution. If ignition source then possibility of fire (note that diesel and oils are not easily ignited).	- Oil and diesel transported to the Delta Electricity Facility in relatively small quantities and very infrequently. - Corrosive liquids transported to the Delta Electricity Facility using tanker designed to relevant standards. - Tankers driven by qualified drivers. - Access roads to the Delta Electricity Facility to be of adequate construction for the use and to be maintained / repaired. - General transport risks of such material are handled by transport company's safety requirements. Clean up and incident management as per transport company procedure.

5 POTENTIAL HAZARDOUS INCIDENTS AND THEIR CONTROL

Safety management systems allow the risk from potentially hazardous installations to be minimised by a combination of hardware and software factors. It is essential to ensure that hardware systems and software procedures used are reliable and of the highest standard in order to assure safe operation of the Delta Electricity Facility.

Safety features of particular interest to the present project are detailed below.

5.1 HARDWARE SAFEGUARDS, GENERAL

Hardware safeguards include such factors as the layout and design of the plant and equipment, and their compliance with the relevant codes, technical standards, and industry best practice.

All systems handling dangerous goods will need to comply with the following Acts, Regulations and Codes in their latest edition. Below are listed some of the most relevant:

- NSW Occupational Health and Safety Act and its associated legislation including but not limited to the Dangerous Goods Regulations, Construction Safety Regulations, and the Factories Shops and Industries Regulations.
- NOHSC:1015(2001) - National Occupational Health & Safety Commission (NOHSC): Storage and Handling of Workplace Dangerous Goods.
- AS 4041 - 1992 SAA Pressure Piping Code (was CB18).
- AS 1074 - Steel Tubes & Tubulars.
- AS 1836 - Welded Steel Tubes for Pressure Purposes.
- AS 1210 - Unfired Pressure Vessel Code.
- AS 2919, AS 3765.1 or AS 3765.2 - Protective clothing.
- AS3600 - Concrete Structures (for foundation and plinth).
- AS 1692 - Tanks for flammable and combustible liquids.
- API 620 - Design and construction of large welded low-pressure storage tanks.
- API 650 - Welded steel tanks for oil storage.
- AS1345 - Identification of the Contents of Pipes, Conduits and Ducts.
- ANSI Z 358.1 – For safety shower and eyewash facilities.
- AS 3780 – Storage and Handling of Corrosives.

Pipe fittings, supports, and all other ancillary items will also need to comply with appropriate Australian Standards whether referenced above or not.

5.2 HARDWARE SAFEGUARDS, SPECIFIC

5.2.1 Gas Receiving Station and Gas Pipes

A. Pipeline / Vessel Leaks

The failure modes at the power station associated with transport and use of natural gas are derived from historical failures of similar equipment and are described in the following sections.

- **Piping Failures:** Pressure piping may fail as a result of corrosion, erosion, mechanical impact damage, pressure surge ("water hammer") or operation outside design limitations of pressure and temperature. Pressure surge or significant deviations of pressure or temperature may cause a flanged joint to be overstressed, resulting in a small leak. Larger holes through to complete line fracture may conceivably result from mechanical impact or pressure surge.
- **Pressure Vessel Failures:** Storage and processing equipment in pressurised gas service will be operating at pressures of between 0.2 – 6.2 MPa (normal operating pressure at the turbines is 2.5MPa). Vessels, such as the filter, may suffer from failure due to corrosion, erosion or mechanical impact. Major incidents involving the vessels include catastrophic failure and smaller leaks.

Corrosion and erosion caused failures usually result in small leaks which are detected early and corrected. Leak duration may be of the order of ten minutes for such events. Further, pressure surge or significant deviations of pressure or temperature may cause a flanged joint to be overstressed, resulting in a small leak.

Larger holes through to complete nozzle / pipe fracture may conceivably result from mechanical impact or pressure surge. These events are likely to be detected more rapidly, resulting in quicker isolation of the leak.

The potential to release natural gas will be minimised by:

- Use of fully welded pipework wherever possible;
- Minimizing pipe-runs (pipe lengths);
- Pipes of robust design (designed to comply with the requirements of Australian Standard AS4041 - Pressure piping);
- Overpressure protection provided by three methods:
 - o Rapid control valve closure under alarm conditions;
 - o Emergency isolation valve installed at the inlet to each control valve run; and
 - o Pressure relief valve.
- An actuated isolation valve will installed at the inlet to the Delta Electricity Facility; and
- Control and communications equipment to provide remote monitoring and central control of system by operating staff.

Recommendation 2: Use of leak detection in areas where high risk natural gas piping is used (high likelihood of leak and/or confined locations).

A fire protection system will be installed in the Marulan Site. The fire control system will be developed to meet all requirements of Building Code of Australia and NSW Fire Brigade. Elements of the system will include:

- Provision of water to the Facility;
- Provision of permanent water storage, to meet the supply volume objectives;
- Provision of booster pumps – duty and standby, if required, to meet the specified pressure objectives;
- Provision of fire hydrants and hose reels if required and as nominated by above requirements.

B. Pipe / Vessel Internal Explosion

An explosion within piping or inside a vessel is theoretically possible during start-up, shut-down and maintenance operations. Due to the limited quantities of gas involved the effects of the explosion would however not be expected to pose a threat to nearby businesses or to any residential areas in the vicinity. Therefore, the probability of an explosion due to ignition of an explosive mixture within piping and vessels is considered negligible and will not be analysed further in this PHA. This conclusion is based on the following observations:

- All piping will normally operate at a positive pressure, thereby preventing ingress of air in the event of a pipe or other equipment failure;
- Prevention of ingress of air will be considered throughout the design and operation of the Delta Electricity Facility (for example in the preparation of start-up, shut-down and maintenance procedures).

5.2.2 Gas Turbine Enclosure

A. Introduction and legislative framework

Despite the best efforts during design and management of the Delta Electricity Facility, natural gas turbines are not beyond mishap. Assuming that the gas turbines will be enclosed in acoustic chambers to reduce noise and permit turbine cooling by ventilation, a degree of confinement would be introduced. Ignition of fuels released into the turbine enclosure can cause fire and, because of the confinement, even explosions. Note that the explosive event is not credible in an unconfined scenario, where the gas turbines are not enclosed inside acoustic enclosure.

Gas Turbines typically rely on complex fuel supply pipes with multiple high-pressure joints to deliver the primary fuel, natural gas. *The large number of flanges and joints, combined with high pressures, presents an explosion hazard within the housing in the event of fuel leaks*, noted Mr Hunt, a chemical engineer at Eutech who led the risk assessment study⁴ undertaken as a result of an explosion in a gas turbine acoustic housing at Teeside Power Station, UK in 1996 (Ref 14).

⁴ At 12:25 a.m. on July 17, 1996, a fire and explosion occurred in the unit 106 turbine enclosure at the Teeside Power Station, attributed to a naphtha leak, in a plant that has natural gas, propane and naphtha fuels.

Since the Teeside explosion, guidelines and codes of practice have been developed, and are now in use, notably the European ATEX Directive (Ref 8) and the UK Health and Safety Executive's Guidance Note PM84: *Control of safety risks at gas turbines used for power generation* (Ref 9), both which are gaining wide acceptance in Australia.

The HSE Guidance Note PM84 covers the design and operation of gas turbine installations, making specific and practical recommendations with regard to operational functions such as alarm and engine trip conditions, and the maximum acceptable volume of clouds of explosive mixtures of gas and air.

Although it is not a specific legislative requirement to comply with these guidelines, they provide plant operators and legislators with a framework for assessing whether operation of a plant is satisfactory from a general Health and Safety standpoint (Ref 10). It is therefore appropriate for installations to adhere to the guidelines as far as is reasonably practicable, or other guidance / regulation of equivalent safety.

