

ArcelorMittal

Gas-fired Independent Power Plant to Support Saldanha Steel and Other Industries in Saldanha Bay V1

Quantified Risk Assessment Report

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EXECUTIVE SUMMARY

The International Power Consortium South Africa (IPCSA), have developed a solution to Saldanha Steel's requirement for stable, economical electricity supply over the long term. This solution consists of a 1507 MW Combined Cycle Gas Turbine (CCGT) power plant to be erected adjacent to the ArcelorMittal's Saldanha Steel site.

The project will support both Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) as its main fuel supply. CNG and LNG could be supplied by ship to the Port of Saldanha, where it will be offloaded via a submersible pipeline. LNG, which will be regasified and CNG processing will take place within the Port boundary and will be the subject of another environmental authorisation application. The preparation of either of these feedstocks will result in pressurised Natural Gas being exported to the plant via two proposed pipelines. ERM have undertaken an environmental impact assessment (EIA) on behalf of Saldanha Steel for the CCGT power plant and associated pipelines. The project will involve the construction of the CCGT power plant as well as the Natural Gas pipeline. The CCGT power plant will also operate a 2 MW Propane fuelled black start generator which will be utilised by the site during the construction phase of the project as well as in the event of black starts for the power plant.

The cross country pipelines will comprise two identical 300 mm diameter pipelines running side by side in the same servitude, with a design pressure of 90 barg and an average operating pressure of 67 barg. The pipeline servitude route will extend from the port of Saldanha approximately 4.6 km to the gas receiving station within the Saldanha Steel's site boundary.

In order to better understand the risks posed by the CCGT power plant project, specifically the Natural Gas pipelines and the Propane generator, on the surroundings, a baseline Quantitative Risk Assessment (QRA) was carried out. The objective of this QRA was to assess the risk to the workers associated with the construction and operation phase of the project as well as the general public who could be in the vicinity of the pipelines servitude or CCGT power plant site. The risk assessment utilised the Land Use Planning (LUP) and location specific individual risk (LSIR) of dangerous dose Risk Tolerability approaches.

The scope of work for this specialist study included:

- Conducting a major accident Quantitative Risk Assessment (QRA) of the IPCSA Saldanha Steel Natural Gas pipeline route as well as the construction phase and operation phase of the propane fuel storage installations.

- Focusing on potential incidents that could result in fatalities or serious injury to the public from the Natural Gas pipelines and the Propane fuel storage installation;
- Utilising international best practices i.e. the UK's HSE Land Use Planning (LUP) and Risk Tolerability criteria focussing on Individual Risk of Fatality to assess the acceptability of the risk.

The scope of work for this specialist study excludes the LNG and CNG processing facilities in the port. Only hazards relating to the release of Natural Gas from the cross country pipelines or Propane from the Propane generator installation have been considered for the power station.

CONCLUSIONS

A (QRA) was carried out for the proposed construction of the Saldanha Steel Combined Cycle Gas Turbine (CCGT) power plant. This project includes the construction of two Natural Gas pipelines and a Propane backup electricity generator. The study has shown that the operations have the potential to adversely affect the health and safety of the general public as well as workers within the Saldanha Port area and those workers involved in the construction and operation of the CCGT power plant.

The potential hazards from the proposed project include jet fires, flash fires, vapour cloud and gas cloud explosions, boiling liquid evaporating vapour explosions and fireballs. The risk from these hazards was assessed according to the location specific individual risks (LSIR) of fatality as well as Land Use Planning (LUP) methodologies. An impact assessment was also carried out according to ERM's impact assessment methodology.

The current land uses are considered tolerable from a risk perspective for the proposed development. Future land use around the pipelines' servitude and power plant site should adhere to the restrictions set about by the UK HSE. As the Propane consumption at the power plant site is understood to be highest in the second year of construction, the surrounding land use during this period will be the most restricted.

The location specific individual risk of fatality for persons located indoors and outdoors has also been calculated for the proposed pipelines as well as the proposed Propane generator. During the construction and operational phases of the CCGT power plant project the risks are not considered intolerable. Due to the LSIR level on the CCGT power plant site as well as the area surrounding the site and along the pipelines' servitude, the risk can only be considered tolerable if it can be demonstrated by the site that the risks are As Low As Reasonably Practicable (ALARP).

As the detailed design of the CCGT power plant is not complete at this stage of the project, a risk assessment of the gas receiving station was not

completed. However in the event of a release from this equipment a flammable gas cloud explosion was considered possible. This was modelled and found to extend 57m from the centre of the gas receiving area to a dangerous dose overpressure end point. This does not extend beyond the proposed power plant site boundary.

IMPACT ASSESSMENT

The hazards, as described above, would result in a **direct negative** type of impact on the natural vegetation, structures, employees and people in the immediate area but not within the site boundaries in close proximity of the Natural Gas pipelines as well as the CCGT power plant site.

The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.

The extent for the impact is **local** as the impact of the worst case hazards extends beyond the boundaries of the pipelines' servitude as well as the CCGT power plant site.

The **scale** of the hazard effects to a Dangerous Dose from the Natural Gas pipelines are as follows:

- Jet Fire: 156 m;
- Flash Fire: 676 m; and
- Gas Cloud Explosion: 57 m.

The **scale** of the hazard effects to a Dangerous Dose from the Propane generator installations are as follows:

- Jet Fire: 173 m;
- Flash Fire: 239 m;
- Vapour Cloud Explosion: 13 m; and
- Boiling Liquid Evaporating Vapour Explosion / Fireball: 114 m.

Certain design standards have been assumed for the Natural Gas pipelines and Propane installations. These largely follow prescribed standards, however of particular note is the following:

- Multiple (at least two) safety systems will be implemented for Propane offloading. Such systems include wheel chocks, interlock brakes, interlock barriers, etc. In addition the site will implement an effective pull away mitigation system and inspection and pressure/leak tests to prevent transfer system leaks and bursts.

If facilities and equipment are designed to the prescribed specifications and standards the likelihood of such an events occurring is considered **unlikely**.

The sensitivity of receptors can be differentiated into those associated with the current land use of the area, as addressed by the LUP assessment, and individuals, as addressed by the LSIR assessment.

The area surrounding the Natural Gas pipelines' servitude is currently open land with the exception of Camp road. A portion of this servitude also passes through an area owned by the Port. As these areas are not currently inhabited and future land use within the Port is understood to be categorised as Industrial the land use sensitivity in these areas is categorised as **low**.

The area surrounding the proposed CCGT power plant site is similarly unused with the exception of a small access road. Therefore this land use sensitivity is also categorised as **low**.

Considering individuals, it is understood that the area surrounding the Natural Gas pipelines' servitude is not permanently inhabited as no homes, work places or other gathering areas exist in the vicinity. The general public does however have access to the area surrounding the servitude (with the exception of the Port property). Therefore the sensitivity of the general public in the area surrounding the Natural Gas pipelines' servitude is categorised as **medium**. For workers involved in the construction phase or operational phase of the CCGT power plant project the sensitivity is categorised as **low**. This is due to these individuals being aware of the risks and being more adequately prepared to handle them as a result of emergency planning , PPE, etc.

A similar situation exists for the proposed CCGT power plant site and surrounding area. The general public sensitivity is categorised as **medium** while worker sensitivity is categorised as **low**.

The impact has been assessed for a number of different scenarios which are described below:

- Land Use Planning Impact for the construction phase (represented for the second year of construction) for the Natural Gas pipelines
- Land Use Planning Impact for the construction phase (represented for the second year of construction) for the Propane generator installations
- Location Specific Individual Risk Impact for the construction phase (represented for the second year of construction) for the entire project
- Land Use Planning Impact for the operational phase for the Natural Gas pipelines
- Land Use Planning Impact for the operational phase for the Natural Gas pipelines
- Location Specific Individual Risk Impact for the operational phase for the entire project

Box 1.1

Land Use Planning Impact: Construction Phase: Natural Gas Pipelines

Impact Magnitude – Negligible

The Natural Gas pipelines are understood to only become operational during the operations phase of the project. Therefore no hazards exist during the construction phase

Likelihood – Unlikely

Receptor Sensitivity – The LUP receptor sensitivity has been categorised as **low** as there are no inhabited areas.

LUP IMPACT SIGNIFICANCE DURING CONSTRUCTION PHASE FOR NATURAL GAS PIPELINES (PRE-MITIGATION) – NEGLIGIBLE – The hazards will not exist for the Natural Gas Pipelines during the construction phase

Box 1.2

Land Use Planning Impact: Construction Phase: Propane Generator Installations

Impact Magnitude – Low

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 239 m. The largest land use restriction extends 140 m to the west and 60 m to the north of the CCGT site boundary, centred on the Propane generator.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**.

Receptor Sensitivity – The LUP receptor sensitivity has been categorised as **low** as there are no inhabited areas.

LUP IMPACT SIGNIFICANCE DURING CONSTRUCTION PHASE FOR PROPANE GENERATOR (PRE-MITIGATION) – NEGLIGIBLE – As the majority of the land surrounding the CCGT power plant is unused and uninhabited the impact from hazards is unlikely to have large offsite effects.

Box 1.3

Location Specific Individual Risk Impact: Construction Phase: Natural Gas Pipelines and Propane Generator Installations

Impact Magnitude – High

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 239 m. The largest LSIR contours extend 360 m to the west, 320 m to the north and 80 m to the east of the CCGT site boundary, centred on the Propane generator. The area considered intolerable for the general public extends 60 m to the north of the CCGT site boundary. An area centred on the Propane generator is considered intolerable for workers.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**. As stated, no hazards for the Natural Gas pipelines will be realised during the construction phase.

Receptor Sensitivity – The LSIR receptor sensitivity has been categorised as **medium** for the general public as they can access these areas but do not inhabit them and **low** for workers involved in the construction of the project as they are aware and prepared for the risks.

LSIR IMPACT SIGNIFICANCE DURING CONSTRUCTION PHASE FOR NATURAL GAS PIPELINES AND PROPANE GENERATOR (PRE-MITIGATION) – MODERATE – As the general public and workers are not exposed to LSIR that is considered intolerable.

Box 1.4

Land Use Planning Impact: Operation Phase: Natural Gas Pipelines

Impact Magnitude – Low

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 676 m. The largest land use restriction extends 140 m from the pipeline due to proposed bends which increase the risk in these areas. Risk transects indicate the normal pipeline area restrictions extend 68 m from the centre of the Natural Gas pipelines' servitude.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**.

Receptor Sensitivity – The LUP receptor sensitivity has been categorised as **low** as there are no inhabited areas.

LUP IMPACT SIGNIFICANCE DURING OPERATION PHASE FOR NATURAL GAS PIPELINES (PRE-MITIGATION) – NEGLIGIBLE – As the majority of the land surrounding the Natural Gas Pipelines' servitude is unused and uninhabited the impact from hazard is unlikely to have large offsite effects. Areas within the Port are understood to be reserved for industrial land use.

Box 1.5

Land Use Planning Impact: Operation Phase: Propane Generator Installations

Impact Magnitude – Low

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 239 m. The largest land use restriction extends 120 m to the west and 60 m to the north of the CCGT site boundary, centred on the Propane generator.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**.

Receptor Sensitivity – The LUP receptor sensitivity has been categorised as **low** as there are no inhabited areas.

LUP IMPACT SIGNIFICANCE DURING OPERATION PHASE FOR PROPANE GENERATOR (PRE-MITIGATION) – NEGLIGIBLE – As the majority of the land surrounding the CCGT power plant is unused and uninhabited the impact from hazards is unlikely to have large offsite effects.

Box 1.6

Location Specific Individual Risk Impact: Operation Phase: Natural Gas Pipelines and Propane Generator Installations

Impact Magnitude – High

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 676 m. The largest LSIR contours extend 110 m to the west and 240 m to the north of the CCGT site boundary, centred on the Propane generator.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**.

Receptor Sensitivity – The LSIR receptor sensitivity has been categorised as **medium** for the general public as they can access these areas but do not inhabit them and **low** for workers involved in the construction of the project as they are aware and prepared for the risks.

LSIR IMPACT SIGNIFICANCE DURING CONSTRUCTION PHASE FOR NATURAL GAS PIPELINES AND PROPANE GENERATOR (PRE-MITIGATION) – MODERATE – As no areas which are considered intolerable for the general public or workers exists.

Mitigation measures have been proposed for the design, safety and operation of the Natural Gas pipelines and Propane generator installations. The purpose of these measures is to avoid or minimise the risk of an incident (i.e. fire or explosion) occurring from a loss of containment of Natural Gas or Propane from facilities or ancillary equipment.

Certain key mitigation measures are listed below:

The following proposed engineering design features for the Natural Gas Pipelines that reduce risks should be implemented:

- The pipelines should be designed to an international standard such as:
 - BS EN 14161: *Petroleum and natural gas industries – Pipeline transportation systems*;
 - ASME B31.8 *Gas Transmission and Distribution Piping Systems*; or
 - Other internationally recognised standards.

The following proposed engineering design features for the Propane generator installations that reduce risks should be implemented:

- The installation must comply with all the requirements of SANS 10087-3:2015 *The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations Part 3: Liquefied petroleum gas installations involving storage vessels of individual water capacity exceeding 500 L*

The following protective measures for the Propane generator installations should be put in place to reduce the risks:

- Active or passive fire protection on the Propane storage vessel in line with SANS 10087-3:2015;

If mitigation measures as described above are implemented, the residual impact significance will change to for the construction phase as described in *Table 1* as the only receptors will be workers involved in the construction and operation of the CCGT power plant and their sensitivity is classed as **low**. The residual risk from the operation phase will remain the same.

Table 1 *Pre- and Post- Mitigation Significance: QRA: Storage Facility*

Phase and Assessment	Pre- and Post- Mitigation Significance:	Residual Significance (Post-mitigation)
Construction Phase, Natural Gas Pipelines, LUP Assessment	NEGLIGIBLE	NEGLIGIBLE
Construction Phase, Propane Generator, LUP Assessment	NEGLIGIBLE	NEGLIGIBLE
Construction Phase, Natural Gas Pipelines and Propane Generator, LSIR Assessment	MODERATE	MODERATE
Operation Phase, Natural Gas Pipelines, LUP Assessment	NEGLIGIBLE	NEGLIGIBLE
Operation Phase, Propane Generator, LSIR Assessment	NEGLIGIBLE	NEGLIGIBLE

Phase and Assessment	Pre- and Post- Mitigation Significance:	Residual Significance (Post-mitigation)
Operation Phase, Natural Gas Pipelines and Propane Generator, LSIR Assessment	MODERATE	MODERATE

IMPACT STATEMENT

The findings of the Quantified Risk Assessment for the Saldanha Steel Independent Gas-fired Power Plant indicate that the Project will have negative impacts on the immediate areas around the developments by increasing the risk of a major accident. However the risk levels from the developments are not considered intolerable according to the criteria utilised for this assessment. In addition these risks can be managed through the implementation of the mitigation measures outlined in this QRA, the EIR and other specialist reports

It is, therefore, recommended that the Project be supported subject to the implementation of the mitigation measures outlined in this QRA, the EIR and other specialist reports.

1.1 PROJECT DESCRIPTION AND LOCATION

The International Power Consortium South Africa (IPCSA), have developed a solution to Saldanha Steel's requirement for stable, economical electricity supply over the long term. This solution consists of a 1507 MW Combined Cycle Gas Turbine (CCGT) power plant to be erected adjacent to the ArcelorMittal's Saldanha Steel site.

ArcelorMittal and IPCSA have signed a Power Generation and Natural Gas Project Development and Pre-Off Take Agreement that binds both parties to certain deliverables in developing the project up to the Bankable Feasibility Study (BFS) completion.

The project will support both Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) as its main fuel supply. CNG and LNG could be supplied by ship to the Port of Saldanha, where it will be offloaded via a submersible pipeline. LNG, which will be regasified and CNG processing will take place within the Port boundary and will be the subject of another environmental authorisation application. The preparation of either of these feedstocks will result in pressurised Natural Gas being exported to the plant via two proposed pipelines.

The project will supply the power needs of ArcelorMittal Saldanha Steel (+/- 160MW of base load energy, peaking up to 250MW) and excess electricity will be made available to industries within the Saldanha Industrial Development Zone (IDZ) and/or Municipalities within the Western Cape Province.

ERM have undertaken an environmental impact assessment (EIA) on behalf of Saldanha Steel for the CCGT power plant and associated pipelines. The project will involve the construction of the CCGT power plant as well as the Natural Gas pipeline. The CCGT power plant will also operate a 2 MW Propane fuelled black start generator which will be utilised by the site during the construction phase of the project as well as in the event of black starts for the power plant.

The cross country pipelines will comprise two identical 300 mm diameter pipelines running side by side in the same servitude, with a design pressure of 90 barg and an average operating pressure of 67 barg. The pipeline servitude route will extend from the port of Saldanha approximately 4600m to the gas receiving station within the Saldanha Steel's site boundary. The location of the proposed Project is shown in *Figure 1.1*.

Figure 1.1 *A Map of the Proposed Natural Gas Pipelines to the Proposed CCGT Power Plant*



A series of major accidents at fuel storage, handling and production facilities as well as a number of incidents involving cross-country pipelines have focused worldwide attention on the need to control the design and management of facilities and cross-country pipelines where potential for major accidents exists.

In order to better understand the risks posed by the CCGT power plant project, specifically the Natural Gas pipelines and the Propane generator, on the surroundings, a baseline Quantitative Risk Assessment (QRA) was carried out. The objective of this QRA was to assess the risk to the workers associated with the construction and operation phase of the project as well as the general public who could be in the vicinity of the pipelines servitude or CCGT power plant site. The risk assessment utilised the Land Use Planning (LUP) and location specific individual risk (LSIR) of dangerous dose Risk Tolerability approaches.

1.2 SCOPE OF THE SPECIALIST STUDY

The scope of work for this specialist study included:

- Conducting a major accident Quantitative Risk Assessment (QRA) of the IPCSA Saldanha Steel Natural Gas pipeline route as well as the

construction phase and operation phase of the propane fuel storage installations.

- Focusing on potential incidents that could result in fatalities or serious injury to the public from the Natural Gas pipelines and the Propane fuel storage installation;
- Utilising international best practices i.e. the UK's HSE Land Use Planning (LUP) and Risk Tolerability criteria focussing on Individual Risk of Fatality to assess the acceptability of the risk.

The scope of work for this specialist study excludes the LNG and CNG processing facilities in the port. Only hazards relating to the release of Natural Gas from the cross country pipelines or Propane from the Propane generator installation have been considered for the power station.

1.3 CONTENT OF THE SPECIALIST REPORT CHECKLIST

The content of this report has been prepared in terms of Regulation GNR 982 of 2014, Appendix 6, as shown in *Table 1.1*.

Table 1.1 Specialist Report Checklist

Contents of this report in terms of Regulation GNR 982 of 2014, Appendix 6	Cross-reference in this report
(a) details of – the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a curriculum vitae;	<i>Section 1.4</i>
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	<i>Section 1.4.1</i>
(c) an indication of the scope of, and the purpose for which, the report was prepared;	<i>Section 1.2</i>
(d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Not Applicable
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process;	<i>Section 2</i>
(f) the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	<i>Sections 7.1 and 7.2</i>
(g) an identification of any areas to be avoided, including buffers;	None
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Not Applicable
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	<i>Section 4.3</i>
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	<i>Sections 7 and 8</i>
(o) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Refer to Comments and Responses Report, Annex B
(p) any other information requested by the competent authority.	<i>Section 7.4</i>

This Risk assessment was carried out by Tim Price and Peter Instone.

Tim Price is a Senior Consultant in ERM Southern Africa's Risk Team. Prior to joining ERM, Tim completed his Masters Degree in Chemical Engineering at the University of Pretoria in the field of Process Integration and Optimisation. His Masters thesis focused on the modelling and analysis of steam systems, specifically heat exchanger networks (HENs) and steam boilers with a focus on boiler efficiency and pressure drop. While at ERM, he has been involved with all aspects of Major Hazard Installation Risk Assessments including consequence modelling, frequency and risk analysis of explosive liquids and gasses as well as toxic substances. He has also developed emergency response plans and worked on the creation of a fit for purpose Quantitative Risk Assessment and Operational Safety Case for an offshore platform. In work not related to risk assessments he has been involved in basic fuel site environmental assessments and was involved in the creation of a multi-site and fuel refinery carbon footprint calculator tool.

