Preliminary Hazard Analysis – Summary of Outcomes

The Preliminary Hazard Analysis (PHA) assessment has been carried out in accordance with the Department of Planning's HIPAP No 4 (*Risk Criteria for Land Use Planning*) and HIPAP No 6 (*Guidelines for Hazard Analysis*). The main hazard associated with the proposed project is associated with the handling of the distillate, a combustible fuel used to power the gas turbines.

Other, less significant hazards may arise in fixed plant, storage and associated pipelines. The risk analysis showed that the risk of fatality does not extend anywhere outside the boundaries and 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 materials is very low. The most stringent risk criteria, as required by the Department of Planning, are adhered to.

The risk assessment carried out in this study assumed that the safety assessment process would continue throughout the design, construction and commissioning of a potentially hazardous facility to refine and update the outcome of the development approval / environmental risk process.

Chapter 18 Preliminary Hazard Analysis

18.1 Introduction

The Department of Planning's *Multi Level Risk Assessment Guidelines*, aim to provide a guide to the level of assessment necessary for an operation being studied. In accordance with these guidelines and as part of the Environmental Assessment, a quantitative Preliminary Hazard Analysis (PHA) was prepared for the proposed Buronga Peaking Power Plant Project. The following sections summarize the results of the PHA undertaken by Planager Risk Management Consulting for the proposed peaking power plant. The full report is presented in **Appendix H**.

The assessment has been carried out in accordance with the Department of Planning's Hazardous Industry Planning Advisory Paper (HIPAP) No 4 (*Risk Criteria for Land Use Planning*) and No 6 (*Guidelines for Hazard Analysis*). 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.

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 a potentially hazardous facility to refine and update the outcome of the development approval / environmental risk process.

18.2 Methodology

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

The objective of the PHA is to present the hazards and risks associated with the proposed distillate fuelled gas turbine peaking power plant. Through the evaluation of likelihood and consequence of the major hazards, the risks to the community associated with the proposed peaking power plant may be estimated and compared to Department of Planning risk criteria.

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 and activities:

- The distillate fired peaking power plant; and
- Transport of potentially hazardous material (such as fuels) to the facility.

The PHA notes that there are five stages in risk assessment, each of which is described below.

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 peaking power plant 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 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.

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. The risk for each incident is calculated according to:

Risk = Consequence x Frequency

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

The results of the risk analysis are presented in three forms:

- Individual Fatality Risk, i.e. the likelihood (or frequency) of fatality to notional individuals at locations around the 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. For distillate pipelines (as for other transport activities), the individual risk contours are best represented as risk transects, showing the risk as a function of the distance from the distillate pipeline.
- Injury and irritation risk, i.e. the likelihood of injury to individuals at locations around the 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.

Stage 5 – Risk Reduction

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

18.3 Risk Criteria

Once the risk from a development is determined 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.

18.3.1 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*.

18.3.2 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:

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

The societal risk criteria specify levels of societal risk which must not be exceeded by a particular activity. The same criteria are currently used for existing and new developments. Two societal risk criteria are used, defining acceptable and unacceptable levels of risk due to a particular activity. 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.

18.4 Potential for Hazard Incidents and Mitigation Measures

18.4.1 Summary of Hazard Identification Process

Hazard Identification

The main hazard associated with the proposed development is related to the handling of combustible liquids (distillate). A list of the typical chemicals to be stored on site is provided below in **Table 18-1**.

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. 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. In the case of distillate, the probability of ignition is very low seeing the relatively high flash point of the material (about 65^{o}C), indicating that the source of ignition must be very energetic and that the material would need to have been heated prior to the incident for ignition to occur;
- In case of ignition, the result of ignition of distillate would be a pool fire. The size of the pool fire depends on the release conditions, including the mass of material involved and how rapidly it is ignited; and
- Finally, for there to be a risk, people must be present within the harmful range (consequence distance) of the fire. How close the people are will determine whether any injuries or fatalities result.