B. Basis of safety requirements

Basis of safety of gas turbine operation is generally achieved through a combination of:

- Elimination or control of sources of ignition as far as reasonably possible, following legislative requirements and Australian Standard requirement (e.g. for control of sources of ignition in potentially explosive atmosphere). Note that it may not be technically possible to reduce the temperature of all hot surfaces to eliminate the potential for an ignition of natural gas released into the gas turbine enclosure; and
- Limitation of the volume of the explosive atmosphere by the application of all or a combination of:
 - o **Dilution ventilation.** Note that dilution ventilation reduces the size of any flammable cloud to below that which would result in a hazardous explosion if ignited. In order that the dilution ventilation ensures a negligible risk of an explosive atmosphere at all times, the ventilation system should have additional safety features such as e.g.: a 100% standby fan; an uninterruptible power supply to the ventilation fans; interlocks so that the gas turbine cannot start without sufficient ventilation; proven automatic isolation of fuel supply if ventilation fails;
 - o **Flammable gas detection** combined with automatic shut-down of turbine and alarms;
 - o **Explosion relief,**
 - o **Explosion suppression.**

Recommendation 3: The detailed design of the gas turbine enclosure and associated equipment should clearly outline the 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 (Ref 8) and the UK HSE PM84 (Ref 9) or other guidance / regulation of equivalent safety.

Recommendation 4: Fire protection inside the gas turbine enclosure to be determined, including use of explosion panels and use of fire retardant material.

Recommendation 5: A system should be put in place to ensure that any removal of critical safety function (e.g. for repair or exchange) is subject to careful scrutiny by plant management (decisions on whether to shut down the plant or a gas turbine if a critical safety function is removed need to be canvassed).

C. Assumptions Used for this PHA

It is assumed that the basis of safety design for the turbine will include:

- A highly reliable ventilation system, designed to remove even small leaks before lower flammable limits are reached;
- A number of gas detectors linked to automatic shut off of the gas supply;
- Explosion panel(s) which will blow out in an explosion, thereby reducing the risk of a confined explosion.

5.2.3 Violent mechanical failure of rotating machine creates projectile(s)

In case of a mechanical failure of the turbine, projectile may be ejected with high energy, creating a personnel hazard if in the vicinity. Further, if a gas pipe is hit by the projectile or associated equipment / instrumentation then it may fail, causing gas release and fire / explosion if ignition source present.

All rotating machines will be subject to regular and periodic preventative maintenance, including vibration monitoring. If any issues are identified, the machine would be shut down and repaired (as required).

Note that buried pipeline is not at risk from such projectiles.

5.2.4 Storage and Handling of Combustible Liquids (combustible distillate and oils)

The following combustible liquids will be stored and handled at the Delta Electricity Facility:

- Distillate (5kL tank) used for emergency diesel generator;
- Combustible oils (see Table 6 above) will be used in the pumps and turbines).

All the requirements for risk management of these combustible liquids will be as per AS1940 (*Storage and handling of flammable and combustible liquids*, Ref11), including:

- Bunding requirements as per AS1940, i.e. 100% of the largest tank, with bonding design and construction as per Section 5.9.3 in AS1940.

- Any valve controlling the drainage from the bunds is to be located outside the bund.
- Overflow line from all tanks is / will be open to atmosphere and directed to bund.
- Run-off from external (unbunded) areas would be captured in the first flush stormwater system which is designed to retain the first flush runoff from these areas.
- Fire protection as per AS1940.
- Valving and piping associated with the storage as per AS1940 Section 7.
- Control of ignition sources as per AS1940 Section 9.7.6.
- Communication systems.
- Visual inspection of tanks, lines and equipment. Preventative maintenance program.
- Overfill protection through level switch and auto shut off of transfer.
- Overflow line and vent line on top of diesel tank to minimise risk of overpressurisation of tank.
- Foundations, supports, bearing etc. designed and constructed in accordance with AS1940. Tanks and associated equipment are protected from external impact by the bund wall (concrete) which is designed to comply with criteria in AS1940.
- Spill during tanker unloading, in case of leaks of the pipeline during fuel forwarding to the turbines or inside the turbine enclosure would be captured in the interceptor pit (capable of capturing 5000L spills).
- Disposal of spills in accordance with established procedures.

Provided that the requirements from AS1940 and the above recommendations are adhered to, the risk of an incident involving the combustible material stored and handled is small.

5.2.5 Water Treatment

The main risk associated with the water treatment plant is related to the storage and handling of corrosive liquids and toxic gases (see Table 6 above).

Loss of containment of corrosive liquids to ground could cause a possible danger of exposure to people in the vicinity and an environmental hazard if not contained on site. Loss of containment of toxic compressed gases could cause a danger of exposure to people in the vicinity.

This risk will be minimised by a combination of:

- Preventative measures:
 - Minimising pipe lengths by placing the storage areas adjacent to their points of use. Use of hard piping where possible;
 - Preventative maintenance and periodic inspections of plant;
 - Handling procedures and training; and

- Chlorine and ammonia cylinders and drums comply with stringent requirements in terms of construction.
- Protective measures:
 - Bunding of liquid corrosive storages to AS3870 requirements (110% of volume of storage tank);
 - Ensuring the operator is in attendance during transfer operations into storage area;
 - Provision of emergency shower and eye wash station at storage area, and
 - Ensuring Personal Protective Equipment (PPE) requirements are adhered to as per MSDS specifications.
- Emergency measures: if spill into bund the material will be neutralised and cleaned up in accordance with company procedures.

5.2.6 Electricity

Fire or explosion at transformers may be caused by a faulty connection or internal fault in the transformer. Such a transformer incident may cause fire in the switchyard, material damage, potential for propagation to bush or grass outside Marulan Site boundaries and personnel injury.

- Preventative measures include monitoring and alarm systems to ensure early warning.
- Protective measures include automatic isolation of electrical energy sources; provision of clearance zone around high voltage (HV) electrical equipment for separation distance from neighbouring combustible material (grass, bush, etc.); and bunding to contain oil spill.
- Emergency measures include blast walls at the transformers to control a potential blast from destroying neighbouring equipment or endanger people; fire protection system to be available on Marulan Site to minimise damage from fire; and emergency response plan and mustering point for evacuation and emergency services contacted as required.

5.2.7 Cumulative Risk Assessment

A complete risk assessment must consider potential knock-on effects from a hazardous event within the Delta Electricity Facility or outside of the Facility that may have undesirable effects on the proposed Delta Electricity Facility, or where the proposed Delta Electricity Facility may increase the risk of an event occurring.

The impact on the risk of the proposed Delta Electricity power station due to having a second power station (as proposed by EnergyAustralia) located within the same site is assessed below.

Risks that are assessed are risk of domino effects from the Delta Electricity power station onto the EnergyAustralia power station (and vice versa), with the potential to cause fatality and injury from fires and explosions from the acute effects of incidents involving flammable material and electricity at the Marulan Site.

The spills scenarios analysed and detailed in Appendix 1 would take anywhere from a few minutes for a large release and up to one hour for a small release.

As per the Department of Planning guidelines in Ref 2, the heat radiation which is considered for potential knock on effects is 23 kW/m^2 (refer Table 3) above.

The following assumptions for prevention of knock-on effects have been made in this risk assessment:

- The closest turbines at the two facilities are separated by at least 100 metres.
- The layout of the Marulan Site is open and as far as possibly free of confinements.
- An explosion within the turbine enclosures is prevented as per Section 5.2.2 above.
- A spill of liquid combustible material is contained on Marulan Site and directed to safe location well away from nearby EnergyAustralia Facility.

The calculations in Sections 6.3 and 6.4 below show that none of the incidents identified for the Delta Electricity Facility will reach the EnergyAustralia Facility at radiation levels of 23 kW/m^2 (refer Table 15 and Appendix 1). Similarly, as per Ref 3, none of the incidents identified for the EnergyAustralia Facility will reach the Delta Electricity Facility at radiation levels of 23 kW/m^2 .