Peter Instone joined ERM in 2012 as a Consultant within the specialist Industrial Risk team of ERM based in the Johannesburg Office in South Africa. Peter has a background in Mechanical Engineering and has completed a MEng at Durham University in the United Kingdom in 2011. In the field of Industrial Risk, Peter has been involved in several Quantitative Risk Assessments, many of which were to allow the clients to comply with the requirements of the South African Major Hazard Installation Risk Assessments. These MHI Risk Assessments covered a wide and diverse range of industrial installations. Peter has acquired skills in project management, consequence modelling, risk estimation and risk analysis. Peter has also been involved in Qualitative Risk Assessments such as Hazard and Operability Studies (HAZOPs), Hazard Identification Studies (HAZIDs) and Process Hazard Analysis studies (PHAs).



environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	12/12/20/ or 12/9/11/L
NEAS Reference Number:	DEA/EIA
Date Received:	

Application for environmental authorisation National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014

PROJECT TITLE

Environmental Impact Assessment for a Gas-fired Independent Power Plant to Support Saldanha Steel and Other Industries in Saldanha Bay
--

Specialist:	ERM SSA Risk
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4.2 The specialist appointed in terms of the Regulations_

I, Tim Price, declare that -

General declaration:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.


Signature of the specialist:

ERM

Name of company (if applicable):

06/07/2016

Date:

2.1 PROCESS OF RISK MANAGEMENT

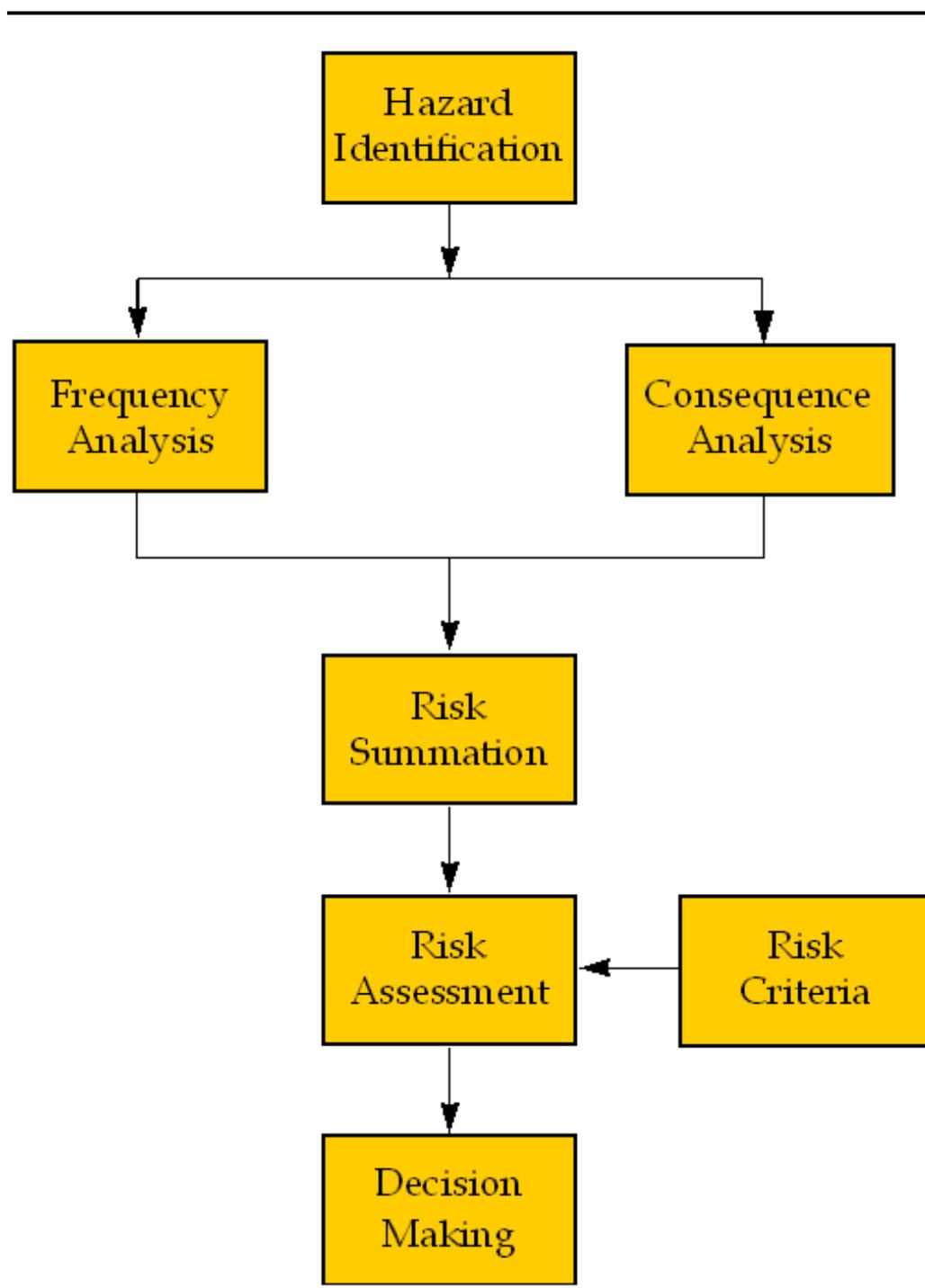
Risk management has become widely used as a technique to aid decision-making. Five specific elements are involved:

1. **Hazard Identification:** to determine the incident scenarios, hazards and hazardous events, their causes and mechanisms.
2. **Consequence Analysis:** to determine the extent of the consequences of identified hazardous events.
3. **Frequency Estimation:** to determine the frequency of occurrence of identified hazardous events and the various consequences.
4. **Risk Summation:** to determine the risk levels.
5. **Risk Assessment:** to identify if the risk is tolerable/intolerable and to identify risk reduction or mitigation measures and prioritise these using techniques such as risk ranking and cost-benefit analysis.

These elements are shown in the flow diagram *Figure 2.1*. The elements of the procedure are used both to generate information and as an aid to decision-making in managing the risk. For decision-making, the procedure is only taken as far as is necessary to generate the information required or to make the decision.

The extent of application of the various elements and degree of quantification employed therefore varies significantly from one situation to another.

Figure 2.1 Risk Assessment Process



2.2 HAZARD IDENTIFICATION

The first stage in any quantified risk assessment is to identify the potential incidents that could lead to the release of a hazardous material from its normal containment, in this case the release of Natural Gas from the Natural Gas pipelines as well as Propane from the Propane generator installations, and result in a major accident. This is achieved by a systematic review of the pipelines to determine where a release of the Natural Gas could occur from the pipelines or their associated equipment.

The major hazards considered are generally one of three types: flammable, reactive and or toxic. In this study, only flammable hazards are relevant involving loss of containment of the flammable Natural Gas being transferred in the pipelines, or the Propane from storage at the power station. Flammable hazards may manifest as high thermal radiation from fires and overpressures following explosions that may cause direct damage, building collapse, etc. Fires may occur if flammable materials are released to the atmosphere and ignition takes place.

2.3 CONSEQUENCE ANALYSIS

2.3.1 Harm Criteria for Consequence Analysis

During the analysis it is necessary to define harm criteria (or 'end points') for use with the consequence models. In the case of this study, these harm criteria are levels of thermal radiation intensity and where relevant, overpressure (in the case of vapour cloud explosions).

The derivation of the harm criteria used in this study is described in Section 5.2.

2.3.2 Consequence Modelling

Factors Affecting Consequences

There are several factors which affect the consequences of materials released into the environment. These include (but are not limited to):

- Release quantity or release rate
- Duration of release
- Initial density of the release
- Source geometry
- Source elevation
- Depth of burial of pipelines
- Prevailing atmospheric conditions
- Surrounding terrain
- Physical and chemical properties of the material released
- Risk reduction measures implemented on the pipelines and their servitude.

Such factors will affect the consequence zones for the specific hazardous materials, eg the distance at which the level of thermal radiation from a fire has reduced sufficiently so that it is no longer dangerous.

Factors Affecting Fire Hazards

When considering large Natural Gas fires, the principal hazard is from thermal radiation. The primary concerns are safety of people and potential

damage to nearby facilities or equipment. Determination of thermal radiation hazard zones involves the following three steps:

- Geometric characterisation of the fire, that is, the determination of the burning rate and the physical dimensions of the fire;
- Characterisation of the radiative properties of the fire, that is, the determination of the average radiative heat flux from the flame surface; and
- Calculation of radiant intensity at a given location.

These, in turn, depend upon the nature of the flammable material, size and type of fire, prevailing atmospheric conditions and the location and orientation of the target/receptor.

Consequence Models

The hazards described above can be modelled analytically by standard models used for consequence analysis. Many of these models are performed by computer software and ERM has access to a range of such models. The modelling of event consequences is described in *Section 6.2*.

2.4 FREQUENCY OF MAJOR ACCIDENT HAZARDS

For each hazard identified, the frequency is assessed.

A simple way of defining the frequency of major accident events within a QRA is to use a 'top down' approach. This provides frequencies of the events of interest (fires, explosions, etc.) by reference to historical accident data sources regarding pipelines, without considering the causes or development of these events in detail.

Alternatively, if more detail is required, a 'bottom up' approach may be used, where the frequency of individual release scenarios from pipelines is considered. The different outcomes that may result from these releases and the associated frequencies are then developed using techniques such as event tree analysis.

A release of Natural Gas from the pipelines, or the Propane storage may be considered for a range of hole sizes, which will depend on the various causes considered. For example, a leak from a pipeline due to corrosion will tend to be small, whereas external impact, say, by a mechanical digger, is likely to produce a much larger hole.

ERM utilises the *Planning Case Assessment Guide (PCAG)* ⁽¹⁾ developed by the UK Health and Safety Executive (HSE). ERM has also incorporated historical statistical data from the HSE's Update of pipeline failure rates for land use planning assessments ⁽²⁾, this report summarises data from the CONCAWE group, UKOPA and EGIG. For third party activity, a modifier has been added to reduce the likelihood of TPA for the portion of the proposed pipelines that exist within the Saldanha port boundary as this area is understood to have strict access controls.

The frequency of the various outcomes (accident scenarios) is then estimated by multiplying the frequency of the release by the probability of the various outcomes. In this study, for flammable releases from the pipelines, these outcomes are principally jet fires and explosions of various sizes.

2.5 RISK CALCULATION

The individual risk for a specified level of harm is calculated taking the following variables into consideration:

- The frequency of the hazardous outcome (consequence), e.g. jet fire event
- The probability that the hazardous outcome (consequence) will reach the location specified (This includes variation of wind direction with consequent change to flame tilt; both downwind and crosswind distances need to be taken into account)
- Probability of an individual being at the location
- Probability of escape into shelter by an individual
- The probability that, given exposure to the hazardous outcome, the person suffers a defined level of harm.

The frequency of harm (f_h) being present from each hazardous outcome (consequence) event must be calculated and summed to give the maximum individual risk (IR) from all events at one location.

$$IR_{(\max)} = \sum_{\text{for all consequences}} f_h$$

As individual risk is location specific, the above process needs to be repeated for each location considered. The individual risk from other facilities can be summed to give the overall individual risk level from several major hazards. Calculation can be avoided if it is obvious that the event would not be able to affect a location e.g. the specified location is too far away.

(1) Planning Case Assessment Guide, 09/07/2002

(2) HSE Research report RR1035

The frequency of harm will be different for differing weather categories and needs to be calculated for each weather category used. The frequency of harm for a given consequence and weather category is expressed as follows:

$$f_h = f_e \times P_w \times P_d \times P_{exp} \times P_{harm}$$

Where:

f_e = frequency of the hazardous outcome (consequence)

P_w = probability of that weather category

P_d = probability of the wind blowing in the required direction for event to affect the individual ($P_d = 0$ if event cannot reach a particular location)

P_{exp} = probability of exposure

P_{harm} = probability that defined level of harm results given that exposure has occurred

The probability of the wind blowing in the required direction depends on the angle of entrainment, or the circular sector where a particular hazardous outcome encompasses the specified location. This is a function of the distance from the source, the size, and shape of the hazard 'footprint'.

The size and shape of the footprint is determined from the results of the consequence analysis, but gives a complex shape and is correspondingly difficult to calculate the angle of entrainment. These complex shapes are often simplified to regular shapes in order to calculate the angle of entrainment.

The frequency of harm for a specific event is the sum of the frequencies of harm for the different weather conditions:

$$f_h = \sum_{\text{all weathers } i} f_{h, \text{weather } i}$$

The stability category and wind speed combinations used in the study are discussed in *Section 4.6*.

ERM's proprietary *ViewRisk* computer software has been used to calculate iso-risk transects, which show the distribution of individual risk of harm to people from the centre of the pipelines.

2.6

RISK ASSESSMENT

The final and most significant step in the process is the assessment of the meaning and significance of the calculated risk levels. Risk assessment is a process by which the results of a risk evaluation are used to make judgements,

either through relative risk ranking of risk reduction strategies or through comparison with established risk targets (criteria).

Where off-site risk criteria relevant to QRA have been issued (in this case based on criteria used in the UK), it is possible to assess the calculated risk levels against these set criteria.

This determines whether the risks are tolerable, broadly acceptable, or if risk reduction/mitigation measures are required to reduce the risk to levels which can be considered to be as low as reasonably practicable (ALARP). The risk events can then be ranked to determine the relative contribution of each to the overall risk level.

In general the higher risk events should be examined for possible areas of reduction or mitigation as a first step. Measures that prevent the potential incident from occurring should be considered first, followed by measures that reduce the probability (e.g. reduction in flanges, increased pipeline wall thickness), then measures that may limit the amount released (e.g. remotely operated valves, ROVs) and finally measures that may reduce the potential consequences (e.g. water sprays).

The risk assessment will thus enable decisions to be made on whether an investment should be made on particular risk reduction or mitigation measures so that the risk is effectively managed. The residual risk will then be managed by appropriate safety management systems to ensure safe operations, maintenance, good practice, etc.

The risk criteria used in this study are presented in *Section 3.2*.

3.1 TERMINOLOGY

Individual Risk: The frequency at which an individual may be expected to sustain a given level of harm from the realisation of specific hazards. It is a measure of the risk of harm to an individual with defined characteristics at a given point.

Maximum Individual Risk: The individual risk to persons exposed to the highest risk in an exposed population.

Risk Contours: Lines that connect points of equal risk around the facility or installation (also known as risk iso-lines).

Risk Notation: The numerical expression of risk. Risk assessment results involve small numbers and so an exponential notation or a scientific notation is often used. A 'unit conversion table' is presented in *Table 3.1*.

Table 3.1 Risk Notation Conversion Table

Exponential/ scientific	Power	Decimal	Chance per Million (cpm)	Description
1 E-05/yr	1 x 10 ⁻⁵ /yr	0.00001/yr	10 cpm	1 in 100 000 per year
1 E-06/yr	1 x 10 ⁻⁶ /yr	0.000001/yr	1 cpm	1 in million per year
1 E-07/yr	1 x 10 ⁻⁷ /yr	0.0000001/yr	0.1 cpm	1 in 10 million per year

3.2 ASSESSMENT CRITERIA

South Africa does not currently offer criteria with which to assess the acceptability of developments from a major accident risk perspective. Therefore the risk criteria used are based on those adopted by the Health and Safety Executive (HSE) in the United Kingdom. This methodology is internationally recognised and accepted as a basis for risk management.

The HSE has developed different sets of risk criteria for different applications. One role that the HSE fulfils in the UK is to advise on development of land in the vicinity of existing major hazard installations. For this purpose the HSE uses its so-called land use planning (LUP) criteria. Another set of criteria is used by the HSE to judge the acceptability of risk from existing major hazard installations. These are known as risk tolerability criteria.

For this QRA the proposed Natural Gas pipelines as well as the Propane generator will be assessed against the UK HSE LUP methodology in order to ascertain whether the surrounding developments are compatible with the risks posed by the proposed pipelines servitude.

The Individual Risk tolerability criteria will also be used to assess whether the risks posed by the Natural Gas pipelines or Propane generator are acceptable to individuals in the vicinity of the pipeline servitude. These criteria are now described in more detail.

3.2.1 *Land Use Planning Around Hazardous Installations*

A number of countries have well developed approaches to land-use planning around major hazard installations and hazardous pipeline servitudes, being either primarily probabilistic (i.e. risk based) or deterministic (i.e. consequence based).

The purpose of such systems is to prevent the growth of incompatible land-uses around major hazard sites or hazardous pipeline servitudes, or the location of new major hazard sites in inappropriate locations. An overview of the approach used by the UK HSE is given below⁽¹⁾:

A three zone system is applied - Inner Zone, Middle Zone and Outer Zone with the outermost extent of the Outer Zone referred to as the Consultation Distance (CD). In combination with this, land-uses are classified according to Sensitivity Level, with Sensitivity Level 1 (typically places of work) being the least sensitive and Sensitivity Level 4 (typically large schools or hospitals) being the most sensitive. A set of rules (in the form of a 'decision matrix') is applied to determine which land-uses are appropriate for which zones.

In practice, the zones are related to the risk of an individual being exposed to a dangerous dose or load which would "...cause severe distress to almost everyone, many [would] require medical treatment, some [would] be seriously injured and highly vulnerable people might be killed". This approach appreciates the general public's aversion not only to fatality but also to injury and other distress (i.e. the concept of harm) - and is distinct from approaches solely related to fatality.

Proposals for new developments in the vicinity of major hazardous sites or hazardous pipeline servitudes are assessed by the authorities. Different types of developments are assigned to different 'sensitivity levels', with schools and hospitals being amongst the most sensitive; and factories the least sensitive. The authorities recommend that a proposed development does not proceed if the level of risk is above the value that has been established for developments of that type. Similar approaches may be used for new hazardous installations or hazardous pipelines in developed areas.

The extent of the three zones may be determined by either a probabilistic assessment (i.e. on a risk basis) or by performing a consequence assessment (i.e. on a 'protection' basis). For this study, the extent of each zone is based on probabilistic assessment, taking account of, *inter alia*:

(1) PADHI, HSE's land use planning methodology, Health and Safety Executive, May 2011

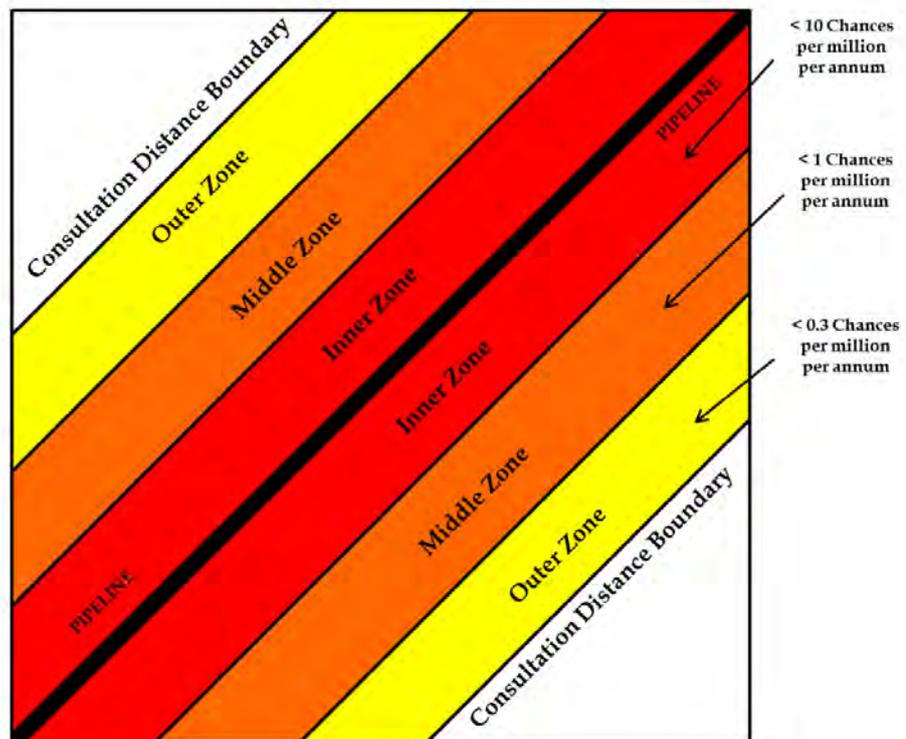
- Control measures;
- Frequency of events;
- Event duration;
- Weather conditions;
- Specified harm criteria; and
- Likelihood of exposure.