Table 18-1 Typical Chemicals Stored On Site

Plant Area / Use	Chemical/Product	Anticipated Storage Qty
Fuel for gas turbines	Low Sulphur Distillate	2 x 1,000 kL in fixed tanks
Turbines	Turbine oils (combustible oil)	3 x 7,000 L in containment integral to each turbine
Transformers, pumps, air compressor, lubrication, fire pump	Insulating oil (non PCB)	1,000 L in one bulk container or drums
Water treatment plant (RO Plant)	Caustic soda (50%)	1,000L in one bulk container
	Hydrochloric acid (36%)	1,000L in one bulk container
	Antiscalant	1,000L in one bulk container
	Citric acid	1,000L in one bulk container
	Sodium hypochlorite	Minor quantities in lockable chemicals cabinet
Chemicals for maintenance / repair work and clean-up	Carbon dioxide	In cylinders, auto fire protection inside gas turbine enclosures

A total of 17 hazards were identified for the peaking power plant. These hazards are listed in **Table 18-2** below. For each of the hazards identified, potential causes, possible consequences and relevant prevention / protection measures are detailed within **Appendix H**.

Table 18-2 Summary of Identified Hazards

Number	Hazardous Event Potential	Offsite Impact Potential
1	Loss of containment of distillate during unloading and storage	Y
2	Loss of containment of distillate during fuel forwarding to gas turbine	Y
3	Loss of distillate inside gas turbine enclosure	Y
4	Unburned distillate inside gas turbine enclosure	Y
5	Loss of lube oil inside gas turbine enclosure	Y
6	Loss of containment of corrosive liquids	N
7	Violent reaction between incompatible materials	N
8	Loss of containment of water treatment plant effluent	N
9	Fire at step-up transformers	Y
10	Flooding results in process upsets and damage to plant and equipment	Y
11	Land subsidence, earthquake or mining activity results in plant damage	Y
12	Aircraft crash results in process upsets, potential damage to process / piping / storage facilities resulting in hazardous releases	Y
13	Damage to plant through terrorism / vandalism / unlawful entry to site / sabotage	Y
14	Bush / grass fire	Y
15	Storm damage	Y
16	Incident during maintenance and repair work	Y
17	Transport of potentially hazardous material to and from the site (distillate, oils, corrosives)	Y

18.5 Consequence and Frequency Analysis

For distillate (a combustible liquid), credible incidents arise from ignition of leaks or spills, giving rise to pool fires, where a liquid pool burns at its surface. Pool fires can occur within tanks, in the bunds around tanks or elsewhere that a pool of liquid collects.

PHAs focus on the risk to surrounding land use from a potentially hazardous development. Analysing the incident scenarios summarised in **Table 18-2** above shows that the bund fire scenario caused by a loss of containment of distillate during unloading and during storage has the potential to reach outside the site boundaries.

The likelihood of ignition depends on the properties of the material, and the size and location of the leak. In the case of distillate, the ignition source must be very strong (high in energy) and the material would most likely need to be heated to above its flash point before ignition could occur (distillate flashpoint is about 65^{o}C). A detailed study of storage tank incidents in industrial facilities over a 40 year period showed that lightning was the most frequent cause of accident and maintenance error was the second most frequent cause.

Leak Rates and 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 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 or even hour(s) to isolate. The approach used in this hazard analysis has been to assume that in 50% of leak cases, the leak is not discovered until the bund area is 10% covered and that in the other 50% of the leak cases the leak is not discovered until the entire bund surface is covered. This is a highly conservative approach as revealed during the analysis process where the tank overfill scenario accounts for about 80% of the leak cases and that operators are present during the tanker unloading.

Radiation Effects – The Point Source Method

Radiation effects have been 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 (i.e. 100m or more).

18.5.1 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 18-3** below.