5.2.8 Marulan Site General

Flooding: Marulan Site elevation and surface run-off design to ensure potential for flooding is minimised. Appropriate level of flood study will be integrated into the Marulan Site design.

Land subsidence, earthquake or mining activity results in plant damage: The Marulan Site is not affected by mine subsidence. Detailed geotechnical study will be performed and the outcomes of this study will be integrated into the design of the plant; Seismic review will be performed and the requirements will be incorporated into the design. Structures and plant will be designed to withstand earthquake effects using well-established procedures in accordance with relevant Australian or international standards. (Note that geological stability has not been assessed as part of the present PHA).

Aircraft crash on Power Station Marulan Site: General aircraft and airline safety measures makes airplane crash unlikely. This scenario, while theoretically possible, does not appear credible for the present development.

Bush / grass fire: A bush or grass fire outside Marulan Site boundaries may, if not managed, affect the site, and a fire on the Marulan Site may cause risk outside site boundaries, possible threat to nearby structures, dwellings etc. and risk to people in the vicinity. A 40m wide bush /grass fire asset protection zone will be provided around the Marulan Site. Further, emergency response plan and work management processes will include care to take during times of bush fire risk.

Storm damage: The risk of damage to plant and structures from storms will be managed through the design phase (through the use of engineering design standards to cope with winds, storms and lightning strikes), and throughout the

operation of the plant (through preventative inspection and maintenance of Marulan Site).

Incident during maintenance and repair work: Incidents during maintenance and repair work may result in a fire, personnel injury and plant damage. This risk is managed through the use of a robust Safety Management System (see Recommendation 1), including trained staff; adequate work processes; adequately checked and maintained equipment; buildings designed to Building Code requirements (including use of fire extinguishers); the use of a dedicated hazardous material storage; gas cylinders (oxyacetylene) stored in accordance with standards, etc.

5.2.9 Road Transport Risks

Once the Delta Electricity Facility has been built and put into operation, the frequency of road transportation to the Delta Electricity Facility of dangerous goods and potentially hazardous material will be relatively low.

It is expected that about 50 deliveries per year will be sufficient for the operation of the Delta Electricity Facility, mainly consisting of the distillate deliveries and delivery of corrosive liquids to the Water Treatment Plant, oil top up for rotating machinery. There will also be transport of other materials used for maintenance or cleaning.

Road transportation would use Canyonleigh Road in Brayton to access the Marulan Site. The entrance road to the Marulan Site is to be of adequate construction for the use and to be maintained and repaired as required.

General transport risks of these materials are handled by transport companies' internal safety requirements. Clean up and incident management will be as per the transport company's procedures.

The quantities and transport movement of potentially hazardous materials for this Facility are well below those listed in the *Transportation Screening Threshold* table (Table 2 in the guidelines on applying SEPP 33 (Ref 12)) as defined by the Department of Planning.

The review of road transport risks concludes that the risk associated with the transport of dangerous goods and potentially hazardous material to the Delta Electricity Facility is very low.

5.3 SOFTWARE SAFEGUARDS

Delta Electricity has a commitment to Occupational Health and Safety (OH&S) and has numerous policies and procedures to achieve a safe workplace. Written safety procedures will be established. An established incident reporting and response mechanism will be established, providing 24 hour coverage. The plant itself will develop procedures specific to the plant and its environment and they will be incorporated into the safety system.

The plant will need to comply with all codes and statutory requirements with respect to work conditions. In addition, special precautions are observed as required by the Marulan Site conditions, in particular, standards and requirement on the handling of pressurised, flammable gases. All personnel required to work with these substances

are trained in their safe use and handling, and are provided with all the relevant safety equipment.

Emergency procedures will be developed. All staff will need to be trained in these procedures and they will be incorporated in the plant's quality system. The emergency procedures will include responses to emergency evacuation, injury, major asset damage or failure, critical power failure, spillages, major fire, and threats.

The Delta Electricity Facility will have a manager (potentially located off-site) with overall responsibility and who is supported by experienced personnel trained in the operation and support of the plant.

A Permit to Work system (including Hot Work Permit) and Control of Modification systems will be in use at the Delta Electricity Facility to control work on existing plant and to control existing plant and structure from substandard and potentially hazardous modifications.

Injury and incident management will be proceduralised and people will be trained in how to report incidents.

Protective Systems will be tested to ensure they are in a good state of repair and function reliably when required to do so. This will include scheduled testing of trips, alarms, gas detectors, relief devices and fire protection systems.

All persons on the premises will be provided with appropriate personal protective equipment suitable for use with the specific corrosive substances.

A first aid station will be provided comprising an appropriate first aid kit and first aid instructions, i.e. MSDSs, for all substances kept or handled on the premises. At least one person on the premises is trained in first aid; and a list of persons trained in, and designated as being responsible for the administering of, first aid is shown on the noticeboards on the premises. Further, the relevant and up-to-date MSDS will be kept in safe location.

6 CONSEQUENCE ANALYSIS

6.1 EVALUATION TECHNIQUES

As none of the material used, produced or handled are toxic, the evaluation of consequences requires only the determination of fire radiation and explosion overpressure. For both fires and explosions, it is necessary to determine the leak rate and duration for each incident. Radiation effects are then determined using the point source method while overpressure effects are determined using the TNT equivalent model in Ref 13.

The explanation of the nomenclature used in the equations below is listed in Table 13 at the end of this Chapter.

6.1.1 Leak Rates

The rate at which a liquid leaks from a hole can be determined using a standard orifice flow equation:

$$\dot{m} = 0.8A\sqrt{(2\rho\Delta P)}$$

For the case where two-phase flow occurs, the calculation technique is much more involved. An acceptable approximation is to divide the liquid flow rate determined in the equation by 3 to allow for two-phase flow.

For gas or vapour flows (as for natural gas), the appropriate equation is:

$$\dot{m} = 0.8AP\sqrt{\frac{M\gamma}{zRT}} \left(\sqrt{\frac{2}{\lambda + 1}} \right)^{\frac{\gamma+1}{\gamma-1}}$$

Note that this applies to the condition known as critical or choked flow, which applies when the internal pressure is more than double the atmospheric pressure (approximately).

6.1.2 Duration

The duration of a leak will depend on the hardware systems available to isolate the source of the leak, the nature of the leak itself and the training, procedures and management of the Delta Electricity Facility. While in some cases it may be argued that a leak will be isolated within one minute, the same leak under different circumstances may take 10 minutes to isolate.

The approach used in this study for failure scenarios identified is to assume three possible event durations and to assign to each the same probability of occurrence. For this analysis, the three leak durations considered were 1 minute, 5 minutes and 10 minutes for manual responses to leaks.

The engineering design is not completed and hence the instrumented protective systems required for the plant operation and safety have not been defined. Hence, assumptions have had to be made in this respect giving rise to the following recommendation:

Recommendation 6: To ensure adequate safety of the operation of the Delta Electricity Facility it is necessary to install an automatic emergency isolation valve at

Facility boundaries which would isolate natural gas supply to the Facility in case of a major leak at one of the natural gas pipes at the Facility. In this risk assessment, 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.

The pressure tapping point associated with the emergency isolation valve is assumed to allow a drop in line pressure to be quickly ascertained. For the purposes of the present risk assessment, closure of the emergency isolating valve is assumed to be able to be triggered either automatically by the sensor (e.g. upon a rapid loss of pressure), or by the operator in the control room. The SCADA system, which includes telemetered data from the valve stations instrumentation, would give the operator sufficient details upon which to make a decision to close the valve.

The mass of flammable gas contained in a cloud which could flash or explode is set at the total amount which would leak out in 3 minutes. This is based on the assumption that a cloud travelling in the direction of the wind will either encounter a source of ignition within this time⁵ or would disperse to concentrations below the Lower Flammable Limit (LFL).