In the absence of 'official' South African guidance, the risk levels applied in this assessment are those employed by the UK Health and Safety Executive (HSE) when setting zones around cross country pipelines. The zones for an annual individual being harmed from exposure to flame/heat, explosion overpressure, toxic gas or asphyxiant (i.e. a specified frequency of receiving a dangerous dose); have been set to correspond to the following risk levels:

- Inner Zone - 10 chances per million per year (1×10^{-5});
- Middle Zone - 1 chance per million per year (1×10^{-6}); and
- Outer Zone (Consultation Distance) - 0.3 chances per million per year (3×10^{-7}).

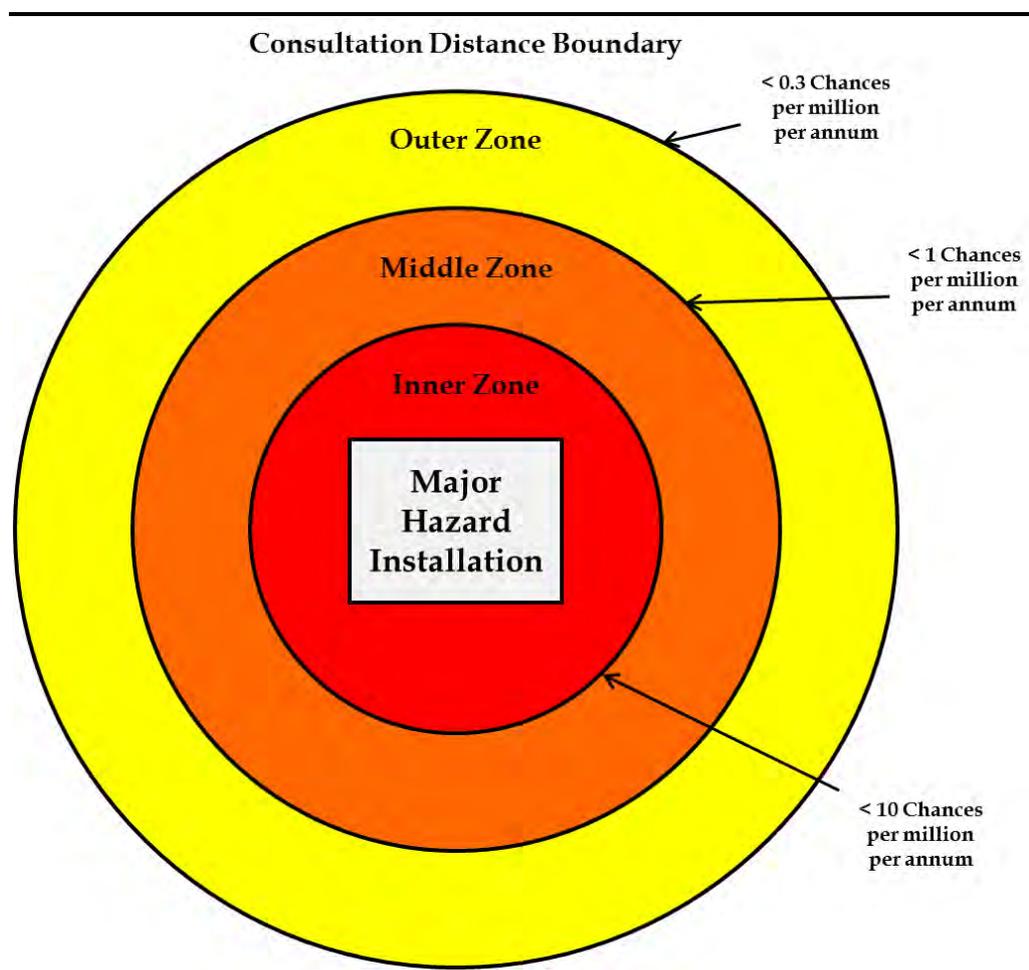
An example of the various zones for cross country pipelines are shown in *Figure 3.1*.

Figure 3.1 *Land Use Planning Consultation Zones around Hazardous Pipelines*



Examples of the various zones for major hazard sites are shown in Figure 3.2.

Figure 3.2 Land Use Planning Consultation Zones around Hazardous Sites



In November 2001 the UK HSE modified its zoning criteria. This is summarised in Table 3.2 with proposed developments categorised as either 'advise against' (AA) or 'don't advise against' (DAA). This refers to the advice the HSE would give to the local authority in relation to a development proposal of a given type in the vicinity of hazardous pipelines.

For example, the HSE would advise the local authority against building of a new housing development in the inner zone.

Table 3.2 Land-use Sensitivity to Risk

Level of Sensitivity	Inner Zone	Middle Zone	Outer Zone
1. The normal working public	DAA	DAA	DAA
2. The general public at home	AA	DAA	DAA
3. Vulnerable members of the public (schools, hospitals, etc.)	AA	AA	DAA
4. Large examples of No 3 & large outdoor examples of No 2 (i.e. recreational areas)	AA	AA	AA

Note that some types of development can change Sensitivity Level depending on their size. For example, large industrial / office land-uses (for more than 100 persons) would move up a Sensitivity Level from Sensitivity Level 1 to Sensitivity Level 2.

It should also be noted that HSE does not apply these criteria retrospectively to existing land-use around existing major hazardous sites or hazardous pipeline servitudes. This is because the cost of turning down proposals for a development that does not yet exist is much lower than the costs involved in relocating existing land-uses. For example, the costs involved in relocating the occupants of houses in a residential area to new housing elsewhere would be very large compared to the cost of turning down a similar development before it is built. For this reason the land-use planning risk criteria are somewhat more stringent than the criteria applied to existing major hazardous sites.

As stated above, the HSE uses these criteria to consider the suitability of proposed, new land-uses in the vicinity of an existing major hazardous sites or hazardous pipeline servitude. In this study, the criteria have been used as a screening step to judge whether further risk assessment studies would be appropriate.

Where land-uses are identified that would be advised against if they were submitted as new applications, this is used to indicate that further risk studies, potentially with application of risk reduction measures at the site or on the pipelines are required to show that the risks are as low as reasonably practicable (ALARP). Land-uses that would be advised against if they were proposed as new applications are termed 'potentially incompatible'.

The presence of potentially incompatible land-uses does not necessarily mean that the risks from the major hazardous site or the pipelines are intolerable. It simply means that further studies would be worthwhile to determine whether or not more needs to be done to reduce the risk.

If no potential incompatibilities are identified, then further, more detailed risk analyses would not be considered necessary at this time.

In this assessment it was found that the consequences could extend beyond the pipelines' servitude as well as the CCGT power plant site boundary and affect members of the public. Further calculations were undertaken to show whether the risks can be considered to be as low as reasonable practicable.

3.2.2 *Risk Tolerability Criteria*

The HSE risk tolerability criteria are used to judge the acceptability of the risks from existing MHIs or pipeline servitudes. In the HSE tolerability of risk

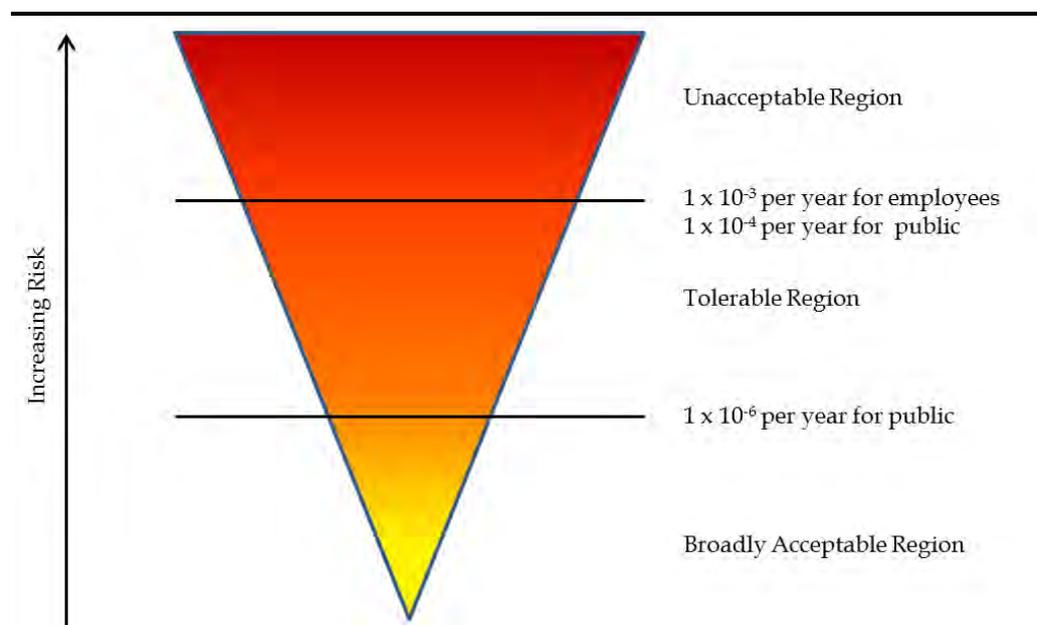
framework ⁽¹⁾, risk levels are divided into three bands of increasing risk, as shown in *Figure 3.3*.

In the lowest band, within the 'broadly acceptable' region, the risk is considered to be insignificant and adequately controlled. Risks that are within the 'unacceptable' level fall into the uppermost band. In such cases, either action should be taken to reduce the risk levels, or the activity giving rise to the risk should be halted.

Between the unacceptable and broadly acceptable regions, the risk is considered to be tolerable if it is As Low As Reasonably Practicable (ALARP). The risk is ALARP when the cost of any further risk reduction measures would be grossly disproportionate to (ie much greater than) the benefits gained.

This is demonstrated in *Figure 3.3*.

Figure 3.3 *HSE Risk Criteria Framework*



3.2.3 *Individual Risk of Fatality Criteria*

The individual risk is the risk to which a hypothetical person (usually with defined characteristics and behaviour pattern) is exposed. The HSE criteria ⁽²⁾ are stated in terms of individual risk of fatality for two types of hypothetical person: a person who is engaged in the industrial activity under consideration (eg, an employee); and, a person who is not involved in the activity (eg, a member of the public).

(1) HSE (2001). *Reducing Risks, Protecting People*. HSE Books, C100.

(2) HSE (2001). *Reducing Risks, Protecting People*. HSE Books, C100.

The HSE has provided individual risk values corresponding to the boundaries between the different regions indicated in *Figure 3.3*. These are summarised in *Table 3.3*.

Table 3.3 *Individual Risk Criteria*

Level	Individual Risk to Personnel Engaged in the Activity (yr)	Individual Risk to People not Engaged in the Activity (yr)
Unacceptable	Greater than 1 in 1,000 (10^{-3})	Greater than 1 in 10,000 (10^{-4})
Broadly Acceptable	No greater than 1 in 1,000,000 (10^{-6})	No greater than 1 in 1,000,000 (10^{-6})

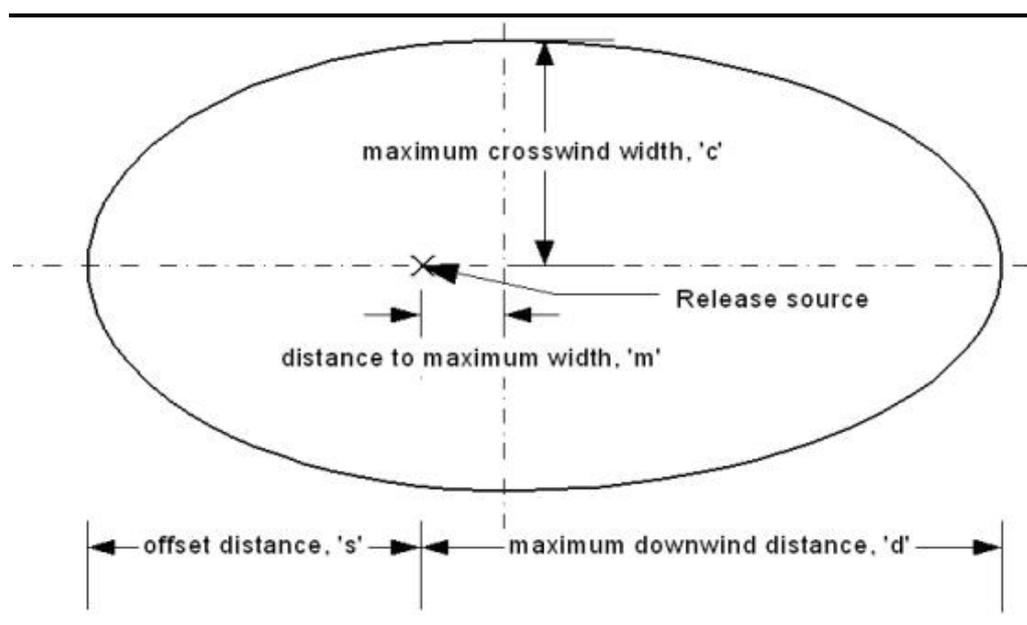
3.3 METHODOLOGY

The source term and thermal radiation analyses were undertaken using the *DNV Phast v6.7* package. This package has been developed by DNV and has been used extensively globally for modelling such incidents. The software package integrates a suite of programmes to perform consequence calculations related to release events and quantifies the resulting hazardous effects and calculates the impact at a specified distance or target.

The *ViewRisk* risk summation package (developed by ERM) was used for the summation, analysis and presentation of risks related to the installations. The results from the consequence analysis were used as inputs to calculate risks for every scenario.

Consequence dimensions are expressed in terms of a number of parameters as illustrated in *Figure 3.4*.

Figure 3.4 *Harm Envelope Dimension Parameters*



4.1 NATURAL GAS PIPELINES' CHARACTERISTICS

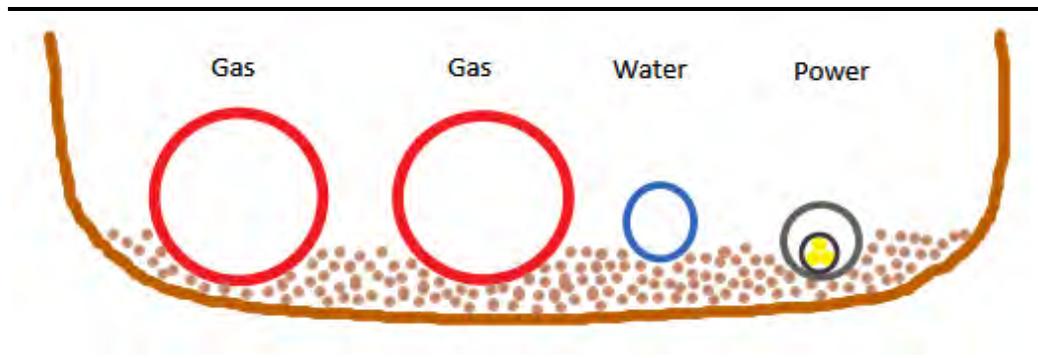
The Natural Gas pipeline route is described in *Section 1*. The pipelines are approximately 4.6 km long and have control valves to limit flow in emergency shut downs. For this assessment the pipeline has been considered from the downstream of the gasification plant to upstream of the power plant. General pipeline characteristics are shown in *Table 4.1*.

Table 4.1 Pipelines Characteristics

Product	Line Diameter (mm)	Line Length (km)	Max Pumping Pressure (barg)	Average Pumping Pressure (barg)
Natural Gas	300	4.6	90	67

It is understood that the two Natural Gas pipelines will run side by side in the pipeline servitude. The intention of the dual pipeline arrangement is understood to be for security of continuous supply. The pipeline servitude will also contain a seawater line and an electrical conduit line. A cross section of the servitude is shown in *Figure 4.1*.

Figure 4.1 Cross Section of Pipeline Servitude



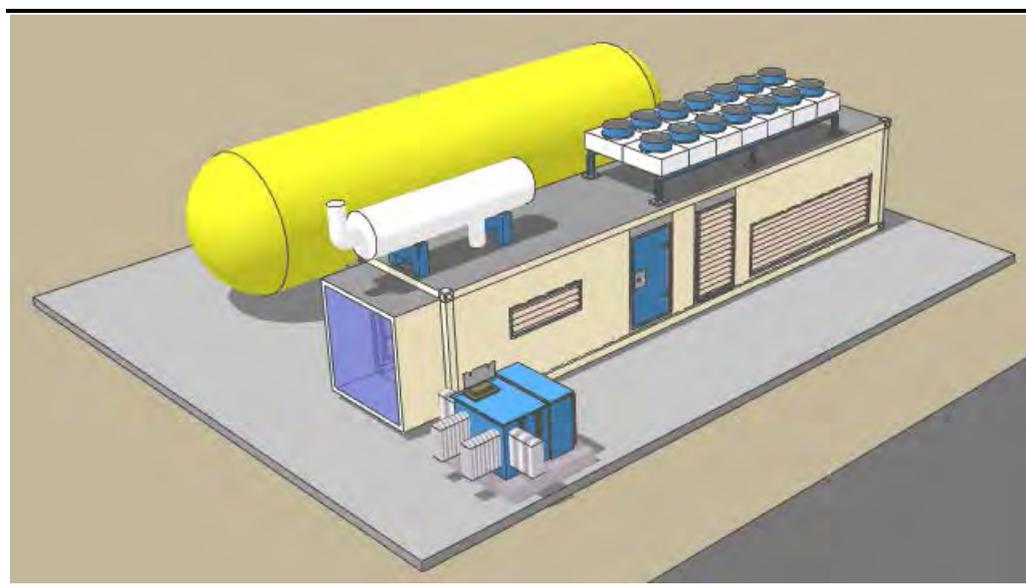
4.2 PROPANE INSTALLATION CHARACTERISTICS

It is understood that a single Propane storage vessel will be installed on site to power any one of three specialised generators. The characteristics of the vessel are shown in *Table 4.2*. Due to the current stage of this project, only the maximum volume of the storage vessel has been confirmed by IPCSA. The operating volume, operating temperature and operating pressure have been therefore been assumed. A design impression of the Propane vessel has been shown in *Figure 4.2*. The location of the vessel on the site was taken from the general arrangement site layout.

Table 4.2 *Propane Vessel Characteristics*

Product	Maximum Volume (m ³)
Propane	30

Figure 4.2 *Design Impression of Propane Vessel*



During the construction phase it is understood the Propane backup generator will operate in two different modes:

- First year operation: the generator will operate at 1.5 MW and consume approximately 389 kg/hr and operate for approximately 3,000 hours; and
- Second year operation: the generator will operate at 2 MW and consume approximately 518 kg/hr and operate for approximately 3,000 hours

During normal operation the generator is understood to operate for approximately 100 hours per year. It is assumed that during this period the Propane consumption will be equivalent for the 2.0 MW generation case at 518 kg/hr.

4.3 ASSUMPTIONS

Based on information provided to ERM, further assumptions for the models were considered and are listed. Where information was unavailable or not confirmed due to the current stage of the project, assumptions were made in line with good design practice.

4.3.1 Pipelines

Assumptions regarding the Natural Gas pipelines are shown in *Table 4.3*.

Table 4.3 Assumptions Register

Question	Answers
Pipeline coating	Yes with fusion bonding epoxy
Impressed current cathodic protection (CP)	Yes
Pipeline wall thickness	10.31 mm buried
ILI (intelligent pigging)	Yes
Pipeline in urban area	No
Pipeline cover depth (CD)	>1 m normal burial depth
Pipeline marker posts	Within line of site
Concrete slab at road crossing	Yes
Plastic marker tape (above pipeline)	Assumed yes in line with good practice
Pipeline protection in the trench	No
Continuous awareness programme	Assumed yes in line with good practice
ROW inspections	Assumed yes in line with good practice
Pipeline security guards	Assumed yes in line with good practice
SMS and training programme	Assumed yes in line with good practice
Landslide areas	Assumed no
Seismic fault crossings	Design assumed no in line with good practice

It is understood that details of the pipelines’ tie ins at the power plant and gas receiving station will be outlined during the detailed design stage of the project but at this stage only the pipelines containing Natural Gas are considered downstream of the liquefied Natural Gas and CNG processing facilities at the port and the power station tie ins.