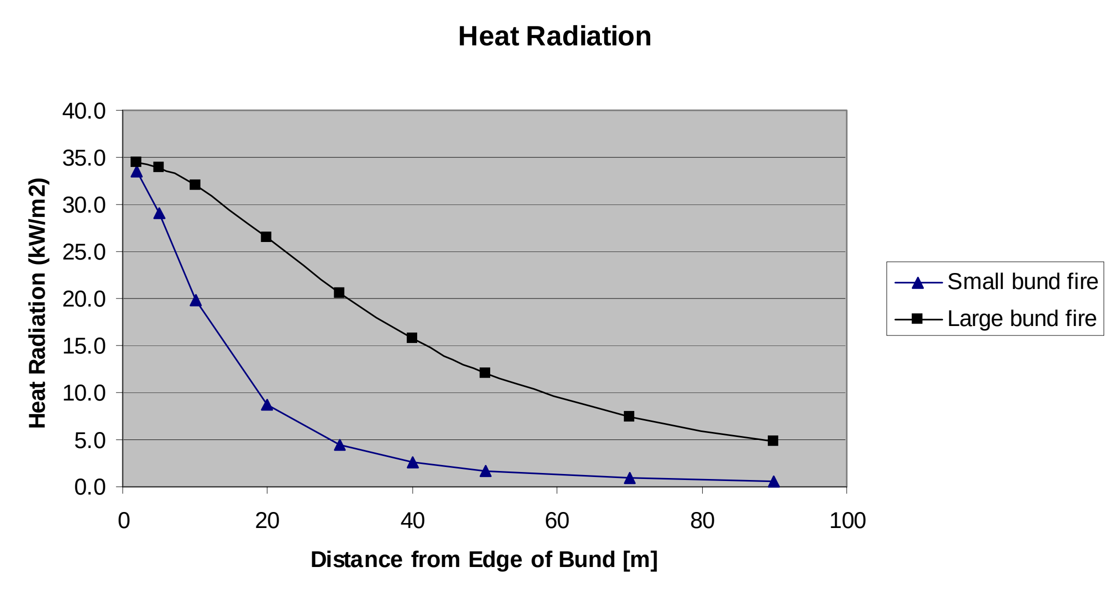
Table 18-3 Effects of Heat Radiation

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

18.5.2 Consequence Calculations – Distillate Fire

The consequence of a bund fire of distillate, as calculated using the Point Source method, are presented in **Figure 18-1** below. A detailed calculation sheet is included in **Appendix H**. Two scenarios were investigated, namely a 'small' and a 'large' fire, covering 10% and 100% of the surface of the bund respectively[1]. Serious (potentially fatal) consequences from a 'small' bund fire do not extend beyond the site boundaries.

Figure 18-1 Heat Radiation from Distillate Bund Fire



18.5.3 Probability of Operation of Plant

The peaking power plant is expected to operate for a maximum of 10% of the time. Conservatively, this risk assessment has assumed that the peaking power plant will operate 100% of the time and that all parts of the plant will be pressurised, capable of releasing distillate if damage occurs, 100% of the time.

[1] The bund has not been designed at the time of this PHA. This PHA assumed that the bund would be 35 m x 30 m (1050 m^2).

18.5.4 Frequency and Probability Data

The data used for the fault tree analysis as presented within **Appendix H** of this Environmental Assessment, is listed in **Table 18-4** below together with the basis for the calculation and, where possible, the reference used.

Table 18-4 Frequency and Probability of Hazard Events

Ref.	Item	Frequency/Probability		Basis of Calculation / Reference
2B	External Fire Plan Fails	0.05	[t/d]	Conservative estimate. Risk engineering best judgment
4B	Ignition	0.001	[t/d]	Estimated from Cox, Lees & Ang - Chapter 15, considered conservative.
4C	Local fire fighting inadequate/not available	0.3	[t/d]	Conservative estimate. Risk engineering best judgment (site workforce present approx 10% of time, but most incidents will occur during filling)
5A	Pump seal failure into bund	0.005	[t/yr]	Single mechanical seal, ISORIS data
5B	Major leak from tank	1.0E-04	[t/yr]	Atmospheric storage tank leak (historical data)
5C	External events	1.0E-04	[t/yr]	Conservative estimate. Risk engineering best judgment
5D	Faulty fabrication or corrosion at tank	1.0E-04	[t/yr]	Data from the Rijnmond study (Cremer & Warner), subsequently used by Bureau Veritas for the Kwinana study
5E	Flange leak inside bund	2.5E-05	[t/yr]	Estimated from Cox, Lees & Ang - Chapter 15, assuming 5 flanges per tank
5G	Foam u/s or empty	0.2	[t/d]	Conservative estimate. Risk engineering judgment
5H	Too windy / no access makes foam useless	0.2	[t/d]	Conservative estimate. Risk engineering judgment
6A	Pipe failure inside bund	3.0E-04	[t/yr]	Estimated from Cox, Lees & Ang - Chapter 15.
6B	Vandalism	0.002	[t/yr]	Conservative estimate. Risk engineering judgment
6C	Operator fails to act on overflowing tank	0.01	[t/d]	Orica Engineering HAZAN Course Notes, Section 11.
7A	Level transmitter fails	0.1	[t/y]	Orica Engineering HAZAN Course Notes, Section 5.
8A	Operator fails to intervene at high level	0.05	[t/d]	Orica Engineering HAZAN Course Notes, Section 11.
8B	No of fills per tank per year	50	[t/yr]	Site data