6.1.3 Radiation Effects - The Point Source Method

Radiation effects are evaluated using the point source method, which assumes that a fire is a point source of heat, located at the centre of the flame, and radiating a proportion of the heat of combustion. The radiation intensity at any distance is then determined according to the inverse square law, making allowance for the attenuating effect of atmospheric water vapour over significant distances (e.g. 100m or more).

$$I = \frac{Qf\tau}{4\pi r^2}$$

The rate of heat release, Q , is given by:

$$Q = \dot{m}H_C$$

6.1.4 Explosion Effects - The TNT Model

For explosions, the amount of gas or vapour resulting from the leak is important. For gases this is the total quantity leaking out for the duration of interest.

The equivalent mass of TNT is then determined using the following relationship:

$$m_{TNT} = \frac{\alpha H_C m_V}{4600}$$

The overpressure effect from the vapour cloud is determined using a correlation developed for TNT, which relates the scaled distance (a function of actual distance and mass of TNT) to the overpressure. The scaled distance is given by the relationship in equation:

⁵ In a relatively moderate wind force of say 4 m/s, the cloud would after 3 minutes have covered a distance of 240 metres.

$$\lambda = \frac{r}{(m_{TNT})^{1/3}}$$

6.2 IMPACT ASSESSMENT

The above techniques allow the level of radiation or overpressure resulting from fires and explosions to be determined at any distance from the source. The effect or impact of heat radiation on people is shown in Table 11 while Table 12 shows the effects of explosion overpressure.

Table 11 - Effects of Heat Radiation

Radiant Heat Level (kW/m ²)	Physical Effect (effect depends on exposure duration)
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds' exposure
12.6	Significant chance of fatality for extended exposure High chance of injury
23	Likely fatality for extended exposure and chance of fatality for instantaneous (short) exposure
35	Significant chance of fatality for people exposed instantaneously

Table 12 – Effect of Explosion Overpressure

Overpressure (kPa)	Physical Effect
3.5	90% glass breakage. No fatality, very low probability of injury
7	Damage to internal partitions & joinery 10% probability of injury, no fatality
14	Houses uninhabitable and badly cracked
21	Reinforced structures distort, storage tanks fail 20% chance of fatality to person in building
35	Houses uninhabitable, rail wagons & plant items overturned. Threshold of eardrum damage, 50% chance of fatality for a person in a building, 15% in the open

Overpressure (kPa)	Physical Effect
70	Complete demolition of houses Threshold of lung damage, 100% chance of fatality for a person in a building or in the open

Table 13 – Nomenclature for Section 6

Label	Explanation
A	Area of hole, m ²
C _p	Average liquid heat capacity, kJ/kg.K
f	Fraction of heat radiated
H _c	Heat of combustion, kJ/kg
H _v	Heat of vaporisation, kJ/kg
I	Radiant heat intensity kW/m ²
M	Molecular weight
m	Mass, kg
m _v	Mass of vapour (in cloud), kg
m _{TNT}	Equivalent mass of TNT, kg
$\dot{m}$	Mass flow rate of leak, kg/s
P	Pressure, Pa
P ₁	Upstream absolute pressure, Pa
Q	Heat release rate, kW
R	Universal gas constant, 8.314 J.K/mol
r	Distance from fire/explosion, m
T	Temperature, K
T ₁	Storage temperature, K
T _b	Boiling point, K
t	Duration of leak/time, seconds
z	Gas compressibility factor
α	Explosion efficiency factor
γ	Ratio of specific heats (~1.4)
λ	Scaled distance
ρ	Density, kg/m ³
τ	Atmospheric transmissivity

6.3 CONSEQUENCE CALCULATIONS – NATURAL GAS INCIDENT

This initial outflow rates estimated for natural gas releases are shown in Table 14. The results predict that the rate of decrease in outflow rate for a full bore rupture is dramatic with a drop to less than half of the initial flow within seconds and further rapid decay. However, the present PHA has assumed that the initial release rate remains until isolation can be achieved - this is a highly conservative approach.

Table 14 – Release Rates

Release rate [kg/s]	Hole Size					
	Small leak (3mm)	Flange leak (13 mm)	Intermediate leak (25 mm)	Major leak (80 mm)	Massive leak (100 mm)	Full bore (guillotine)
Upstream of the Pressure Regulator						
Instantaneous	0.08 kg/s	1.4 kg/s	5.3	54	84 kg/s	526 kg/s (first few seconds)
Downstream of the Pressure Regulator						
Instantaneous	0.03 kg/s	0.6 kg/s	2	22	34 kg/s	215 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 below.

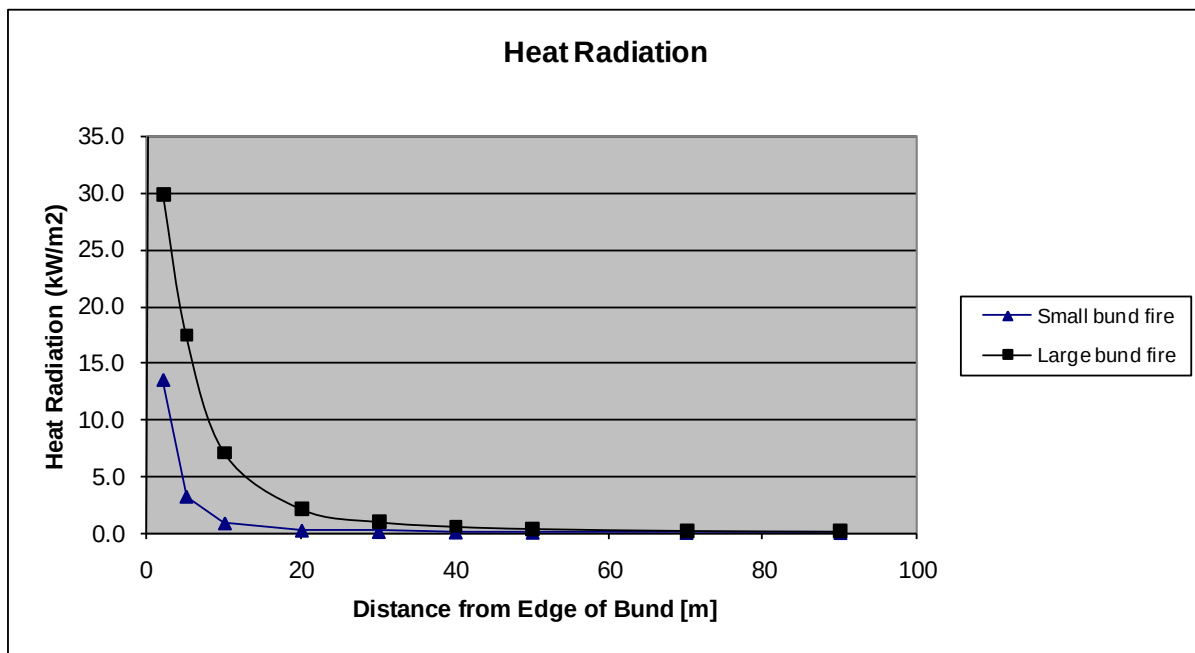
Table 15 – Heat Radiation from Jet Fires

Hole size	Distance to Heat radiation (metres)		
	4.7kW/m ²	12.5kW/m ²	23.5kW/m ²
Upstream of the Pressure Regulator			
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
Downstream of the Pressure Regulator			
Small leak (5mm)	3	2	1.5
Intermediate leak (25 mm)	16	10	8
Massive leak (100 mm)	65	40	30
Full bore (guillotine)	165	100	75

6.4 CONSEQUENCE CALCULATIONS – DISTILLATE FIRE

The consequences of a distillate fire, as calculated using the Point Source method, have been presented below (detailed calculation sheet is included in appendix 1). Two scenarios were investigated, namely a “small” and a “large” fire, covering 10% and 100% of the surface of the bund respectively⁶.