4.3.2 Propane Backup Generator

Storage Vessel

Assumptions regarding the Propane vessel are shown in Table 4.4.

Table 4.4 Assumed Propane Vessel Characteristics

Product	Operating Volume (m³)	Operating Temperature (°C)	Operating Pressure (barg)
Propane	25.5	20	Saturated liquid, ambient temperature

Transfer Pipework

Assumptions regarding the transfer and operation of the Propane backup generator are shown in Table 4.5.

Table 4.5 Assumed Propane Transfer Pipework Characteristics

Equipment	Diameter (mm)	Length (m)	Operating Pressure (barg)
Propane offloading pipework to vessel	100	10	Saturated liquid, ambient temperature
Propane transfer pipework to vapouriser	50	20	Saturated liquid, ambient temperature
Propane transfer pipework to generator	50	20	3 barg, ambient temperature

Road Tanker Off-Loading Operations

In addition, the number of road tanker operations has been assumed based on the following:

- The Propane storage vessel will be filled when the contents drops to approximately 30%; and
- Considering the operational fill level of 85%, the Propane storage vessel will require a fill approximately every 8,234 kg.

With this information the following number of fills will be required for the various operational modes (assuming a single fill can deliver the required contents):

- First year operation: 142 fills;
- Second year operation: 189 fills; and
- Normal operation: 7 fill.

It is assumed that the Propane road tanker will have a capacity of 30m³. It is further assumed Propane will be offloaded from the tanker through a pump on the tanker at a pressure of 10 barg and offloading operations will take 90 minutes to complete and only take place during the day. It is further assumed that multiple (at least two) safety systems will be implemented for Propane offloading. Such systems include wheel chocks, interlock brakes, interlock barriers, etc. In addition the site will implement an effective pull away mitigation system and inspection and pressure/leak tests to prevent transfer system leaks and burst.

Vapouriser

The Propane Vapouriser will be assumed to comprise a shell and tube heat exchanger with the Propane being heated on the tube side. The tube diameter has been assumed as 50 mm.

4.4 DESCRIPTION OF PRODUCTS

The composition of the material transported in the pipelines considered in this QRA was provided to ERM by IPCSA.

The material was classified as Natural Gas and the material composition as broken down in *Table 4.2*.

Table 4.6 *Saldanha Steel Natural Gas Pipelines Transported Material Characteristics*

Material	Percentage (%)
Methane	96.109
Ethane	1.807
Propane	0.164
i-Butane	0.028
n-Butane	0.011
n-Pentane	0.007
n-Hexane	0.008
n-Heptane	0.013
Nitrogen	0.357
Carbon Dioxide	1.468

The scenarios involving Propane were modelled as pure Propane in *DNV Phast v6.7*.

4.5 LEAK DETECTION AND THIRD PARTY ACTIVITY PREVENTION

Third party activity (TPA) in relation to pipeline operation can include accidental damage to the pipelines as well as intentional damage for the purpose of sabotage or theft.

IPCSA have provided ERM with the document *Pipeline Leak Detection System Selection* ⁽¹⁾. This outlines the possible options for leak detection and interference detection.

Third party activity detection and leak detection methods limit the size of consequences from potential incidents by enabling detection once leaks have occurred and enacted emergency shutdown procedures. This can limit the release duration from the pipelines.

The following leak detection measures are understood to have been included in the project for the pipelines:

- In – pipeline instrumentation based on acoustic sensors;
- In – pipeline condition assessment with pigging;

(1) #1026.1.3 EIA/ Pipeline specialist study information

- Above-ground air sampling along the pipeline route (drone or manually operated);
- Detection of tracer chemical introduced into the gas pipeline which can be detected above ground;
- Automatic solar-powered leak detection sensors capable of triggering a control room alarm;
- Radio/WiFi instrumentation information transmitted to control room/pipeline operator; and
- Pipeline monitoring data collected regularly by plant operated security drone.

Leak detection and third party activity (TPA) has been considered in this assessment to limit consequence size and frequency. For TPA the assessment assumes that adequate measures will be taken to limit TPA in line with the standards at which the pipelines investigated under the HSE pipeline failure data that were developed.

This assumption has been carried forward for all areas accessible to the general public, which are understood to be outside the Transnet National Port Authorities (TNPA) port boundary. Within the port boundary third party activity around the pipelines is anticipated to be reduced, therefore a reduction in the likelihood of TPA failure scenarios of one order of magnitude has been assumed.

4.6

METEOROLOGY

Typically, quantitative risk assessments (QRAs) require information regarding the ambient temperatures, wind speed, wind direction and stability class.

Atmospheric stability is difficult to measure and often varies dramatically over relatively short distances. Atmospheric stability classes need to be defined in the dispersion modelling to facilitate estimates of lateral and vertical dispersion parameters.

The preferred stability classification scheme for use in air quality modelling applications is the scheme proposed by Pasquill (1961).

The Pasquill Stability Classes are defined by the letters A to F and are described as follows:

- A. Extremely unstable conditions
- B. Moderately unstable conditions
- C. Slightly unstable conditions
- D. Neutral conditions

- E. Slightly stable conditions
- F. Moderately stable conditions.

Neutral conditions correspond to a vertical temperature gradient of approximately 1 °C per 100 m. The meteorological conditions defining Pasquill stability classes are given in *Table 4.7*.

Table 4.7 *Pasquill Stability Classes*

Surface Wind Speed (m/s)	Day-time Insolation			Night-time Insolation	
	Strong	Moderate	Slight	>4/8 low cloud	≤4/8 cloud
<2	A	A - B	B		
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
>6	C	D	D	D	D

Site-specific wind speed data was obtained for the Port of Saldanha. It is understood that to date no weather stations in South Africa measure both wind speed and stability categories. Therefore, ERM selected the following stability classes and wind speed scenarios as being considered representative for modelling purposes:

- C4 - meaning a stability class of C (slightly unstable conditions) where the wind speed is greater than 4 m/s.
- C8 - meaning a stability class of C (slightly unstable conditions) where the wind speed is greater than 8 m/s.

The above weather scenarios give a conservative daytime weather condition.

- F2 - meaning a stability class of F (moderately stable) where the wind speed is less than or equal to 2 m/s. This class is often used by the US Environmental Protection Agency for determining worse case scenarios for vapour cloud dispersion consequence analysis. F2 gives a conservative night time weather condition.

Selecting the above categories gives an average and a ‘worst case’ condition for the risk assessment study.

The average ambient temperature and humidity for Saldanha Bay were obtained from www.weatherbase.com. A summary of the data is as follows:

- Average ambient temperature is 15.9 °C; and
- Average relative humidity is 78 %.

5.1 INTRODUCTION

There are a number of hazards that are present for a loss of containment from the pipelines or the Propane installation that may result in injury to people or a fatality in more serious cases. Some hazards may even give rise to multiple fatalities. This study is only concerned with 'major hazards', which are outlined below.

Natural Gas is considered a flammable gas while Propane exists as a flammable liquefied gas in storage which will flash to vapour upon release to the atmosphere.

5.1.1 Flash Fires

If a flammable gas release is not immediately ignited then a vapour cloud may be formed and moves away from the point of origin under the action of the wind. If the flammable gas cloud or vapour cloud is unconfined and is less dense than air then it will disperse upwards. However, releases generating gas or vapour that is denser than air tend to stay close to ground level.

This drifting flammable cloud may undergo delayed ignition if an ignition source is reached, resulting in a flash fire if the cloud ignites in an unconfined area or a gas or vapour cloud explosion if within a confined area (an unconfined gas or vapour cloud explosion is also possible under certain conditions).

Upon ignition, the flame front travels back through the cloud towards the release source. The speed of the flame front depends on the material reactivity and the degree of turbulence within the cloud. If the source of material which created the cloud, in this case Natural Gas or Propane is still present then the fire will flash back to the source giving a jet fire which will continue after the flash fire.

The main aim in modelling flash fires is to estimate the size of the flammable cloud. Inside the cloud, direct contact with the burning cloud may cause fatalities, but the relatively short duration of the fire means that thermal radiation effects are not significant outside the cloud.

The flash fire is typically modelled through simulating the dispersion of the initial cloud to the Lower Flammability Limit (LFL). The damage area then corresponds to the LFL cloud footprint.

The material which may cause flash fires is released as Natural Gas or Propane. The effects of flash fires are discussed in *Section 5.2*.

5.1.2

Jet Fires

Jet fires result from ignited continuous releases of pressurised flammable gas. The momentum release carries the material forwards in a long plume entraining air to give a flammable mixture. Jet fires have a high flame temperature and can produce very high intensity thermal radiation.

The high temperatures pose a hazard not only from direct effects of heat on human beings, but also from the possibility of event escalation; if a jet flame impinges upon a target such as a vessel, pipe or structural member, it can cause the target to fail within a few minutes.

The material which may cause jet fires in this case is Natural Gas or Propane. As a worst-case scenario, it was assumed that all failures of the pipelines occur at a 45 degree angle to the horizontal as the pipelines are buried, allowing the jet to extend above ground level with all failures of Propane equipment assumed to be in a horizontal position (ie the flame is orientated horizontally).

The effect of jet fires is discussed in *Section 5.2*.

5.1.3

Flammable Gas or Vapour Cloud Explosions

If the generation of heat in a fire involving a flammable vapour-air mixture is accompanied by the generation of pressure then the resulting effect is a flammable gas cloud or a vapour cloud explosion. The amount of overpressure produced in an explosion is determined by the reactivity of the gas, the strength of the ignition source, the degree of confinement of the flammable cloud, the number of obstacles in and around the cloud and the location of the point of ignition with respect to the escape path of the expanding gases.

In most explosions the expanding flame front travels more slowly than the pressure wave; this type of explosion is called a deflagration and the maximum overpressure is determined by the expansion ratio of the burning gases. If the flame front travels fast enough to coincide with the pressure wave then the explosion is called a detonation and very severe overpressures can be produced. Detonation is most likely to occur with more reactive gases such as hydrogen and ethylene.

Effects on people may be primary, secondary or tertiary. Primary effects are injury to the body as a result of the pressure change (overpressure). Secondary effects are injury as a result of fragments or debris produced by the overpressure impacting on the body, eg due to collapse of structures. Tertiary effects are injury as a result of the body being thrown by the explosion and impacting on stationary objects or structures.

The degree of confinement of the flammable cloud and the number of obstacles in and around the cloud for the majority of releases along the length of the pipeline route are considered to be low due to the open area along the

route. The CCGT power plant is likely to provide a degree of confinement and obstacles and therefore explosions will only be considered in this area.

The effect of flammable gas cloud explosions is discussed in *Section 5.2*.

5.1.4

BLEVEs

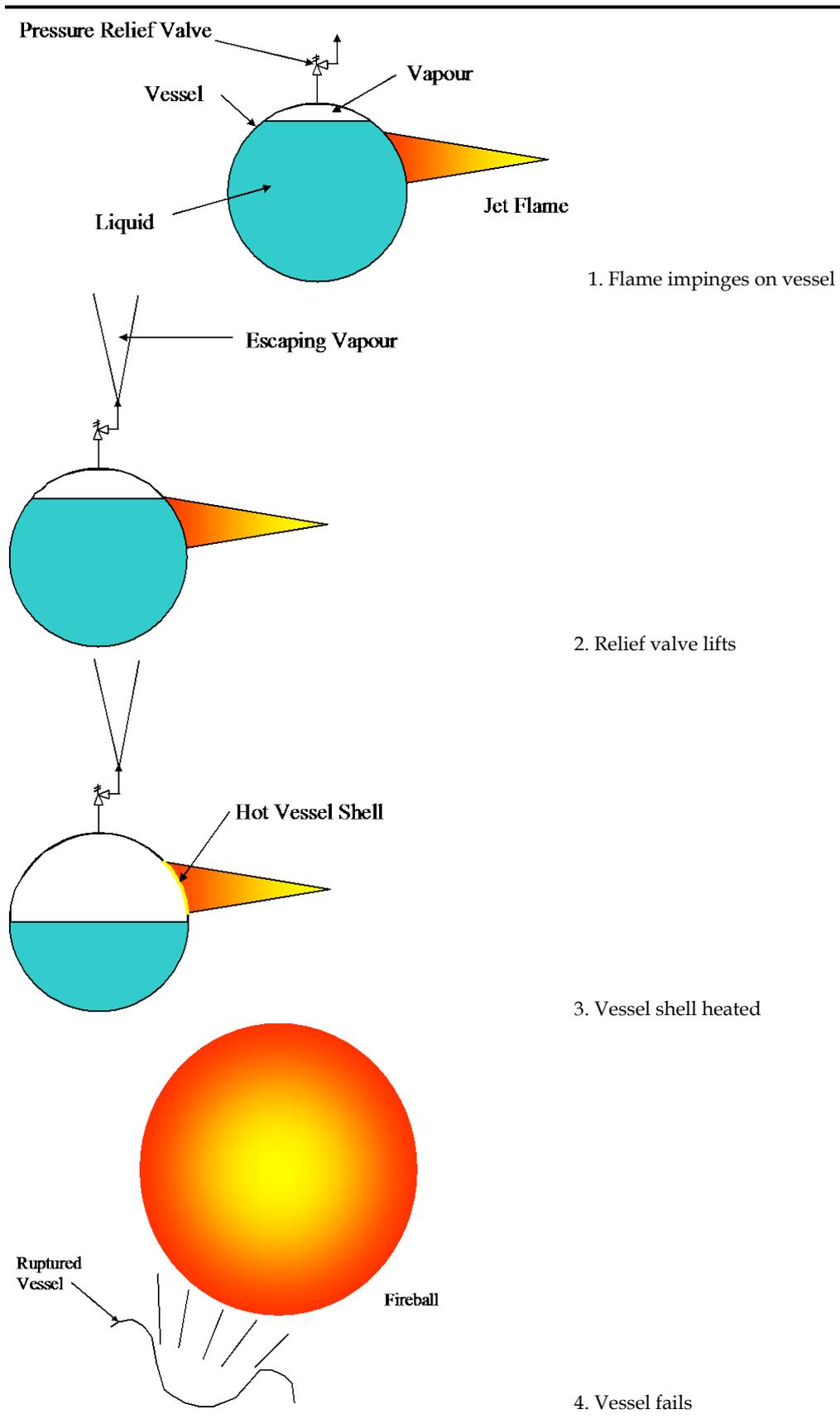
One important flammable vapour hazard is the Boiling Liquid Expanding Vapour Explosion (BLEVE). A BLEVE results from heating of a vessel containing a pressurised liquefied flammable gas. Hence a BLEVE can occur when fire impinges on a flammable vapour vessel shell, particularly at a point or points above the liquid level of the contents of the vessel. This impingement causes the metal to weaken and fail from the internal pressure. The sequence of events that generates a BLEVE is illustrated in *Figure 5.1*.

In *Figure 5.1 (1)*, a jet fire from another part of the installation impinges upon a vessel containing a pressurised liquefied flammable gas (such as Propane). Although a jet fire is used in this illustration, a pool fire may also result in a BLEVE. The jet flame is in contact with the vessel shell over an area below the initial liquid level. The heat from the jet flame is conducted away from the vessel shell quite effectively by the liquid contents. As a result, the pressure in the vessel begins to increase, until the pressure relief valve (PRV) operates. Operation of the PRV prevents the pressure in the vessel increasing further, but material is lost from the vessel and the liquid level starts to drop, as shown in *Figure 5.1 (2)*.

Eventually the liquid level falls to a point where the jet flame is impinging on an area of vessel shell that is now in contact with vapour instead of liquid, as illustrated by *Figure 5.1 (3)*. The vapour is much less effective at conducting heat away from the vessel wall; hence the temperature of the shell in the region of the flame starts to increase markedly. As the shell is heated it begins to lose its strength, until it is no longer able to contain the pressure within the vessel. When this occurs the vessel fails catastrophically, releasing any remaining contents (see *Figure 5.1 (4)*). Once pressure is lost, the liquid rapidly and violently transforms into a fuel rich gas cloud, which burns as a fireball when ignited.

Often, the catastrophic failure of the vessel also generates missiles (fragments of the vessel shell), which can be projected considerable distances.

Figure 5.1 BLEVE Mechanism



5.1.5 *Fireballs*

A fireball can also occur following an instantaneous release of flammable vapour due to cold catastrophic failure of the vessel with immediate ignition. A cold catastrophic failure of the vessel can result from mechanical damage, for example. Such events have very high thermal radiation, similar to jet fires.

5.2 *HARM CRITERIA*

5.2.1 *Thermal Radiation*

One of the causes for harm to people considered in this study is thermal radiation, which occurs as a result of a fire. The vulnerability of people exposed to thermal radiation depends on the intensity of the incident radiation and the duration of exposure. Thermal flux values are used as criteria for long duration fires. Thermal dose values are used as criteria for short duration fires.

Fatality Criteria

Thermal flux impact criteria chosen to be used in the fatality assessment have been selected based on the effects of thermal radiation summarised in Lees ⁽¹⁾ and have been reproduced in *Table 5.1*.

Table 5.1 *Thermal Flux Impact Criteria for Fatality Assessments (Lees)*

Thermal Flux (kW.m ⁻²)	Effect
37.5	Intensity at which damage is caused to process equipment
12.5	Intensity at which piloted ignition of wood occurs
6.3	Intensity in areas where emergency actions lasting up to 1 minute may be required without shielding but with protective clothing

The UK HSE has developed criteria based on a research report ⁽²⁾ that used the following relationship to calculate the thermal dose:

$$tdu = tF^{4/3}$$

where

tdu thermal dose units ([kW/m²]^{4/3}).s

T time (s)

F thermal flux (kW/m²)

The HSE thermal radiation impact criteria for short duration fires are described in *Table 5.2*.

(1) Lees F P (2001). Loss Prevention in the Process Industries. 2nd Edition, reprinted with corrections

(2) Hymes I, The Physiological Effects of Thermal Radiation, SRD R 275, September, 1983.

Table 5.2 Thermal Dose Impact Criteria (HSE)

Thermal Dose (tdu)	Effect
1800	50% fatalities among a 'typical' population
1000	Dangerous dose to a 'typical' population – equates to approximately 1% fatalities
500	Dangerous dose to a vulnerable / sensitive population

This risk assessment uses 1000 tdu as the dangerous dose criterion for land use planning based on the HSE planning case assessment guide ⁽¹⁾. Assuming that the maximum exposure time is 30 seconds (allowing for exposed persons to escape or find shelter), the thermal flux required to meet the above criteria of 1000 tdu is 13.9 kW/m². These values for land use planning are summarised in *Table 5.3*.

Table 5.3 Thermal Flux Impact Criteria for Land Use Planning Assessments (HSE)

Impact	Effect
1000 tdu	Dangerous dose to a 'typical' population – equates to approximately 1% fatalities
13.9 (kW.m ⁻²)	Intensity to reach a thermal dose of 1000 tdu in 30 seconds

5.2.2 Flash Fire Flammability Limit

The extent of a flash fire is defined by dispersion of the released Natural Gas or Propane until the Lower Flammability Limit (LFL) is reached. Within the 0.5LFL contour there is still a possibility of fatality due to exposure to burning pockets of gas. Therefore, for the fatality assessment, the dangerous dose end point criteria for flash fires have been designated as the extent to the LFL and half LFL.

For land use planning, the dangerous dose end point criterion for flash fires has been designated as the extent to the LFL. The dangerous dose end point criteria for flash fires have been highlighted in *Table 5.4*.

Table 5.4 Flash Fire Impact Criteria

Criteria	Effect
LFL	Vapour is able ignite and produce a flash fire
0.5 LFL	Burning pockets of vapour can still occur

5.2.3 Blast Overpressure Criteria

With respect to gas or vapour cloud explosions, the impact criteria used is based on the effects of the blast overpressures. These are discussed in the

(1) Planning Case Assessment Guide, 09/07/2002

TNO Green Book ⁽¹⁾, and summarised in *Table 5.5*; furthermore, Clancy ⁽²⁾ describes the effects of blast overpressures which was reproduced by Lees ⁽³⁾ and is shown in *Table 5.6*.