18.6 Risk Assessment

18.6.1 Fatality Risk Calculation

The likelihood of a bund fire, taking into account the properties of the distillate and its use within the site, is very low. For the two tank bund proposed for the site, the likelihood of a large fire (covering the entire surface of the bund) is about 0.5 pmpy. It then follows that the offsite individual risk from the site is less than 0.5 pmpy off the site.

Hence, the risk of a distillate fire is minimal, provided the storage is designed in accordance with code requirements (in particular AS1940) and the layout design and on site fire protection and management systems as presented in **Chapter 13 Bushfire Risk**.

18.6.2 Environmental Risk

Some materials to be stored and handled on site are potentially highly damaging to the environment, such as the water treatment chemicals and distillate. The possible sources of risks are liquid loss of containment or firewater runoff while a fire is being extinguished.

The liquid inventories on-site are listed in **Table 18-1** above. Losses of containment of materials can be caused in the ways discussed in the Hazard Identification Word Diagram provided within **Appendix H**. However if a spillage occurs into a sealed bund which has sufficient volume to contain the spill, there is no contamination of ground or water. Spillages to ground while filling tanks or unloading from tankers are thus the most probable source of loss of containment. Pollution is prevented by ensuring that liquids handling areas are paved, contained or drained to the interceptor pit.

18.6.3 Transport Risk

It is expected that about 30 deliveries per year will be sufficient for the operation of the site, mainly consisting of the distillate deliveries and the occasional delivery of corrosive liquids to the Water Treatment Plant, oil top up for rotating machinery and possibly the transport of material used for maintenance or cleaning.

Road transportation would use the Arumpo Road to access the site. The entrance road to the site is to be of adequate construction for the use in accordance with Wentworth Shire Council and RTA requirements, and would be maintained and repaired as required (**Chapter 10** *Traffic*).

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 site are well below those listed in the Transportation Screening Threshold table (Table 2 in the guidelines on applying SEPP 33) 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 site is very low.

18.7 Risk Results - Adherence to Risk Criteria

The quantitative analysis showed that:

Individual Risk of Fatality: The risk of fatality at the nearest residential area is well below the criterion for new installations of one chance in a million per year (1 x 10^{-6}/yr). The 1 x 10^{-6}/yr individual fatality risk for the proposed peaking power plant is contained well within the site boundaries.

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

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

Propagation Risk: The risk of propagation of an incident at the proposed peaking power plant does not encroach into any other industrial areas.

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

18.8 Mitigation Measures

A summary of mitigation measures in terms of hazard is provided in **Table 18-5**.

Table 18-5 Summary of Mitigation Measures

Mitigation Measures	Implementation of Mitigation Measures		
	Design	Construction	Operation
The detailed design of the distillate fired gas turbine enclosure and associated equipment should clearly outline the basis of safety used to ensure that the explosive situations do not arise (the risk is rendered negligible).	✓		
Fire protection inside the gas turbine enclosure to be determined, including use of explosion panels and use of fire retardant material where required by design standards.	✓		
The site as a whole will be monitored by infra red beam heat detectors to ensure fire protection and management systems for the site are activated in case of fire from adjoining land. The distillate tanks will be equipped with fire detection instrumentation, stationary sprinkler system and transportable foam mixing equipment and fire pump. The transportable distillate fired fire pump and foam mixing equipment will provide a wider fire protection capability across the site.	✓		✓
The site will be equipped with a reserved 150kL supply of “Fire Protection Water” with up to 2,000kL of additional plant process water in storage tanks.	✓		✓
Carry out an assessment of the safety management system implemented and used at the site, specifically as it applies to the proposed hazardous materials handling, fuel reticulation and storages within the first year of operation.			✓
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 plan or a turbine if a critical safety function is removed need to be canvassed).			✓