Figure 5 – Heat Radiation from Distillate Bund Fire



⁶ The bund has not been designed at the time of this PHA. This PHA assumed that the bund would be 5 m x 4 m (20 m²).

7 FREQUENCY ANALYSIS

7.1 GENERIC EQUIPMENT FAILURES

A summary of all incident scenarios that are incorporated into the PHA are listed in Appendix 1. The frequency of each postulated equipment failure was determined using the data in the table below.

The frequencies used for fixed plant and above ground piping are those that have been in use by Orica Engineering for over 15 years of risk assessments in Australia. These frequencies are based on Orica Engineering's interpretation of published and unpublished (internal ICI and Orica) data.

Table 16 - Equipment Failures and Associated Frequencies

Type of Failure	Failure Rate (pmpy)
PIPELINES WITHIN FIXED PLANT (DELTA ELECTRICITY FACILITY)	
3 mm hole	9 / m
13 mm hole	3 / m
50 mm hole	0.3 / m
3 mm gasket (13 mm hole equivalent)	5 / joint
Guillotine fracture (full bore):	
< 50 mm	0.6 / m
> 50 mm but < 100 mm	0.3 / m
> 100 mm	0.1 / m
VESSELS	
6 mm hole	24
13 mm hole	6
25 mm hole	3
50 mm hole	3

The design of the power station has not been finalised and accurate P&IDs are not available at the time of this PHA. In such cases, conservative assumptions relating to the design need to be made, including the length of pipe, number of flanges required, operating pressures used etc.

Further, the article by Professor Michael Valenti for The American Society of Mechanical Engineers (Ref 14) provides an estimate of the complexity of the pipework and flange-systems inside the acoustic housing of the turbines: *For example, a 250-megawatt turbine's pipework may have more than 200 flanges and 90 flexible joints.*

7.2 PROBABILITY OF OPERATION OF PLANT

This risk assessment has assumed that the both the peaking plant (Stage 1) and the combined cycle plant (Stage 2) will operate 100% of the time and that all parts of the plant will be pressurised, capable of releasing gas if damage occurs, 100% of the time. This is conservative, especially for the peaking plant which is designed to operate for about 7% of the time.

7.3 FAILURE OF AUTOMATIC PROTECTION

Automatic isolation valves will be positioned at the lateral gas supply pipeline, closing automatically in case of a major leak of gas. The following estimates of probabilities have been used as a guide for the purposes of determining the reliability of the automatic protection (Ref 15).

While the design of the control system is not finalised, it is assumed that the protective systems will be designed to SIL 1 requirements.

Table 17 - Probability of Human Error

Safety Integrity Level (SIL)	Low Demand Mode of Operation (probability of failure to perform as intended on demand)
4	$\geq 10^{-5}$ to $< 10^{-4}$
3	$\geq 10^{-4}$ to $< 10^{-3}$
2	$\geq 10^{-3}$ to $< 10^{-2}$
1	$\geq 10^{-2}$ to $< 10^{-1}$

7.4 HUMAN ERROR

The following estimates of human error have been used as a guide for the purposes of determining human responses (Ref 16):

Table 18 - Probability of Human Error

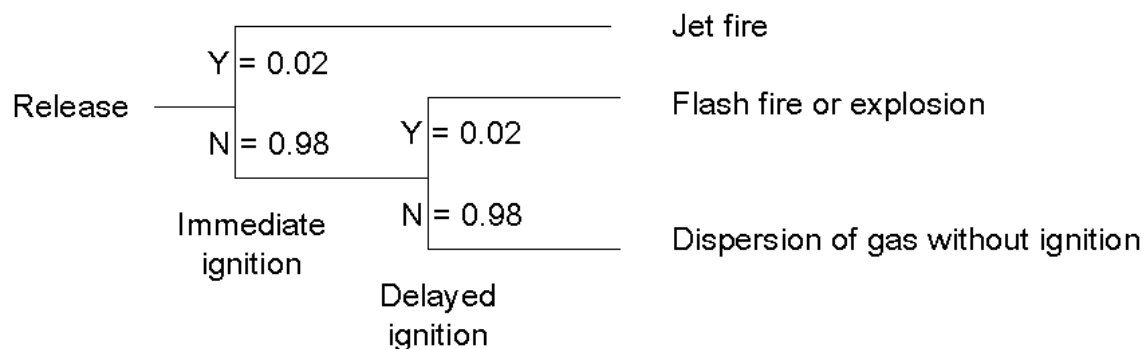
ACTIVITY	Probability of error
Probability of failing to take correct action in high stress situations with one minute in which to act	0.9-1.0
Error in non-routine operation when other duties required	0.1
Error in routine operation where some care is needed	0.01
Error in routine simple operation	0.001

7.5 PROBABILITY OF FLAMMABLE OUTCOME

The ignition probabilities used in this study were those used in the NSW Locational Guidelines for Methane Gas Wells (Ref 17) as per the note from the Department of

Planning to Planager 10 March 2007 (Ref 18).), as shown in Figure 6 below. These probabilities were developed by the Department to determine the likelihood of a flammable event following a release of gas from gas well installations located within a number of different types of development (open space, business, residential and sensitive development), and for the types of ignition sources which may be encountered within these developments. This data was deemed relevant for the proposed development in its location close to the proposed EnergyAustralia Facility.

Figure 6 – Ignition Probabilities

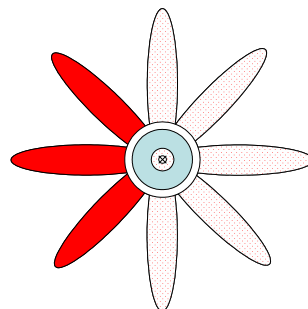


The probability of an explosion in open plant is very low for a natural gas leak out in the open and is not considered a credible event for a release of gas outside of the enclosures of the gas turbine. This event is considered as a credible event for a flammable incident inside the gas turbine enclosure (see below).

The frequency of outcome of each individual incident scenario is listed in the spreadsheet in Appendix 1.

Jet fires are directional (as opposed to flash fires that are omni directional). While a jet fire can be directed towards any point in the sphere, about one third of all jet fires are assumed to be directed towards a boundary. This is based on the concept depicted in Figure 7 below, with the dark jets being those assumed to be directed towards the boundary and the light being assumed to be directed away from the boundary.

Figure 7 – Jet Fire Distribution



7.6 RELATIONSHIP BETWEEN EXPOSURE AND EFFECT

The relationship between exposure and effect was estimated based on the probit equation for heat radiation. In the case of flash fires, 100% fatality was assumed for anyone engulfed within the flaming cloud, and 0% probability outside it. (In the case of a Vapour Cloud Explosion (where relevant), the relationship between overpressure and probability of fatality defined in the Orica course material (Ref 13) is taken as defining the lethal zone.)

8 RISK RESULTS AND COMPARISON WITH RISK CRITERIA

8.1 RISK CALCULATION – POWER STATION

8.1.1 Risk of a Confined Explosion Inside the Turbine Enclosure

The likelihood of a confined explosion inside the gas turbine enclosure was estimated taking into account that the basis of safety would include in the minimum (see Recommendations 2, 3, 4, and 5):

- Highly reliable ventilation fan system,
- Gas detection linked to automatic emergency shut-down system,
- Prevention of ignition sources within the enclosure, and
- Separation distances to nearby gas turbines and pressure piping.

The frequency of explosion inside the turbine enclosure can be estimated as follows:

Explosion frequency = (Gas release frequency within enclosure) x (Ventilation fan failure probability) x (Gas detection and emergency shutdown failure probability) x (Ignition probability of accumulated gas) x (Explosion if ignition probability).