Table 5.5 *Direct Effects of Blasts on Structures (TNO Green Book)*

Blast Overpressure (kPa)	Effect
8-10	Minor damage to steel frames
20	Collapse of steel frames and displacement of foundation
7	Collapse of roof of storage tank
20-30	Cracking in empty oil storage tanks
50-100	Displacement of cylindrical storage tank, failure of connecting pipes
35-80	Damage to fractionating column
20-30	Slight deformations of a pipe-bridge
35-40	Displacement of pipe-bridge, breakage of piping
40-55	Collapse of a pipe-bridge

Table 5.6 *Direct Effects of Blasts on Structures (Lees)*

Blast Overpressure (kPa)	Effect
0.2	Occasional breakage of large glass windows already under strain
0.7	Breakage of windows, small, under strain
1.0	Typical pressure for glass failure
3.5-6.9	Large and small windows usually shattered; occasional damage to window frames
4.8	Minor structural damage to house structures
6.9	Partial demolition of houses, made uninhabitable
17.3	50% destruction of brickwork of house
20.7 - 27.6	Steel frame building distorted and pulled away from foundations. Frameless, self-framing steel panel building demolished
34.5 - 48.3	Nearly complete destruction of houses

From the information in these tables, the impact criteria that were considered for the fatality assessment are summarised in *Table 5.7*.

Table 5.7 *Blast Overpressure Impact Criteria*

Blast overpressure (bar)	Effect
0.35	Almost complete destruction of typical masonry structures. Significant damage to steel frame structures
0.20	Deformation of structures like pipe bridges, steel frames. Serious damage to masonry structures.
0.05	Minor damage to masonry structures. Conventional windows broken.

For land use planning, the dangerous dose end point criterion for blast overpressure is 0.14 bar.

(1) TNO Green Book, Methods for the Determination of Possible Damage to People and Objects Resulting from Releases of Hazardous Materials, CPR 16E, First Edition 1992, Chapter 2, Section 7, Tables 5

(2) Clancy, V.J., 1972, Diagnostic features of explosion damage, 6th Int Mtg of Forensic Sciences, Edinburgh.

(3) Lees F P (2001). Loss Prevention in the Process Industries. 2nd Edition, reprinted with corrections, Chapter 17, Page 201

5.2.4 *Fatality Probabilities*

Based on the impact criteria described in *Section 5.2.2*, fatality probabilities have been assigned based on the information below.

Thermal Radiation

To assign a probability of fatality to people exposed to the thermal flux values in *Table 5.1*, probabilities of fatality have been assigned based on the required time to reach thermal doses and the probability of fatality that the HSE has assigned to these thermal doses shown in *Table 5.2*. Information on the time taken to reach a given thermal dose level at different levels of thermal flux is given in *Table 5.8*.

Table 5.8 *Thermal Dose Impact Criteria*

Thermal Flux (kW.m ⁻²)	Time to 1800 tdu (s)	Time to 1000 tdu (s)	Time to 500 tdu (s)
37.5	14.5	8.0	4.0
12.5	62.0	34.5	17.2
6.3	154.7	85.9	43.0

At a thermal flux of 37.5 kW.m⁻²:

- For outdoors, a high thermal dosage (1800 tdu) is reached rapidly offering little chance of escape and leaving a high probability of fatality; and
- For indoors, although a building may offer some degree of protection, as 37.5 kW.m⁻² is above the spontaneous ignition threshold of wood (1) , there is a high probability that the building will catch fire and force occupants to escape into a higher thermal flux field resulting into a high probability of fatality.

At a thermal flux of 12.5 kW.m⁻²:

- For outdoors, a thermal dose of 1000 tdu is reached after 30 seconds and 1800 tdu after 1 minute, leading to a fatality probability of 1% and 50% respectively. This offers some chance of escape at this level; and
- For indoors, piloted ignition of wood is possible during long exposure at this thermal flux causing a building to catch fire. However, even if the building does ignite, there is still a possibility of the occupants escaping to alternative shelter.

(1) Lees F P (2001). Loss Prevention in the Process Industries. 2nd Edition, reprinted with corrections

At a thermal flux of 6.3 kW.m⁻²:

- For outdoors, a thermal dose of 1000 tdu is reached after 1.5 minutes and 1800 tdu after 2.5 minutes, leading to a fatality probability of 1% and 50% respectively. This offers a chance of escape resulting in a low fatality; and
- For indoors, thermal flux levels are below the piloted ignition threshold for wood and therefore the likelihood of fatality for building occupants is considered to be very low.

Therefore the probabilities of fatality are assigned as presented in *Table 5.9*.

Table 5.9 *Fatality Probability for Thermal Effects*

Thermal Effects	Fatality Probability	
	People Indoors	People Outdoors
Jet fire, Flux > 37.5 kW/m ² (or within flame boundary if not reached); Fireball, Dose > 1800 tdu (or within flame boundary if not reached)	0.80	1.00
Jet fire, 37.5 kW/m ² / flame < Flux < 12.5 kW/m ² ; Fireball, 1800 / Flame < Dose < 1000 tdu	0.25	0.50
Jet fire, 12.5 kW/m ² < Flux < 6.3 kW/m ² ; Fireball, 500 < Dose < 1000 tdu	0.00	0.05

Flash Fires

People outdoors within the LFL envelope will be enveloped by the flash fire and are assumed to be fatally injured. Within the 0.5LFL contour, exposure to burning pockets of vapour is possible, leading to a fatality. A fatality probability of 0.2 is to be assigned in this instance.

For people indoors, contact with the flame might result in ignition of an engulfed building, endangering occupants. A fatality probability of 0.3 is assigned within the LFL envelope. Beyond the LFL boundary, the likelihood of fatality for persons indoors is considered to be very low.

Blast Overpressure

The blast overpressures (peak side-on overpressures) of interest are 35 kPa (350 mbar), 20 kPa (200 mbar) and 5 kPa (50 mbar).

The UK CIA guidance on occupied buildings ⁽¹⁾ provides curves of fatality probability against overpressure for a number of structure types. Reading the values from the curve for a concrete-framed office structure gives the data in *Table 5.10*.

(1) CIA (2003). *Guidance for the location and design of occupied buildings on chemical manufacturing sites*. RC21 2nd Edition.

Table 5.10 *Fatality Probability for People in Structures Subject to Blast (CIA)*

Blast Overpressure (kPa)	Fatality Probability
100	1
60	0.9
50	0.85
30	0.6
20	0.15
< 10	0

The overpressures and corresponding fatality probability values to be used for the study are shown in *Table 5.11*.

Table 5.11 *Fatality Probabilities for Blast Overpressure, Summary*

Blast Overpressure (kPa)	Fatality Probability, People Indoors	Fatality Probability, People Outdoors
>35	0.75	0.01
20-35	0.45	0
5-20	0.05	0

6.1 HAZARD IDENTIFICATION

The main hazards associated with potential releases of Natural Gas from the pipelines or Propane from the Propane storage facility are jet fires (immediate ignition), flash fires (delayed ignition) and explosions (delayed ignition of the gas or vapour in a confined space). The hazards may be realised due to leaks/failures in the pipelines and ancillary equipment, or from the Propane storage vessel, off-loading road tanker or associated equipment, all of which can release significant quantities of flammable materials on failure.

Section 5 previously provided an explanation of the events which may occur as a result of release of flammable gas or vapour, followed by ignition.

6.1.1 Pipeline Leak Scenarios

The following representative scenarios for the pipeline leaks were considered based on the categorisation of the failure frequency.

Table 6.1 Leak sizes modelled

Leak Category	Report range	Size Modelled
Pin hole	<= 25 mm	25 mm
Small hole	>25 to <=75 mm	50 mm
Large hole	>75 to <=110 mm	100 mm
Rupture	> 110 mm	300 mm

Due to the high operating pressure of the system, leaks will result in the depressurisation of the system. Due to the requirements for uninterrupted supply for the power stations, the gas supply control system is assumed to adjust to small changes in conditions. Therefore for all releases, the average pipeline pressure has been utilised. This is taken as 67 barg.

The leak detection and TPA prevention measures are credited to reduce the duration of a release. As such the following assumptions have been made regarding release duration:

- For small hole sizes (pinhole and small) it was assumed that, even with leak detection, small releases would not be detected immediately and therefore it was assumed that release duration would be 15 minutes or until steady state has occurred; and
- For larger hole sizes (large hole and rupture), it is assumed the leak will be detected more rapidly by leak detection systems or human intervention. Therefore shorter release durations were assumed, based on reporting and system shutdown timing, of 5 minutes.

6.1.2 *Power Station Scenarios*

As information with regards to the Natural Gas infrastructure will be developed in the detail design stage of the project, only a consequence assessment of a Natural Gas release from the power station gas receiving station will be completed.

As the gas pressure is understood to be controlled and restricted at the gas receiving station, the consequences from a release in this area are expected to be smaller than that of a pipeline release. However, if the equipment is located within a confined area there is the potential for a flammable gas cloud or vapour cloud explosion.

Using an approximation of the footprint gas receiving area, an explosion will be modelled with the following characteristics:

- TNO Multi Energy Model - Explosion Curve 5; and
- Confined volume approximately 10,000m³.

An explosion was also modelled in the vicinity of the Propane bullet and generator. Considering the dimensions of the bullet and generator, the following explosion conditions were modelled:

- TNO Multi Energy Model - Explosion Curve 5; and
- Confined volume approximately 100 m³ considering the space in and around the Propane storage vessel.

6.1.3 *Propane Scenarios*

The scenarios considered for the Propane backup generator system will comprise the following elements:

- Propane storage vessel;
- Propane pipework from vessel to vapouriser;
- Propane vapouriser;
- Propane pipework from vapouriser to generator;
- Propane offloading and pipework from road tanker to vessel; and
- Propane road tanker with associated offloading hoses.

These elements have been selected based on the basic system description provided although the system was not described in detail in the documentation provided for the study.

As the planned construction period in the second year is expected to consume the most Propane, this scenario has been modelled along with the proposed normal Propane backup generator operation scenario. As operation of the pipeline is understood to take place after the construction phase, the risk of a Natural Gas release during this phase will not be realised.

There is a risk of fire or explosion in relation to the Natural Gas transfer operations via pipelines to the CCGT power plant site or from the Propane generator system on this site. The thermal radiation and explosion overpressures could potentially impact members of the public in the surrounding areas and as well as operational personnel.

This assessment estimates the effects of thermal radiation from fires and overpressures from explosions on human beings. The meteorological characteristics that govern the extent of the thermal radiation and overpressure zones are described in *Section 3.3*.

6.2.1 Jet Fires

Table 6.2 shows the maximum jet fire consequence distances for failure scenarios associated the Natural Gas transfer and the Propane system. The distance to the maximum jet fire consequence envelopes are illustrated in *Figure 6.1*.

Table 6.2 *Maximum Jet Fire Consequence Distances*

Location and Equipment	Scenario and Weather	Radiation Level (kW/m ²)	Maximum Distance(m)
Pipelines	Pipeline Rupture	37.5	94
		13.9 (Dangerous Dose)	156
		12.5	164
		6.3	323
Propane Installation	Full bore transfer hose failure	37.5	144
		13.9 (Dangerous Dose)	173
		12.5	177
		6.3	207

6.2.2 Flash Fires

Table 6.3 shows the maximum flash fire consequence distances for failure scenarios associated with Natural Gas transfer or the Propane installation. The distance to the maximum flash fire consequence envelopes are illustrated in *Figure 6.2*.

Table 6.3 *Maximum Flash Fire Consequence Distances*

Location and Equipment	Scenario and Weather	Concentration	Maximum Distance(m)
Pipelines	Catastrophic Failure	LFL (Dangerous Dose)	676
		0.5LFL	998
Propane Installation	Full bore transfer hose failure	LFL (Dangerous Dose)	239

Location and Equipment	Scenario and Weather	Concentration	Maximum Distance(m)
		0.5LFL	501

6.2.3 *Flammable Gas or Vapour Cloud Explosion Overpressure*

Table 6.4 shows the maximum flammable gas or vapour cloud explosion consequence distances for failure scenarios associated with Natural Gas transfer or the Propane installation.

The distance to the maximum flammable gas or vapour cloud explosion consequence envelope is illustrated in Table 6.4.

Table 6.4 *Maximum Flammable Gas Cloud or Vapour Cloud Explosion Consequence Distances*

Location and Equipment	Scenario and Weather	Overpressure (mbar)	Maximum Distance(m)
Gas receiving station	Natural Gas release	140 (Dangerous Dose)	57
	Confined Volume - 10,000m ³ TNO Explosion Curve 5		
Propane backup generator	Propane release	140 (Dangerous Dose)	13
	Confined Volume - 100m ³ TNO Explosion Curve 5		

From Figure 6.3 it can be seen that these overpressures do not extend beyond the proposed CCGT power plant boundary.

6.2.4 *BLEVEs and Fireballs*

Table 6.5 shows the BLEVE or fireball consequence distances for failure scenarios associated with the Propane generator installation.

The distance to the maximum BLEVE or fireball consequence envelope is illustrated in Figure 6.4.

Table 6.5 *Maximum Flammable Gas Cloud or Vapour Cloud Explosion Consequence Distances*

Location and Equipment	Scenario and Weather	Thermal Dose (tdu)	Maximum Distance(m)
Propane Vessel	BLEVE or fireball, all weather	1,800	82
		1,000	
		(Dangerous Dose)	114
		500	157
Propane Road Tanker	BLEVE or fireball, all weather	1,800	82
		1,000	
		(Dangerous Dose)	114
		500	157

Figure 6.1 Areas Enveloped by the Largest Jet Fires

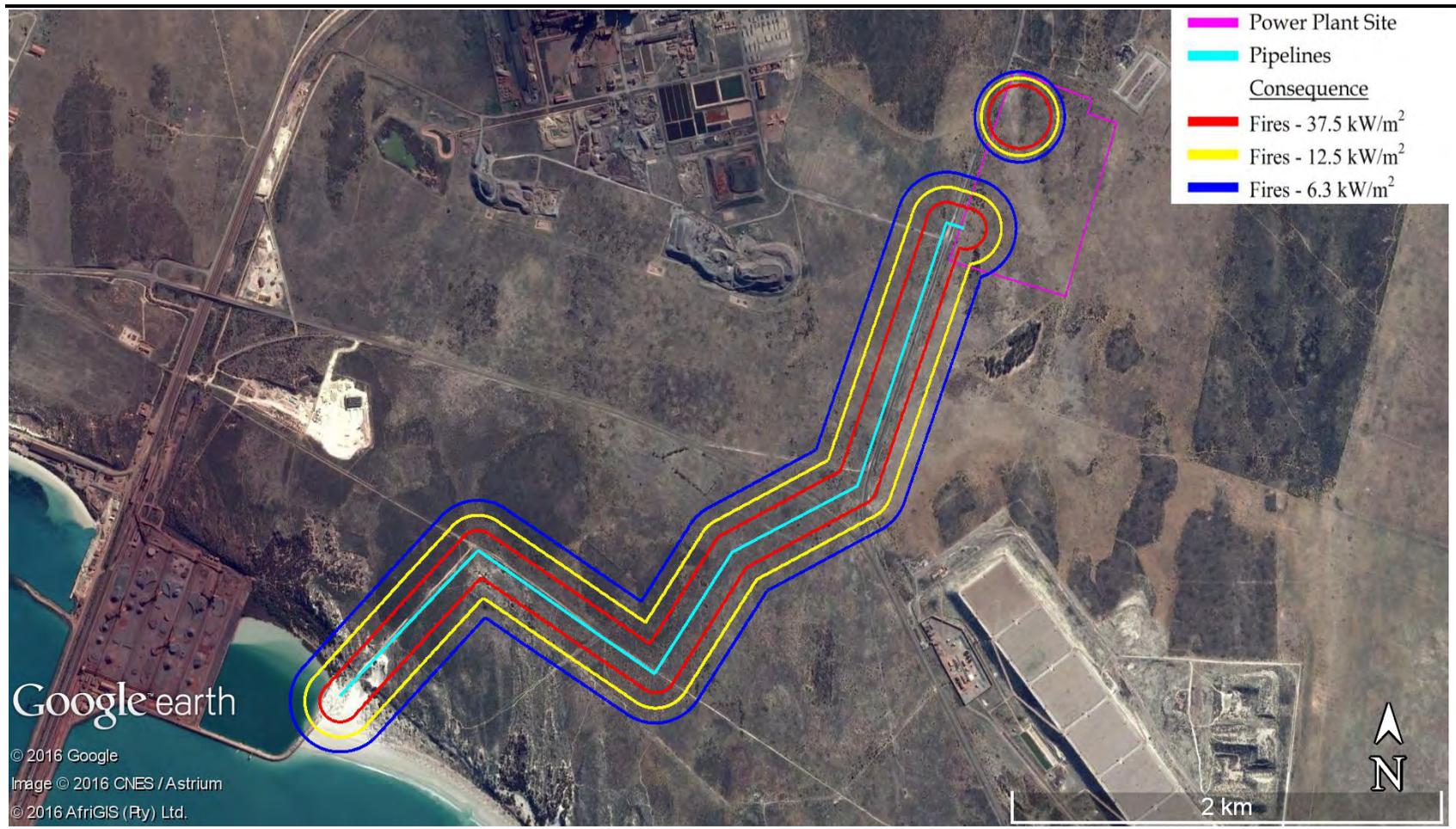


Figure 6.2 Areas Enveloped by the Largest Flash Fires



Figure 6.3 Areas Enveloped by the Largest Flammable Gas Cloud or Vapour Cloud Explosions