With the following assumptions:

- Gas leak frequency = 1.4×10^{-3} t/yr per enclosure (assuming equipment failure frequencies as per Table 16 and 290 flanges and flexible joints as per information in Table 2 above).
- Ventilation fan failure probability, allowing accumulation of gas = 0.01 (see recommendation 3).
- Gas detection failure and failure of the emergency shut-down = 0.05 per gas detector, assume two independent detectors (and that both have to fail or fail to pick up the leak). Also, taken into account is a 0.0025 probability of common mode failure for gas detectors (e.g. due to maintenance failure affecting detector system).
- Ignition probability of accumulated gas = 1. Even though all equipment and instrumented protective equipment used in the enclosure need to be designed for the hazardous zone requirements, a gas turbine could have hot surfaces above the auto ignition temperature of the fluids used even in normal circumstances (operation under fault conditions may increase surface temperatures).
- Explosion if ignition probability = 1 (i.e. assuming that all ignitions of flammable gases inside the enclosure would lead to an explosion. This is highly conservative).

Calculations show:

$$\text{Explosion frequency} = (1.45 \times 10^{-3}) \times (0.01) \times (0.05 \times 0.05 + 0.0025) \times (1) \times (1) = 7.2 \times 10^{-8} \text{ per year per enclosure.}$$

With two enclosures, the total frequency of explosion inside gas turbine enclosure is:

$$F(\text{explosion in gas turbine enclosure}) = 1.45 \times 10^{-7} \text{ per year.}$$

This frequency is very low.

A confined explosion may generate high over pressures which could damage neighbouring equipment and gas turbines. It is however understood that the enclosures will be designed with explosions vents (/ panels) which would blow out in case of a pressure event, thereby reducing the effect of the confinement. Further, the turbines at the neighbouring EnergyAustralia power station will be separated from the Delta Electricity turbines by at least 100 meters.

With proper design it is unlikely that an explosion at one turbine would have serious effect at a neighbouring turbine or at the neighbouring EnergyAustralia power station.

Further, providing recommendations 2, 3, 4 and 5 are carried out, the risk from an explosion at turbine enclosure will be contained well within the Delta Electricity Facility boundary.

8.1.2 Fire Risk – Distillate Storage

The likelihood of a distillate fire at the Delta Electricity Facility, taking into account the properties of the material and its use within the Delta Electricity Facility, is very low.

Hence, the risk of a diesel fire is minimal, provided the storage is designed in accordance with code requirements (in particular AS1940, Ref 11).

8.1.3 Overall Individual Risk of Fatality Risk

For the present development, the risk of fatality of 1 pmpy does not extend beyond the Delta Electricity Facility boundaries and is therefore well away from the residential areas.

Note that all data used in this risk assessment are for a plant operating 100% of the time. The quantitative risk results are valid, though highly conservative, for the plant under the expected operating conditions, which are for a plant operating at about 7% of the time.

8.1.4 Cumulative Risk

The analysis showed that none of the incidents identified for the Delta Electricity Facility will reach the EnergyAustralia Facility at radiation levels where propagation may occur. Similarly, none of the incidents identified for the EnergyAustralia Facility will reach the Delta Electricity Facility at radiation levels where propagation may occur. Hence, there is no increase in the risk associated with the Delta Electricity Facility from having the EnergyAustralia Facility at its proposed location on the same site. Further, the Delta Electricity Facility does not increase the risk associated with the EnergyAustralia Facility.

8.1.5 Overall Societal Risk of Fatality

The above criteria for individual risk do not necessarily reflect the overall risk associated with any proposal. In some cases for instance, where the 1 pmpy contour approaches closely to residential areas or sensitive land uses, the potential

may exist for multiple fatalities as the result of a single accident. One attempt to make comparative assessments of such cases involves the calculation of societal risk. As the risk of fatality of 1 pmpy does not extend beyond the Delta Electricity Facility boundaries the concept of societal risk is not applicable for the proposed development.

8.2 TRANSPORT RISK

The review of road transport risks concludes that the risk associated with the transport of dangerous goods and potentially hazardous material to the Delta Electricity Facility is very low.

9 CONCLUSION AND RECOMMENDATIONS

9.1 OVERVIEW OF RISK

The main hazard associated with the proposed project is associated with the handling of natural gas (predominantly composed of methane gas), which is a flammable gas held under pressure. Other, less significant hazards are associated with the handling of combustible liquids (distillate and oils) and of corrosive liquids for use within the water treatment plant.

Hazards may arise in fixed plant, storage, and pipelines. The predominant mode in which a hazardous incident may be generated is associated with a leak. 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:

- Failure must occur causing a release. There are several possible causes of failure, with the main ones being corrosion and damage to the equipment 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 material involved and how rapidly it is ignited, the results may be a localised fire (for example a so called 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.

9.2 SUMMARY OF RISK RESULTS

The detailed design has not been completed as yet for this development. A set of very conservative assumptions as to the design and operation of the plant have been made, including a 100% on-line operation of the plant (although at this stage it is understood the Delta Electricity Facility that Stage 1 will be operational for approximately 5% of the year and Stage 2 will be operational for 90% of the time, with appropriate fire proof isolation valves separating the plant from pressurised gas supplies).

The qualitative and quantitative analysis showed that:

- 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 Delta Electricity Facility boundaries.
- It follows that the 10×10^{-6} per year fatality risk contour (relevant for open spaces) remains well within the Delta Electricity Facility 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 Delta Electricity Facility boundaries and does not encroach into any business or industrial zones. The criterion for industrial and business zoning is therefore satisfied.
- The 50×10^{-6} per year injury risk contour remain well within the Delta Electricity Facility boundaries. The criterion for injury risk is therefore satisfied.
- The 50×10^{-6} per year propagation risk contour remain well within the Delta Electricity Facility boundaries. The criterion for propagation risk is therefore satisfied.
- The analysis showed that, in terms of cumulative risk impact, there is no increase in the risk associated with each proposed power station Facility (Delta Electricity and EnergyAustralia) from having two facilities on the same site at their proposed location.
- As the risk of fatality does not extend anywhere outside the Delta Electricity Facility boundaries, it is considered that the proposed development does not have a significant impact on societal risk.
- The risk associated with the transport of dangerous goods and potentially hazardous material to the Delta Electricity Facility 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.

9.3 RECOMMENDATIONS

The risk assessment carried out in this study assumed that the Delta Electricity Facility will be operated with appropriate consideration to safety and safety management at all stages.

The following recommendations emphasise the assumptions made in this risk assessment:

Recommendation 1: 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.

Recommendation 2: It is recommended 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, is be conducted within the first year of operation.

Recommendation 3: Leak detection equipment to be used in areas where high risk natural gas piping is used (high likelihood of leak and/or confined locations).

Recommendation 4: The detailed design of the gas turbine enclosure and associated equipment should clearly outline the 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 (Reference 8) and the UK HSE PM84 (Reference 9) or other guidance / regulation of equivalent safety.

Recommendation 5: Fire protection inside the gas turbine enclosure to be determined, including use of explosion panels and use of fire retardant material.

Recommendation 6: 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. In this risk assessment, 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.

Appendix 1

Risk Calculation Sheets

Preliminary Hazard Analysis of Delta Electricity's Gas Turbine Facility at Marulan

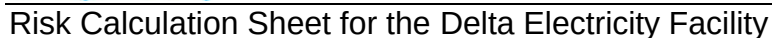
Appendix 1 - Consequence Assessment

OUTFLOW RATES

Gas flow rate = $0.8 \times A \times P \left\{ \frac{M}{zRT} \times \left[\frac{2}{\gamma + 1} \right]^{0.5} \right\}^{\frac{\gamma + 1}{\gamma - 1}} \times \left(\frac{\gamma - 1}{\gamma + 1} \right)^{0.5}$				
R =	8.314	J.K/mol		
T =	293	K		
gamma =	1.31	ratio of specific heat		
z =	1	assume ideal gas		
M =	18	g/mol		
P =	6.20E+06	Pa	Upstream of regulator	
P =	2.53E+06	Pa	Downstream of regulator	

ONSITE PIPE FAILURES - RISK ASSESSMENT

Leak size (m)	Cross section	Flow rate (kg/s)	
3.00E-03	7.07E-06	7.57E-02	Upstream of regulator
1.30E-02	1.33E-04	1.42E+00	Upstream of regulator
5.00E-02	1.96E-03	2.10E+01	Upstream of regulator
2.50E-01	4.91E-02	5.26E+02	Upstream of regulator
3.00E-03	7.07E-06	3.09E-02	Downstream of regulator
1.30E-02	1.33E-04	5.80E-01	Downstream of regulator
5.00E-02	1.96E-03	8.59E+00	Downstream of regulator
2.50E-01	4.91E-02	2.15E+02	Downstream of regulator
5.00E-03	1.96E-05	8.59E-02	Downstream of regulator
2.50E-02	4.91E-04	2.15E+00	Downstream of regulator
1.00E-01	7.85E-03	3.43E+01	Downstream of regulator
2.50E-01	4.91E-02	2.15E+02	Downstream of regulator



Preliminary Hazard Analysis Of Delta Electricity's
Gas Turbine Facility At Marulan

A1.3

c:\curs\07-b108Pha Delta Marulan Rev C
Revision C 14 May, 2008

EQUIPMENT	EAST	NORTH	TYPE	LENGTH metres	#JOINTS	TRIP	LEAK FREQ. /yr	FLASH FIRE FREQ. /yr	EXPL. FREQ. /yr	GAS PRES. Pa	DIAM ORIF. Metres	CROSS AREA m2	REL.HEIGHT m	LEAK RATE kg/s	MW (megawatts)	TNT 4%	CLOUD (KG)	DURAT (S)	DRIFT	
FLASH FIRE SCENARIOS																				!!!! ROW 482 STARTS JET FIRE SCENARIOS
BATGR	0	5	PI	10	20	NO	0.00E+00	0.00E+00	0.00E+00	6.20E+06	3.00E-03	7.07E-06	0.00E+00	7.57E-02	5.68E-01	2.47E-01	4.54E+01	2	0	
BATGR	0	5	PI	10	20	NO	3.00E-08	4.51E-10	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0	
BATGR	0	5	PI	10	20	YES	4.11E-09	9.15E-10	0.00E+00	6.20E+06	5.00E-02	1.96E-03	0.00E+00	2.10E+01	1.58E+02	6.86E+01	1.26E+04	10	0	
BATGR	0	5	PI	10	20	YES	1.78E-10	1.78E-10	0.00E+00	6.20E+06	2.54E-01	5.06E-02	0.00E+00	5.26E+02	3.94E+03	1.71E+03	3.15E+05	23	0	
BATGR	0	5	PI	10	20	NO	3.56E-09	5.35E-11	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0	
GRJTA	27	34	PI	120	5	NO	1.20E-04	3.93E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
GRJTA	27	34	PI	120	5	NO	4.00E-05	2.46E-07	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
GRJTA	27	34	PI	120	5	YES	2.00E-07	1.82E-08	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0	
GRJTA	27	34	PI	120	5	YES	6.67E-08	6.67E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0	
GRJTA	27	34	PI	120	5	NO	2.78E-06	1.71E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTAJTB	90	34	PI	38	5	NO	3.80E-05	1.24E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
JTAJTB	90	34	PI	38	5	NO	1.27E-05	7.78E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTAJTB	90	34	PI	38	5	YES	6.33E-08	5.76E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0	
JTAJTB	90	34	PI	38	5	YES	2.11E-08	2.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0	
JTAJTB	90	34	PI	38	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0	
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0	
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTATA	75	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
JTATA	75	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTATA	75	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0	
JTATA	75	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0	
JTATA	75	45	PI	20	20	NO	1.11E-05	6.83E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTBTB	110	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
JTBTB	110	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTBTB	110	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0	
JTBTB	110	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0	
JTBTB	110	45	PI	20	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0	
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0	
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
BATGR	0	5	PI	10	20	NO	0.00E+00	0.00E+00	0.00E+00	6.20E+06	3.00E-03	7.07E-06	0.00E+00	7.57E-02	5.68E-01	2.47E-01	4.54E+01	2	0	
BATGR	0	5	PI	10	20	NO	3.00E-08	4.51E-10	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0	
BATGR	0	5	PI	10	20	YES	4.11E-09	9.15E-10	0.00E+00	6.20E+06	5.00E-02	1.96E-03	0.00E+00	2.10E+01	1.58E+02	6.86E+01	1.26E+04	10	0	
BATGR	0	5	PI	10	20	YES	1.78E-10	1.78E-10	0.00E+00	6.20E+06	2.54E-01	5.06E-02	0.00E+00	5.26E+02	3.94E+03	1.71E+03	3.15E+05	23	0	
BATGR	0	5	PI	10	20	NO	3.56E-09	5.35E-11	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0	
GRJTA	27	34	PI	120	5	NO	1.20E-04	3.93E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
GRJTA	27	34	PI	120	5	NO	4.00E-05	2.46E-07	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
GRJTA	27	34	PI	120	5	YES	2.00E-07	1.82E-08	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0	
GRJTA	27	34	PI	120	5	YES	6.67E-08	6.67E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0	
GRJTA	27	34	PI	120	5	NO	2.78E-06	1.71E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTAJTB	90	34	PI	38	5	NO	3.80E-05	1.24E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
JTAJTB	90	34	PI	38	5	NO	1.27E-05	7.78E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTAJTB	90	34	PI	38	5	YES	6.33E-08	5.76E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0	
JTAJTB	90	34	PI	38	5	YES	2.11E-08	2.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0	
JTAJTB	90	34	PI	38	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0	
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0	
JTBJTC																				

JTATA	75	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTATA	75	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTATA	75	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTATA	75	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTATA	75	45	PI	20	20	NO	1.11E-05	6.83E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JBTB	110	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JBTB	110	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JBTB	110	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JBTB	110	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JBTB	110	45	PI	20	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
BATGR	0	5	PI	10	20	NO	0.00E+00	0.00E+00	0.00E+00	6.20E+06	3.00E-03	7.07E-06	0.00E+00	7.57E-02	5.68E-01	2.47E-01	4.54E+01	2	0
BATGR	0	5	PI	10	20	NO	3.00E-08	4.51E-10	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0
BATGR	0	5	PI	10	20	YES	4.11E-09	9.15E-10	0.00E+00	6.20E+06	5.00E-02	1.96E-03	0.00E+00	2.10E+01	1.58E+02	6.86E+01	1.26E+04	10	0
BATGR	0	5	PI	10	20	YES	1.78E-10	1.78E-10	0.00E+00	6.20E+06	2.54E-01	5.06E-02	0.00E+00	5.26E+02	3.94E+03	1.71E+03	3.15E+05	23	0
BATGR	0	5	PI	10	20	NO	3.56E-09	5.35E-11	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0
GRJTA	27	34	PI	120	5	NO	1.20E-04	3.93E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
GRJTA	27	34	PI	120	5	NO	4.00E-05	2.46E-07	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
GRJTA	27	34	PI	120	5	YES	2.00E-07	1.82E-08	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
GRJTA	27	34	PI	120	5	YES	6.67E-08	6.67E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
GRJTA	27	34	PI	120	5	NO	2.78E-06	1.71E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTAJTB	90	34	PI	38	5	NO	3.80E-05	1.24E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTAJTB	90	34	PI	38	5	NO	1.27E-05	7.78E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTAJTB	90	34	PI	38	5	YES	6.33E-08	5.76E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTAJTB	90	34	PI	38	5	YES	2.11E-08	2.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTAJTB	90	34	PI	38	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTATA	75	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTATA	75	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTATA	75	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTATA	75	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTATA	75	45	PI	20	20	NO	1.11E-05	6.83E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JBTB	110	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JBTB	110	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JBTB	110	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JBTB	110	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JBTB	110	45	PI	20	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0