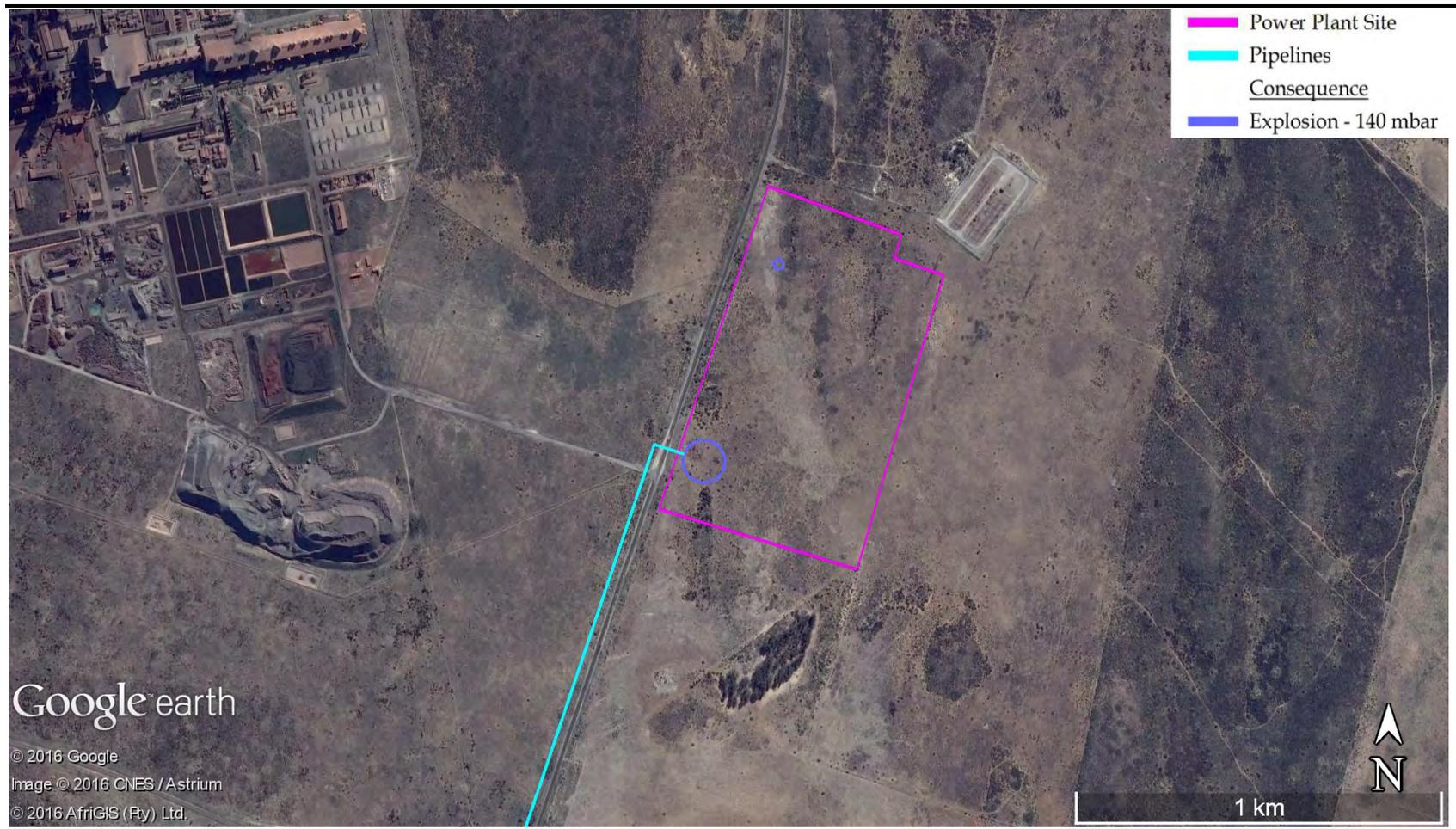
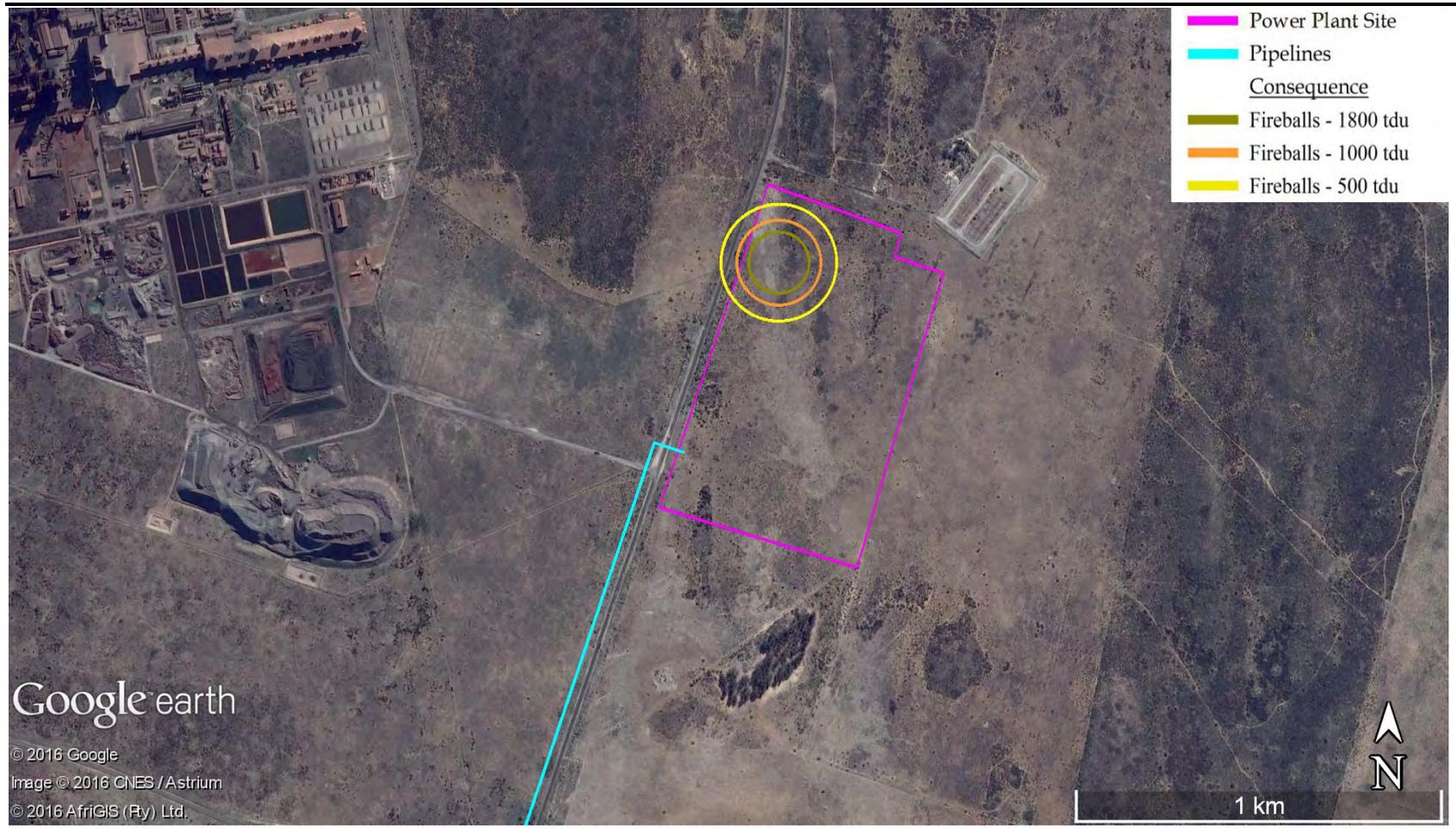


Figure 6.4 Areas Enveloped by the Largest Flammable Gas Cloud or Vapour Cloud Explosions



6.3 ESTIMATION OF INCIDENTS

6.3.1 Loss of Containment Frequency Calculations

To determine the probability of a leak occurring on the Natural Gas pipelines, the failure rate leading to a loss of containment needs to be modified by the probability of the Natural Gas finding an ignition source. The frequency of the release scenarios identified in *Section 5* is shown below.

Failure frequency data has been compiled and evaluated by the Health and Safety Laboratory on behalf of the UK's HSE into this report ⁽¹⁾. This report uses data from CONCAWE (Conservation of Clean Air and Water in Europe) and UKOPA (United Kingdom Onshore Pipeline Operators Association) collected since 1970 and EGIG.

The report presents updated data for a six different substances, one of which is Natural Gas. This dataset is utilised to represent the frequency of pipeline failure used for this risk assessment and is shown in *Table 6.6*.

Table 6.6 *Summary of Pipeline Failure Frequencies (per km per year)* ⁽²⁾

Failure category	Pinhole	Small hole	Large hole	Rupture
Mechanical failure	8.7E-06	1.0E-08	1.0E-08	1.0E-08
Corrosion	1.0E-07	1.0E-08	1.0E-08	1.0E-08
Ground movement/other	1.2E-05	2.5E-06	1.5E-07	2.5E-06
TPA	2.2E-05	2.4E-06	1.0E-07	1.0E-07

It is assumed that this data is for "good practice" pipelines i.e. those pipelines designed, operated and maintained to a good level. For this assessment, this data was used as a baseline for this study. Due to deviations in the design and operating conditions, it is sometimes appropriate to add modifiers to this base data to make the failure frequencies more appropriate to the pipelines of interest.

TPA was considered differently for the section of pipelines within the Transnet National Port Authority (TNPA) area and public areas. Within the controlled area it was considered an order of magnitude less likely that TPA could occur due to the control measures in place and this is reflected in the model.

The failure scenarios considered for the elements of the Propane backup generator system are described in *Section 6.1.3*.

The frequency of the release scenarios for the Propane backup generator system identified in *Section 6.1.3* is represented in *Table 6.7* to *Table 6.11*.

(1) HSE Research report RR1035

(2) CONCAWE Report no 12/13 - Performance of European cross-country oil pipelines. Statistical summary of reported spillages in 2012 and since 1971

Table 6.7 Propane Storage Vessel Failure Rates ⁽¹⁾

Failure Type - Tanks	Frequency
Catastrophic failure – BLEVE (hot failure)	1E-5/ tank year
Catastrophic failure – cold failure	2E-6 / tank year
50 mm hole	5E-6 / tank year
25 mm hole	5E-6 / tank year
13 mm hole	1E-5 / tank year

Table 6.8 Propane Road Tanker and Hose Failure Frequencies

Event	Frequency
Road Tanker Failure	
Catastrophic failure – BLEVE (hot failure) ⁽²⁾	Sites with small tanks (<5 tons) - 1 x 10 ⁻⁷ / delivery
Catastrophic failure – cold failure ⁽³⁾	1 x 10 ⁻⁶ / year
Hose Failure ⁽⁴⁾	
Full bore	2 x 10 ⁻⁷ per operation
15 mm Hole	4 x 10 ⁻⁷ per operation
5 mm Hole	6 x 10 ⁻⁶ per operation

NOTE Hose Failure Data assumes provision for multiple safety systems as described in the failure data reference

Table 6.9 Failure Frequencies for Propane Pipework⁽⁵⁾

Release Hole Size (mm)	Failure Frequency (per metre year) for Pipe Diameter (mm)				
	<50	50-149	150-299	300-499	500-1000
3	1 x 10 ⁻⁵	2 x 10 ⁻⁶			
4			1 x 10 ⁻⁶	8 x 10 ⁻⁷	7 x 10 ⁻⁷
25	5 x 10 ⁻⁶	1 x 10 ⁻⁶	7 x 10 ⁻⁷	5 x 10 ⁻⁷	4 x 10 ⁻⁷
1/3 pipe diameter			4 x 10 ⁻⁷	2 x 10 ⁻⁷	1 x 10 ⁻⁷
Full bore	1 x 10 ⁻⁶	5 x 10 ⁻⁷	2 x 10 ⁻⁷	7 x 10 ⁻⁸	4 x 10 ⁻⁸

Regasification vapourisers are assumed to be shell and tube heat exchangers. Failure frequencies for heat exchangers are not provided in PCAG and therefore other sources of failure data were sought. OGP provides failure data for tube side failures which is shown in *Table 6.10*.

(1) Failure Rate and Event Data for use within Land Use Planning Risk Assessments – FR 1.1.3.2 LPG Pressure Vessels

(2) Failure Rate and Event Data for use within Land Use Planning Risk Assessments – Item FR3.2.2 Road Tankers

(3) TNO Purple Book, Loss Of Containment from pressurised road tankers – Page 3.14.

(4) Failure Rate and Event Data for use within Land Use Planning Risk Assessments – FR 1.2.3 – Hoses and Couplings

(5) Failure Rate and Event Data for use within Land Use Planning Risk Assessments – FR 1.3 – Pipework

Table 6.10 Propane Vapouriser Release Frequency⁽¹⁾

Hole Diameter Range (mm)	Release Frequency (per heat exchanger per year)			
	All Releases	Full Releases	Limited Releases	Zero Pressure Releases
1 - 3	2.0x10 ⁻³	8.2x10 ⁻⁴	7.9x10 ⁻⁴	1.8x10 ⁻⁴
3 - 10	8.8x10 ⁻⁴	3.8x10 ⁻⁴	4.3x10 ⁻⁴	7.7x10 ⁻⁵
10 - 50	4.0x10 ⁻⁴	1.8x10 ⁻⁴	2.5x10 ⁻⁴	3.4x10 ⁻⁵
>50	2.0x10 ⁻⁴	7.6x10 ⁻⁵	1.9x10 ⁻⁴	1.3x10 ⁻⁵
Total	3.4x10 ⁻³	1.5x10 ⁻³	1.7x10 ⁻³	3.0x10 ⁻⁴

In line with the OGP usage guidance for coarse QRAs, the frequencies of ‘full’ and ‘limited’ releases (highlighted in Table 6.10) will be combined in this QRA. These frequencies will be assessed in addition to the general process release frequencies considered earlier in this section, to enable compatibility between the PCAG and OGP datasets. It is assumed that the vapouriser maximum tube diameter will be 50mm. Therefore the release frequencies in the OGP are redistributed into the PCAG hole sizes as shown in Table 6.11.

Table 6.11 Hole Size Equivalencies

PCAG Hole Diameter (mm)	OGP Hole Diameter Range (mm)
3	1 - 3
N/A	3 - 10
25	10 - 50
Full Bore Rupture (50mm)	>50

It is conservatively assumed that in the event of a tube failure a loss of containment will occur. Typically heat exchanger shells are able to accommodate the internal tube pressure and any excess pressure will be vented through a pressure relief system.

6.3.2 Ignition Probabilities

Ignition can occur immediately after a loss of containment of the Natural Gas or Propane if an ignition source is present or the initiating event can cause ignition this can result in a jet fire, flash fire or explosion.

Delayed ignition can occur when a flammable cloud encounters an ignition source away from the point of release. This can typically result in larger flash fires or potential explosions if the cloud envelops a congested area.

The ignition probabilities utilised for the Natural Gas pipelines and Propane scenarios are differentiated below.

(1) OGP Risk Assessment Data Directory, Process Release Frequencies, Report No. 434-1, March 2010

Pipelines

OGP⁽¹⁾ specifies immediate ignition probabilities of 0.001. Several other literature sources quote higher immediate ignition probabilities based on initial release rates. BEVI⁽²⁾ recommends a differentiation of low and high reactivity gasses.

Natural Gas is considered a low reactivity gas. Therefore this immediate ignition probability philosophy will be adopted. For high energy releases, ie some form of third party interference, it has been assumed that immediate ignition will occur.

Delayed ignition probabilities for the pipeline will be modelled as OGP scenario 3 - Pipe Gas LPG Industrial (Gas or LPG release from onshore pipeline in an industrial area). This is due to potential industrial type activity within the Port of Saldanha as well as at Saldanha Steel. This is further supported by the numerous roadways that the pipeline will have to pass below.

Therefore the ignition probabilities used for this assessment have been summarised in *Table 6.12*.

Table 6.12 *Ignition Probabilities*

Immediate Ignition		
Failure Type	Ignition Probability	Release Rate (kg/s)
Small	0.02	<10
Medium	0.04	10 – 100
Large	0.09	>100
Third Party Interference	1.0	
Delayed Ignition		
Location	OGP Scenario	
Onshore Pipeline	3	

Propane

The ignition frequencies have been taken from the OGP report no. 434-6.1 ⁽³⁾ (March 2010). For the Propane scenarios, Scenario 8 - Large Plant Gas LPG (Gas or LPG release from large onshore plant) is used.

(1) OGP Risk Assessment Data Directory, Ignition Probability, Report No. 434-6.1, March 2010

(2) Reference Manual Bevi Risk Assessments, Version 3.1, The National Institute of Public Health and the Environment (RIVM), 2009.

(3) OGP Risk Assessment Data Directory, Report No. 434-6.1, March 2010

7.1 LAND USE PLANNING (LUP) RISK CALCULATION

The scenario frequencies and consequence results are used within the ERM *ViewRisk* risk summation package to calculate the individual risk of receiving a dangerous dose associated with Natural Gas pipelines.

The results will be presented as risk transects for the Natural Gas pipelines and risk contours for the Natural Gas pipelines and Propane generator. The risk transects and risk contours can be compared with the risk criteria used by the UK Health and Safety Executive (HSE) for deciding upon the risk and hence, acceptability of developments around pipeline servitudes. Individual risk lines at 1×10^{-5} , 1×10^{-6} and 3×10^{-7} chances per year of receiving a dangerous dose or worse will also be indicated on the risk transects and risk contours where applicable

The risk criteria are discussed in more detail in *Section 3.2.1*. shows typical examples of typical installations falling into the various sensitivity categories as defined by the HSE.

Table 7.1 *Examples of Sensitivity Levels of Typical Developments*

Sensitivity Level	Typical Examples	Allowed In
Level 1	Any general public at work	Inner Zone, Middle Zone, Outer Zone
Level 2	Housing, accommodation, transport links, outdoor use by the public, Level 1 development with >100 occupants per building or buildings greater than 3 stories.	Middle Zone, Outer Zone
Level 3	Institutional accommodation and education (including hospitals and schools), prisons, large examples of Level 2 developments	Outer Zone
Level 4	Institutional accommodation where 24 hour care is provided or larger than 0.25 hectare, schools or day care larger than 1.4 hectare, very large outdoor use by the public (typically > 1,000 people)	Outside Outer Zone Only

The area around the proposed Natural Gas pipelines' route and CCGT power plant site includes the following land uses:

- Sensitivity Level 1: The Saldanha Port area and the access road running adjacent to the CCGT power plant site as this is a single lane road; and
- Sensitivity Level 2: Camp road which is crossed by the pipelines as this is a dual carriageway

7.1.1 Risk Transects

The LUP risk transect for the pipelines in the general public area are shown in *Figure 7.1* and in the port authority area are shown in *Figure 7.2*.

Figure 7.1 Risk Transect for Land Use Planning for Saldanha Steel Natural Gas Pipelines

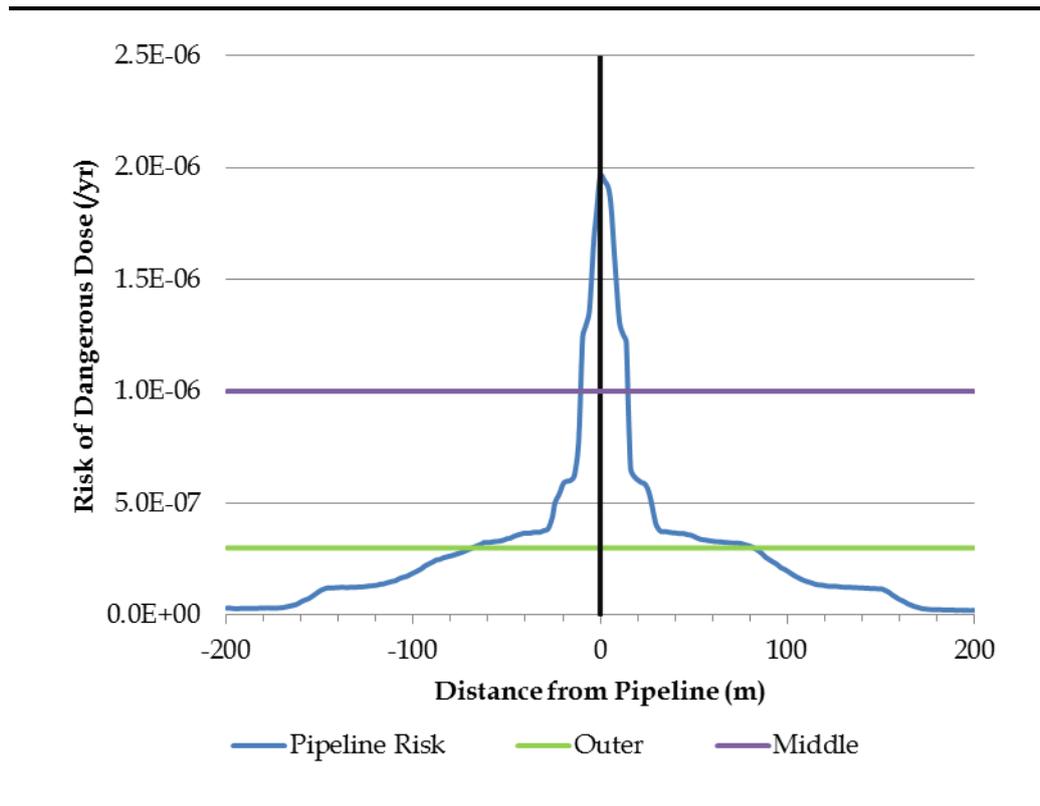
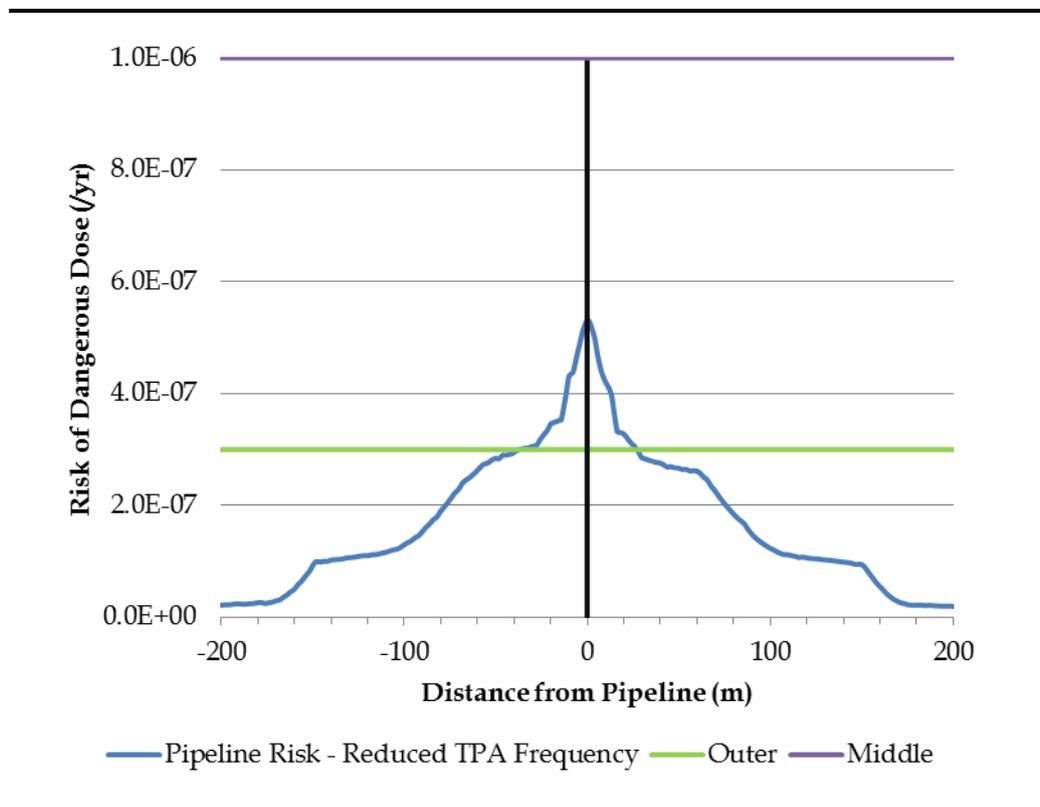


Figure 7.2 Risk Transect for Land Use Planning for Saldanha Steel Natural Gas Pipelines with Reduced TPA Frequency in the Port Area



The area of the Natural Gas pipelines that is accessible to the general public has a risk level within the Middle Zone which is approximately 10 m to either side of the pipelines. Therefore no Level 3 or Level 4 developments such as those described in *Table 7.1* should be allowed within 10m of the centre line of the pipeline servitude. No Sensitivity Level 3 or 4 land uses exist in the surrounding area.

The area of the pipeline that is accessible to the public has a risk level within the Outer Zone which is approximately 68m to either side of the pipelines. Therefore no Level 4 developments such as those described in *Table 7.1* should be allowed within 68m of the centre line of the pipeline servitude. No Sensitivity Level 4 land uses exist in the surrounding area.

The area surrounding the pipelines' servitude within the port boundary is understood to be zoned for industrial use and therefore classified as Sensitivity Level 1 in *Table 7.1*.

Based upon the current land uses around the proposed Natural Gas pipelines' route, the risk level would be classified as 'don't advise against' according to the land use planning criteria. Therefore the current land uses can be considered tolerable. Future land uses around the Natural Gas pipelines should adhere to those of *Table 7.1* for the pipelines' risk transects presented in *Figure 7.1* and *Figure 7.2*.

7.1.2 Risk Contours during the Second Year of Construction

The Land Use Planning risk contours for the pipelines and Propane generator operations during the second year of construction are shown in *Figure 7.3*. As the CCGT power plant will be under construction, no risks of a Natural Gas release are realised at this time.

From the figure it can be seen that the increased Propane consumption results in an area outside the power plant site falling within the 1×10^{-5} contour and therefore falling within the Inner Zone. This area extends approximately 110 m to the west and 40 m to the north of the CCGT site boundary as can be seen in *Figure 7.3*. Therefore no Level 2, Level 3 or Level 4 developments such as those described in *Table 7.1* should be allowed within this area during the second year of construction. The only Sensitivity Level 2 land use identified in the surrounding area is Camp road which exists outside of the inner zone.

From the figure it can be seen that an area outside the power plant site falls within the 1×10^{-6} contour and therefore is within the Middle Zone. This area extends approximately 120 m to the west and 50 m to the north of the CCGT site boundary as can be seen in *Figure 7.3*. Therefore no Sensitivity Level 3 or Level 4 developments such as those described in *Table 7.1* should be allowed within this area during the second year of construction. No Sensitivity Level 3 or 4 land uses exist in the surrounding area.

From the figure it can be seen that an area outside the power plant site falls within the 3×10^{-7} contour and therefore is within the Outer Zone. This area extends approximately 140 m to the west and 60 m to the north of the CCGT site boundary as can be seen in *Figure 7.3*. Therefore no Sensitivity Level 4 developments such as those described in *Table 7.1* should be allowed within this area during the second year of construction. No Sensitivity Level 4 land uses exist in the surrounding area.

The current land uses within these areas result in the risk level being classified as 'don't advise against' during the second year of construction according to the land use planning criteria. Future land uses around the CCGT power plant site within the second year of construction should adhere to those of *Table 7.1* for risk contours presented in *Figure 7.3*.

7.1.3 Risk Contours during Normal Operation

The Land Use Planning risk contours for the pipelines and Propane generator operations during normal operation are shown in *Figure 7.4*.

From the figure it can be seen that an area outside the power plant site falls within the 1×10^{-6} contour and therefore is within the Middle Zone. This area extends approximately 90 m to the west and 50 m to the north of the CCGT site boundary as can be seen in *Figure 7.4*. Therefore no Sensitivity Level 3 or Level 4 developments such as those described in *Table 7.1* should be allowed within this area during normal operation. No Sensitivity Level 3 or 4 land uses exist in the surrounding area.

From the figure it can be seen that an area outside the power plant site falls within the 3×10^{-7} contour and therefore is within the Outer Zone. This area extends approximately 120 m to the west and 60 m to the north of the CCGT site boundary as can be seen in *Figure 7.4*. Therefore no Sensitivity Level 4 developments such as those described in *Table 7.1* should be allowed within this area during normal operation. No Sensitivity Level 4 land uses exist in the surrounding area.

The current land uses within these areas result in the risk level being classified as 'don't advise against' during normal operation according to the land use planning criteria. Future land uses around the CCGT power plant site during normal operation should adhere to those of *Table 7.1* for risk contours presented in *Figure 7.4*.

Figure 7.3 Risk Contours for Land Use Planning for Saldanha Steel Natural Gas Pipelines and Propane backup generator with High Propane Consumption during the Second Year of Construction

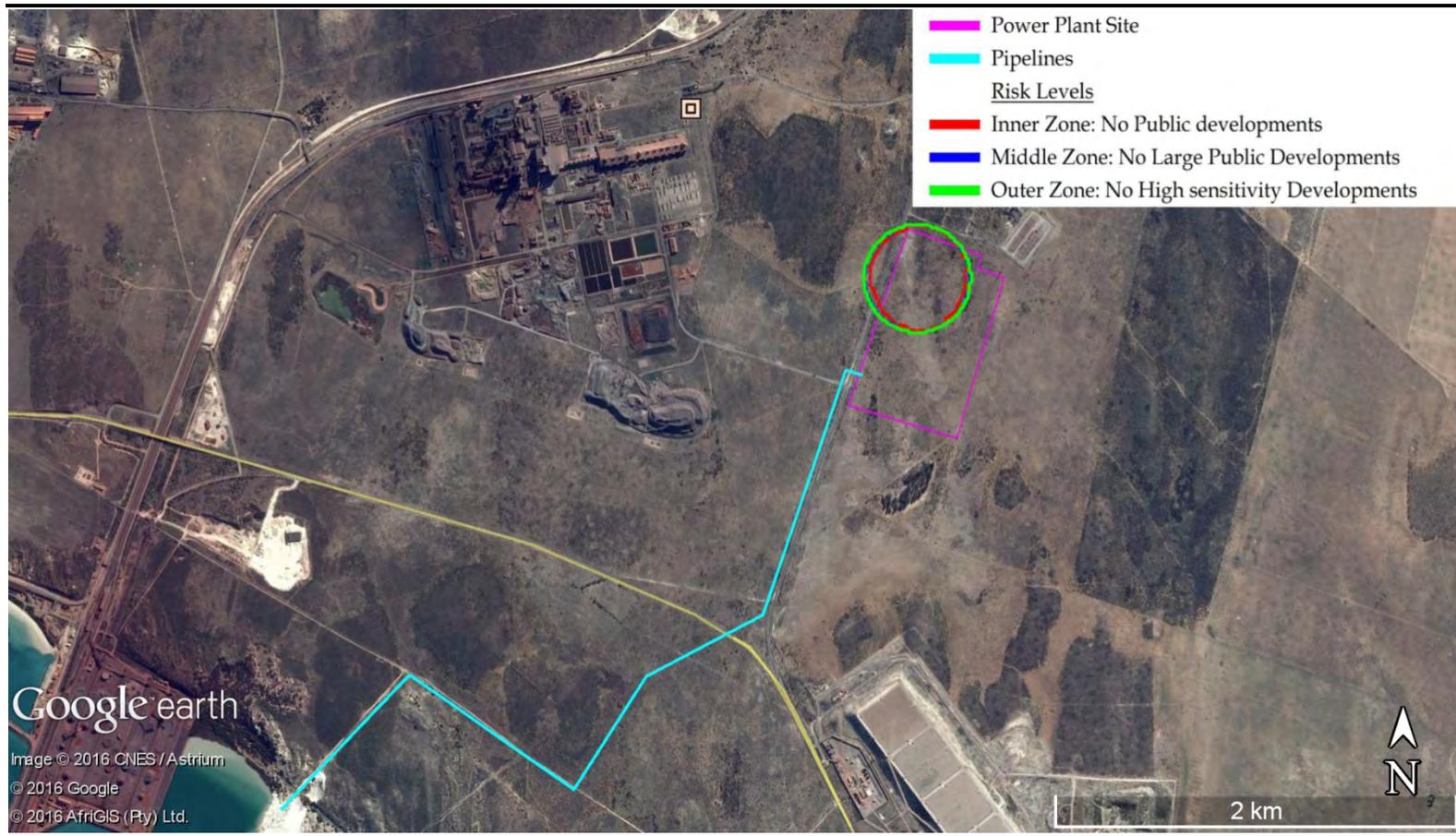
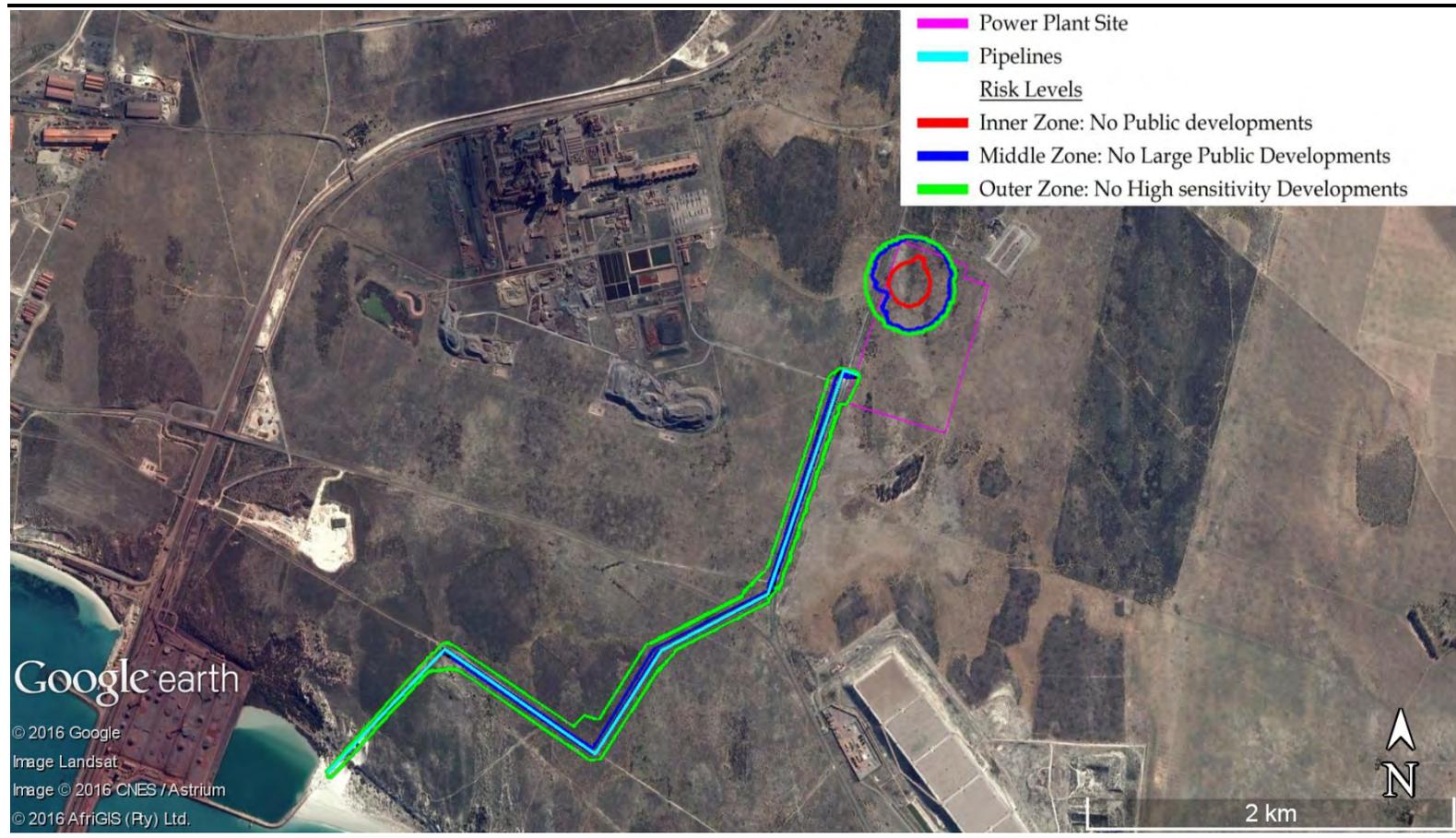


Figure 7.4

Risk Contours for Land Use Planning for Saldanha Steel Natural Gas Pipelines and Propane backup generator with Normal Power Plant Operation Propane Consumption



Individual risks are by definition specific to individuals and need to take into account the extent and circumstances under which exposure arises. For instance, the risk will depend on the amount of time the individual spends outdoors as well as the time they may spend indoors which will afford them some protection. Risks are calculated for hypothetical persons located outdoors and indoors.

The risk contours presented in this section represent Location Specific Individual Risk (LSIR). It should be noted that the LSIR relates to an individual who is permanently exposed 24 hours a day 365 days a year. This is therefore an overestimate of the individual risk to personnel or public who may be present at these locations.

Individual risks of fatality contours for persons located outdoors and indoors at 1×10^{-6} , 1×10^{-5} , 1×10^{-4} and 1×10^{-3} for the Natural Gas transfer operations and Propane installation were calculated using the fatality probabilities detailed in *Section 5.2.4*.

With reference to the risk criteria highlighted in *Section 3.2.3*, the risks posed by the pipelines and Propane installation to areas located beyond the 1×10^{-6} contour would be considered 'broadly acceptable'. The risks posed to areas located between the 1×10^{-6} contour and the 1×10^{-4} contour would be considered tolerable if they can be proved to be As Low as Reasonably Practicable (ALARP) by the Natural Gas pipelines and Propane installation operator. The risks posed to non-Natural Gas operational personnel and establishments as well as sensitive areas within the 1×10^{-4} contour are considered intolerable. The risks posed to Natural Gas pipelines personnel within the 1×10^{-3} contour are considered intolerable and this would constitute a potentially fatal flaw for the development.

The results will be presented as risk transects which present the risk levels at 90 degrees to the pipelines route as well as risk contours for the pipelines and Propane backup generator developments. The risk contours for the Propane developments will be shown for the second year of construction which represents the largest period of propane consumption as well as for normal Propane backup generator operation.

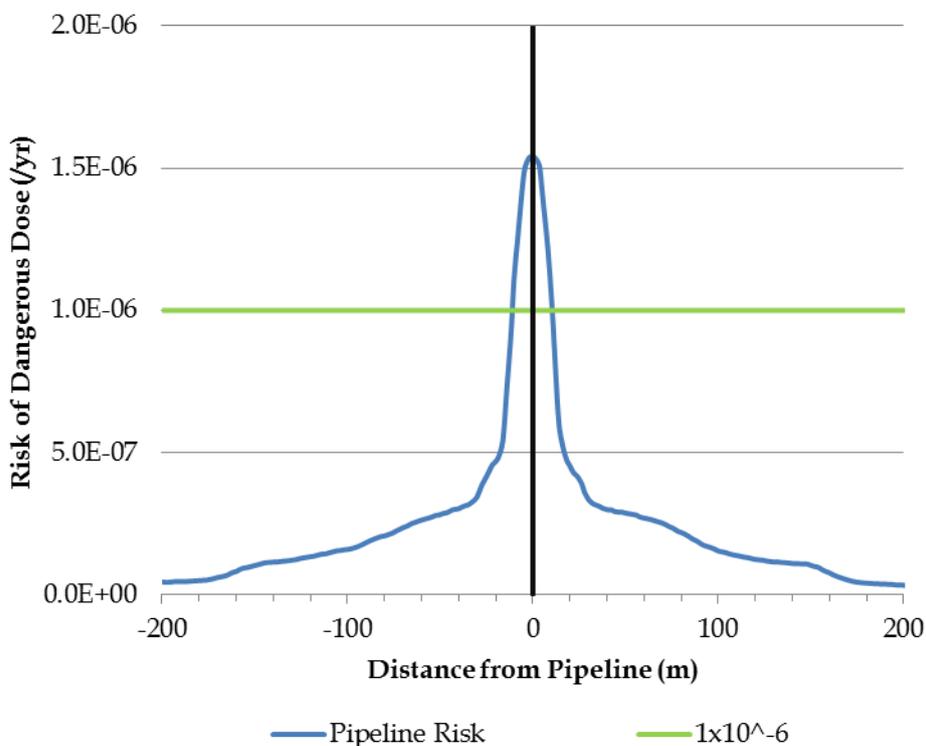
7.2.1

Risk Transects

Risk Transects representing the location specific individual risks (LSIR) risk transect for hypothetical persons located outdoors and indoors for the pipelines were calculated for the areas accessible to the general public as well as those within the Port boundary. Only the transects for persons located outdoors for the area accessible to the general public were found to exceed 1×10^{-6} and therefore all other LSIR transects were excluded from further analysis.

Figure 7.5 represents the location specific individual risks (LSIR) risk transect for hypothetical persons located outdoors for the Natural Gas pipelines. This transect is taken for the area accessible to the general public.

Figure 7.5 Risk Transect for Individual Risk of Fatality for Saldanha Steel Natural Gas Pipelines – Persons Located Outdoors



From Figure 7.5 it can be seen that the individual risk of fatality exceeds the 1×10^{-6} contour. This extends approximately 10m on either side of the pipelines route. As the risk in this area exceeds 1×10^{-6} but does not exceed 1×10^{-4} the LSIR for the pipelines for persons located outdoors along the pipeline route is not considered intolerable according to the risk criteria as defined in Section 3.2.3. The risks within this area can only be considered tolerable if they can be demonstrated by the site to be As Low As Reasonably Practicable (ALARP).

7.2.2 Risk Contours during the Second Year of Construction

The LSIR contours for individuals located outdoors and indoors for the proposed Natural Gas pipelines and Propane backup generator developments during the second year of construction are shown in Figure 7.6 and Figure 7.7 respectively.

Figure 7.6 represents the location specific individual risks (LSIR) for hypothetical persons located outdoors for the proposed pipelines and Propane generator developments during the second year of construction. The areas

surrounding the proposed developments that fall between the 1×10^{-6} contour and the 1×10^{-4} contour are small areas to the north and west of the CCGT power plant site. As the risk exceeds 1×10^{-6} but does not exceed the 1×10^{-4} risk level, the LSIR for the pipelines and Propane backup generator for persons located outdoors in these areas is not considered intolerable according to the risk criteria as defined in *Section 3.2.3*. The risks can only be considered tolerable if they can be demonstrated by the site to be As Low As Reasonably Practicable (ALARP).