EQUIP-MENT	EAST	NORTH	TYPE	LENGTH metres	#JOINTS	TRIP	LEAK FREQ./yr	JET FIRE FREQ. /yr	EXPL. FREQ./yr	GAS PRES. Pa	DIAM ORIF. Metres	CROSS AREA m2	REL.HEIGHT m	LEAK RATE kg/s	MW (megawatts)	TNT 4%	CLOUD (KG)	DURAT (S)	DRIFT
JET FIRE SCENARIOS																			
BATGR	0	5	PI	10	20	NO	0.00E+00	0.00E+00	0.00E+00	6.20E+06	3.00E-03	7.07E-06	0.00E+00	7.57E-02	5.68E-01	2.47E-01	4.54E+01	2	0
BATGR	0	5	PI	10	20	NO	3.00E-08	4.51E-10	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0
BATGR	0	5	PI	10	20	YES	4.11E-09	9.15E-10	0.00E+00	6.20E+06	5.00E-02	1.96E-03	0.00E+00	2.10E+01	1.58E+02	6.86E+01	1.26E+04	10	0
BATGR	0	5	PI	10	20	YES	1.78E-10	1.78E-10	0.00E+00	6.20E+06	2.54E-01	5.06E-02	0.00E+00	5.26E+02	3.94E+03	1.71E+03	3.15E+05	23	0
BATGR	0	5	PI	10	20	NO	3.56E-09	5.35E-11	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0
GRJTA	27	34	PI	120	5	NO	1.20E-04	3.93E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
GRJTA	27	34	PI	120	5	NO	4.00E-05	2.46E-07	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
GRJTA	27	34	PI	120	5	YES	2.00E-07	1.82E-08	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
GRJTA	27	34	PI	120	5	YES	6.67E-08	6.67E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
GRJTA	27	34	PI	120	5	NO	2.78E-06	1.71E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTAJTB	90	34	PI	38	5	NO	3.80E-05	1.24E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTAJTB	90	34	PI	38	5	NO	1.27E-05	7.78E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTAJTB	90	34	PI	38	5	YES	6.33E-08	5.76E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTAJTB	90	34	PI	38	5	YES	2.11E-08	2.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTAJTB	90	34	PI	38	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTATA	75	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTATA	75	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTATA	75	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTATA	75	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTATA	75	45	PI	20	20	NO	1.11E-05	6.83E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBTB	110	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTBTB	110	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBTB	110	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTBTB	110	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTBTB	110	45	PI	20	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
BATGR	0	5	PI	10	20	NO	0.00E+00	0.00E+00	0.00E+00	6.20E+06	3.00E-03	7.07E-06	0.00E+00	7.57E-02	5.68E-01	2.47E-01	4.54E+01	2	0
BATGR	0	5	PI	10	20	NO	3.00E-08	4.51E-10	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0
BATGR	0	5	PI	10	20	YES	4.11E-09	9.15E-10	0.00E+00	6.20E+06	5.00E-02	1.96E-03	0.00E+00	2.10E+01	1.58E+02	6.86E+01	1.26E+04	10	0
BATGR	0	5	PI	10	20	YES	1.78E-10	1.78E-10	0.00E+00	6.20E+06	2.54E-01	5.06E-02	0.00E+00	5.26E+02	3.94E+03	1.71E+03	3.15E+05	23	0
BATGR	0	5	PI	10	20	NO	3.56E-09	5.35E-11	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0
GRJTA	27	34	PI	120	5	NO	1.20E-04	3.93E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
GRJTA	27	34	PI	120	5	NO	4.00E-05	2.46E-07	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
GRJTA	27	34	PI	120	5	YES	2.00E-07	1.82E-08	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
GRJTA	27	34	PI	120	5	YES	6.67E-08	6.67E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
GRJTA	27	34	PI	120	5	NO	2.78E-06	1.71E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTAJTB	90	34	PI	38	5	NO	3.80E-05	1.24E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTAJTB	90	34	PI	38	5	NO	1.27E-05	7.78E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTAJTB	90	34	PI	38	5	YES	6.33E-08	5.76E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTAJTB	90	34	PI	38	5	YES	2.11E-08	2.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTAJTB	90	34	PI	38	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0

JTATA	75	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTATA	75	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTATA	75	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTATA	75	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTATA	75	45	PI	20	20	NO	1.11E-05	6.83E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JBTB	110	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JBTB	110	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JBTB	110	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JBTB	110	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JBTB	110	45	PI	20	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
BATGR	0	5	PI	10	20	NO	0.00E+00	0.00E+00	0.00E+00	6.20E+06	3.00E-03	7.07E-06	0.00E+00	7.57E-02	5.68E-01	2.47E-01	4.54E+01	2	0
BATGR	0	5	PI	10	20	NO	3.00E-08	4.51E-10	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0
BATGR	0	5	PI	10	20	YES	4.11E-09	9.15E-10	0.00E+00	6.20E+06	5.00E-02	1.96E-03	0.00E+00	2.10E+01	1.58E+02	6.86E+01	1.26E+04	10	0
BATGR	0	5	PI	10	20	YES	1.78E-10	1.78E-10	0.00E+00	6.20E+06	2.54E-01	5.06E-02	0.00E+00	5.26E+02	3.94E+03	1.71E+03	3.15E+05	23	0
BATGR	0	5	PI	10	20	NO	3.56E-09	5.35E-11	0.00E+00	6.20E+06	1.30E-02	1.33E-04	0.00E+00	1.42E+00	1.07E+01	4.63E+00	8.53E+02	5	0
GRJTA	27	34	PI	120	5	NO	1.20E-04	3.93E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
GRJTA	27	34	PI	120	5	NO	4.00E-05	2.46E-07	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
GRJTA	27	34	PI	120	5	YES	2.00E-07	1.82E-08	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
GRJTA	27	34	PI	120	5	YES	6.67E-08	6.67E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
GRJTA	27	34	PI	120	5	NO	2.78E-06	1.71E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTAJTB	90	34	PI	38	5	NO	3.80E-05	1.24E-08	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTAJTB	90	34	PI	38	5	NO	1.27E-05	7.78E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTAJTB	90	34	PI	38	5	YES	6.33E-08	5.76E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTAJTB	90	34	PI	38	5	YES	2.11E-08	2.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTAJTB	90	34	PI	38	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTBJTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTBJTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTATA	75	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTATA	75	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTATA	75	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTATA	75	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTATA	75	45	PI	20	20	NO	1.11E-05	6.83E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JBTB	110	45	PI	20	20	NO	2.00E-05	6.54E-09	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JBTB	110	45	PI	20	20	NO	6.67E-06	4.10E-08	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JBTB	110	45	PI	20	20	YES	3.33E-08	3.03E-09	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JBTB	110	45	PI	20	20	YES	1.11E-08	1.11E-08	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JBTB	110	45	PI	20	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	3.00E-03	7.07E-06	0.00E+00	3.09E-02	2.32E-01	1.01E-01	1.85E+01	2	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	5.00E-02	1.96E-03	0.00E+00	8.59E+00	6.44E+01	2.80E+01	5.15E+03	8	0
JTCTC	0	0	PI	0	0	YES	0.00E+00	0.00E+00	0.00E+00	2.53E+06	2.54E-01	5.06E-02	0.00E+00	2.15E+02	1.61E+03	7.00E+02	1.29E+05	18	0
JTCTC	0	0	PI	0	0	NO	0.00E+00	0.00E+00	0.00E+00	2.53E+06	1.30E-02	1.33E-04	0.00E+00	5.80E-01	4.35E+00	1.89E+00	3.48E+02	4	0

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