The 1×10^{-4} contour exists for the area centred on the Propane backup generator. This contour does not extend offsite, therefore only workers involved in the construction and operation of the CCGT power plant are exposed to this risk level and this is not considered intolerable according to the risk criteria as defined in *Section 3.2.3*. The risks can only be considered tolerable if they can be demonstrated by the site to be As Low As Reasonably Practicable (ALARP).

The 1×10^{-3} LSIR contour do not exist for individuals located outdoors, therefore the risk is below these levels.

No risk contours for persons located outdoors exist around the Natural Gas pipelines as it is understood that these will not be operational during this phase of construction.

Figure 7.7 represents the location specific individual risks (LSIR) for hypothetical persons located indoors for the proposed pipelines and Propane generator developments during the second year of construction. Areas located off the power plant site have an individual risk higher than 1×10^{-6} . As the risk exceeds 1×10^{-6} but does not exceed 1×10^{-4} the LSIR for the pipelines and Propane backup generator for persons located outdoors in these areas is not considered intolerable according to the risk criteria as defined in *Section 3.2.3*. The risks can only be considered tolerable if they can be demonstrated by the site to be As Low As Reasonably Practicable (ALARP).

The 1×10^{-3} and 1×10^{-4} LSIR contours do not exist for individuals located indoors, indicating that the risk is lower than this level.

No risk contours for persons located indoors exist around the Natural Gas pipelines as it is understood that these will not be operational during this phase of construction.

7.2.3 Risk Contours during Normal Propane generator Operation

The LSIR contours for individuals located outdoors and indoors for the proposed Natural Gas pipelines and Propane backup generator developments during normal operation are shown in *Figure 7.8* and *Figure 7.9* respectively.

Figure 7.8 represents the location specific individual risks (LSIR) for hypothetical persons located outdoors for the proposed Natural Gas pipelines

and Propane backup generator developments during normal Propane backup generator operation. Areas located off the power plant site have an individual risk higher than 1×10^{-6} . As the risk exceeds 1×10^{-6} but does not exceed the 1×10^{-4} risk level, the LSIR for the pipelines and Propane backup generator for persons located outdoors in these areas is not considered intolerable according to the risk criteria as defined in *Section 3.2.3*. The risks can only be considered tolerable if they can be demonstrated by the site to be As Low As Reasonably Practicable (ALARP).

The 1×10^{-3} and 1×10^{-4} LSIR contours do not exist for individuals located outdoors, therefore the risk is below these levels.

Figure 7.9 represents the location specific individual risks (LSIR) for hypothetical persons located indoors for the proposed pipelines and Propane backup generator developments during normal Propane backup generator operation. Areas located off the power plant site have an individual risk higher than 1×10^{-6} . As the risk exceeds 1×10^{-6} but does not exceed 1×10^{-4} the LSIR for the pipelines and Propane backup generator for persons located indoors in these areas is not considered intolerable according to the risk criteria as defined in *Section 3.2.3*. The risks can only be considered tolerable if they can be demonstrated by the site to be As Low As Reasonably Practicable (ALARP).

The 1×10^{-3} and 1×10^{-4} LSIR contours do not exist for individuals located indoors, therefore the risk is below these levels.

7.3 ESCALATION EFFECTS

7.3.1 Natural Gas Pipelines

No escalation effects (ie a minor incident escalating to a major incident) are considered for the Natural Gas pipelines in this risk assessment. It is judged that escalation impacts (in terms of the immediate effect on members of the public or workers) associated with consequences resulting from incidents involving the hazardous installations are unlikely to result in more severe consequences than the original initiating events.

7.3.2 Propane Installations

The most prevalent escalation effect for pressurised flammable vapour storage vessels is a BLEVE. It is understood that the failure data considered in *Section 6.3.1* includes escalation aspects from pool or jet fires originating from adjacent equipment. Furthermore the assumption and subsequent recommendation that an operator be present during Propane offloading, as well as other fire detection measures has the result that prolonged heating of the Propane vessel are considered unlikely and will not further increase the failure data presented in *Section 6.3.1*.

As such no escalation effects are considered for the Propane installations in this risk assessment. It is judged that escalation impacts associated with consequences resulting from incidents involving the hazardous installations are unlikely to result in more severe consequences than the original initiating events.

7.4 CUMULATIVE IMPACT ASSESSMENT

Known development areas are shown in *Figure 7.10*. The known developments are listed as follows:

- The IDZ development
- Afrisam Cement Plant
- LPG storage Facilities – Sunrise and Avidia
- Vredenburg Industrial Development (located between Namaqua Sands and the Fossil Park):
 - Frontier Separation Plant
 - Chlor-Alkali Facility
- Desalination plant
- One additional 1000 MW gas-fired power plant

Those developments not shown in *Figure 7.10* are located beyond the area presented in this aerial plot.

In order to assess cumulative risk affects from these developments a QRA for each of the sites will need to be carried out. Those sites where a QRA was not considered necessary indicates the risk of a major accident from these sites is considered low by the owner of the site.

ERM has assessed the risk assessments from the Sunrise and Avidia LPG facilities as well as the Chlor-Alkali Facility. These are discussed in more detail below.

7.4.1 Sunrise LPG Facility

A QRA for Sunrise was carried out by Riscom in October 2012. The assessment indicates the following hazardous substances stored on site:

- 15 x 2 495 m³ Liquefied Petroleum Gas (LPG) Vessels (stored at Phase 2 of project).

From a review of the Sunrise LPG QRA, it was found that individual risk of fatality contours from incidents at the Sunrise site would overlap those of the Saldanha Steel Natural Gas pipelines and Propane developments. From observation, the maximum overlap for individual risk of fatality is approximately 1×10^{-6} . This risk level does not however reach the power plant site and therefore does not accumulate with the risk of the Propane facilities. The risk from the Saldanha Steel Natural Gas pipelines is in the order of magnitude of 1×10^{-6} to 1×10^{-5} . Therefore the addition of 1×10^{-6}

from the Sunrise LPG facility will not escalate the risk a further order of magnitude to 1×10^{-4} , making the resulting risk level below that which would be considered intolerable according to the criteria shown in *Section 3.2.3*.

It must be noted that this analysis is purely based on observation of the Riscom report supplied. Technical methodologies and assumptions made as part of the QRAs may differ between Riscom and ERM. This has the potential to make the actual cumulative risk results generated by the two Companies QRAs differ slightly.

7.4.2 *Avidia LPG Facility*

A QRA for Sunrise was carried out by MHR Consultants in July 2013. The assessment indicates the following hazardous substances stored on site:

- 32 x 500 m³ Liquefied Petroleum Gas (LPG) Vessels.

From a review of the Avidia LPG QRA, it was found that individual risk of fatality contours from incidents at the Avidia site would not overlap any contours from the Saldanha Steel Natural Gas pipelines and Propane developments. Therefore no cumulative risk affects are relevant from the Avidia LPG facility. Once again it must be noted that this analysis is purely based on observation of the MHR Consultants report supplied.

7.4.3 *Chlor-Alkali Facility*

A QRA for Sunrise was carried out by ISHECON in September 2014. The assessment indicates the following hazardous substances stored on site:

- 3 x 500 ton Chlorine Vessels;
- 60 x 1 ton Chlorine Vessels;
- 400 x 0.07 ton Cylinders;
- 150 tons Sodium Hypo-chlorite;
- 4 000 tons Hydrochloric acid (31%);
- 25 tons Sulphuric acid (98%);
- 30 tons Sulphuric acid (70%); and
- 170 tons Liquefied Petroleum Gas (LPG).

From a review of the Chlor-Alki QRA, it was found that individual risk of fatality contours from incidents at the Chlor-Alki site would overlap those of the Saldanha Steel Natural Gas pipelines and Propane developments. From observation, the maximum overlap for individual risk of fatality is approximately 1×10^{-9} . This risk level is significantly lower than the risk levels from the Saldanha Steel Natural Gas pipelines and Propane developments. The cumulative risk will therefore not materially increase above those from the Saldanha Steel Natural Gas pipelines and Propane developments.

It must be noted that this analysis is purely based on observation of the ISHECON report supplied. Technical methodologies and assumptions made

as part of the QRAs may differ between ISHECON and ERM. This has the potential to make the actual cumulative risk results generated by the two Companies QRAs differ slightly.

7.4.4 *Overall Cumulative*

The largest contributor to cumulative risk with the Saldanha Steel Natural Gas pipelines and Propane developments is that of the Sunrise LPG facility. The cumulative risk of all the sites discussed above in the vicinity of the Saldanha Steel Natural Gas pipelines and Propane developments is not expected to exceed 1×10^{-4} , making the resulting risk level below that which would be considered intolerable according to the criteria shown in *Section 3.2.3*.

It must be noted that this analysis is purely based on observation of the various QRA reports supplied. Technical methodologies and assumptions made as part of the QRAs may differ between these Companies and ERM. This has the potential to make the actual cumulative risk results generated by the Companies QRAs differ slightly.

Figure 7.6 Risk Contours for Individual Risk of Fatality for Saldanha Steel Natural Gas Pipelines and Propane Developments during the Second Year of Construction – Persons Located Outdoors

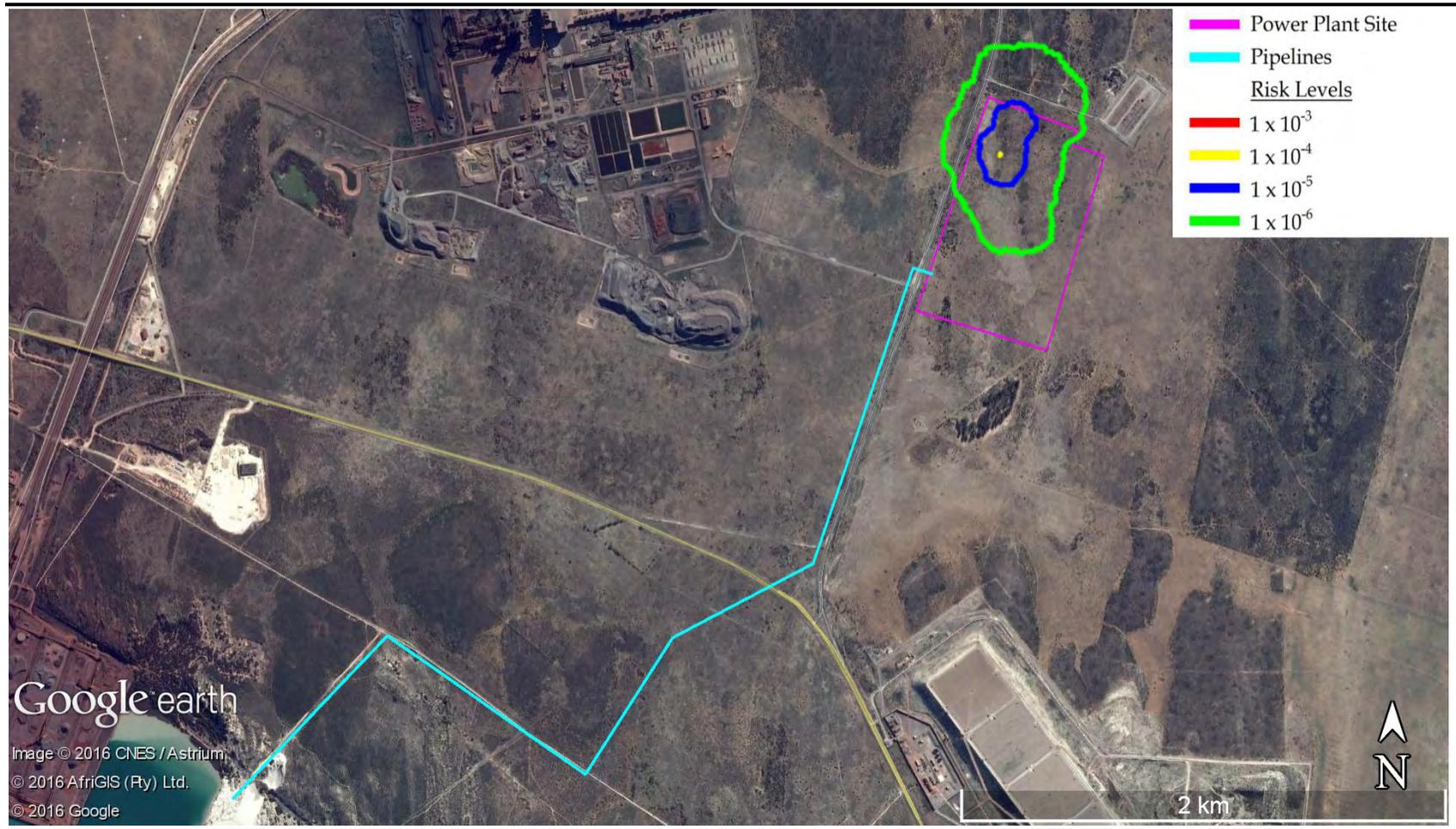


Figure 7.7 Risk Contours for Individual Risk of Fatality for Saldanha Steel Natural Gas Pipelines and Propane Developments during the Second Year of Construction – Persons Located Indoors



Figure 7.8 Risk Contours for Individual Risk of Fatality for Saldanha Steel Natural Gas Pipelines and Propane Developments during Normal Operation – Persons Located Outdoors



Figure 7.9 Risk Contours for Individual Risk of Fatality for Saldanha Steel Natural Gas Pipelines and Propane Developments during Normal Operation – Persons Located Indoors



Figure 7.10 Known Developments in the Vicinity of the Proposed Saldanha Steel Development



The following section presents the Impact Assessment (IA) according to ERM's standard impact assessment methodology.

8.1 *QUANTITATIVE RISK ASSESSMENT FOR NATURAL GAS PIPELINES AND PROPANE GENERATOR*

ERM conducted a QRA on the proposed Natural Gas pipelines and Propane electricity generator as described in *Section 1.1*. In summary a CCGT power plant is planned to supply electricity to Saldanha Steel to alleviate current and future electrical energy constraints. The CCGT power plant is planned to be fuelled by Natural Gas. The project will support both CNG and LNG as its main fuel supply. CNG and LNG could be supplied by ship to the Port of Saldanha. LNG, which will be regasified and CNG processing will take place within the Port boundary and will be the subject of another environmental authorisation application. The preparation of either of these feedstocks will result in are understood to take place in the port. This will result in pressurised Natural Gas being exported to the plant via two proposed pipelines.

The process hazards are described in *Section 5* and are summarised below. Both Natural Gas and Propane represent flammable hazards and a release of either substance could result in a major accident. The following hazards have been considered in the QRA and are described in *Section 5.1*:

- Jet Fire: If a flammable gas or vapour is released and ignites immediately a jet fire may occur;
- Flash Fire: If a flammable gas or vapour is released and does not ignite immediately the gas or vapour may disperse from the point of origin and form a flammable gas or vapour cloud. In the event of delayed ignition the gas or vapour cloud could result in a flash fire;
- Flammable Gas or Vapour Cloud Explosion: If a flammable gas or vapour is released and does not ignite immediately the gas or vapour may disperse from the point of origin. In the event of delayed ignition where the gas or vapour cloud occurs within a confined or congested area, a gas or vapour cloud explosion may occur. Unconfined vapour cloud explosions are also possible under certain conditions;
- Boiling Liquid Evaporating Vapour Explosion (BLEVE): If a fire impinges on a pressurised flammable container such as a Propane storage pressure vessel, a hot catastrophic failure of such a vessel could occur, resulting in a BLEVE; and

- Fireball: If a pressurised Propane storage pressure vessel undergoes cold catastrophic failure (such as from an external impact) and immediate ignition occurs, a fireball could result.

The largest effects from the hazards described above are shown in *Section 6.2*.

The risks of the hazards were assessed according the UK HSE Land Use Planning (LUP) and Risk Tolerability Location Specific Individual Risk (LSIR) criteria as described in *Section 3.2*.

The LUP assessment showed that the current land uses in the proximity of the Natural Gas pipelines and the Propane generator were tolerable, however future land uses should be restricted according to the results shown in *Section 7.1*.

The Risk Tolerability LSIR assessment showed that the risk levels for individuals not involved in the CCGT and Natural Gas pipelines' construction or operation was not considered intolerable. Similarly the LSIR for workers on site, in this instance workers involved in the CCGT and Natural Gas pipelines' construction or operation was also not intolerable. The LSIR can only be considered tolerable if they can be demonstrated by the site to be As Low As Reasonably Practicable (ALARP).

8.1.1 *Summary Assessment*

The hazards, as described above, would result in a **direct negative** type of impact on the natural vegetation, structures, employees and people in the immediate area in close proximity of the Natural Gas pipelines as well as the CCGT power plant site.

The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.

The extent for the impact is **local** as the impact of the worst case hazards extends beyond the boundaries of the pipelines' servitude as well as the CCGT power plant site.

The **scale** of the hazard effects to a Dangerous Dose from the Natural Gas pipelines are as follows:

- Jet Fire: 156 m;
- Flash Fire: 676 m; and
- Gas Cloud Explosion: 57 m.

The **scale** of the hazard effects to a Dangerous Dose from the Propane generator installations are as follows:

- Jet Fire: 173 m;
- Flash Fire: 239 m;
- Vapour Cloud Explosion: 13 m; and
- Boiling Liquid Evaporating Vapour Explosion / Fireball: 114 m.

Certain design standards have been assumed for the Natural Gas pipelines and Propane installations. These largely follow prescribed standards, however of particular note is the following:

- Multiple (at least two) safety systems will be implemented for Propane offloading. Such systems include wheel chocks, interlock brakes, interlock barriers, etc. In addition the site will implement an effective pull away mitigation system and inspection and pressure/leak tests to prevent transfer system leaks and bursts.

If facilities and equipment are designed to the prescribed specifications and standards the likelihood of such an events occurring is considered **unlikely**.

The sensitivity of receptors can be differentiated into those associated with the current land use of the area, as addressed by the LUP assessment, and individuals, as addressed by the LSIR assessment.

The area surrounding the Natural Gas pipelines' servitude is currently open land with the exception of Camp road. A portion of this servitude also passes through an area owned by the Port. As these areas are not currently inhabited and future land use within the Port is understood to be categorised as Industrial the land use sensitivity in these areas is categorised as **low**.

The area surrounding the proposed CCGT power plant site is similarly unused with the exception of a small access road. Therefore this land use sensitivity is also categorised as **low**.

Considering individuals, it is understood that the area surrounding the Natural Gas pipelines' servitude is not permanently inhabited as no homes, work places or other gathering areas exist in the vicinity. The general public does however have access to the area surrounding the servitude (with the exception of the Port property). Therefore the sensitivity of the general public in the area surrounding the Natural Gas pipelines' servitude is categorised as **medium**. For workers involved in the construction phase or operational phase of the CCGT power plant project the sensitivity is categorised as **low**. This is due to these individuals being aware of the risks and being more adequately prepared to handle them as a result of emergency planning , PPE, etc.

A similar situation exists for the proposed CCGT power plant site and surrounding area. The general public sensitivity is categorised as **medium** while worker sensitivity is categorised as **low**.

The impact has been assessed for a number of different scenarios which are described below:

- Land Use Planning Impact for the construction phase (represented for the second year of construction) for the Natural Gas pipelines

- Land Use Planning Impact for the construction phase (represented for the second year of construction) for the Propane generator installations
- Location Specific Individual Risk Impact for the construction phase (represented for the second year of construction) for the entire project
-
- Land Use Planning Impact for the operational phase for the Natural Gas pipelines
- Land Use Planning Impact for the operational phase for the Natural Gas pipelines
- Location Specific Individual Risk Impact for the operational phase for the entire project

Box 8.1 *Land Use Planning Impact: Construction Phase: Natural Gas Pipelines*

Impact Magnitude – Negligible

The Natural Gas pipelines are understood to only become operational during the operations phase of the project. Therefore no hazards exist during the construction phase

Likelihood – Unlikely

Receptor Sensitivity – The LUP receptor sensitivity has been categorised as **low** as there are no inhabited areas.

LUP IMPACT SIGNIFICANCE DURING CONSTRUCTION PHASE FOR NATURAL GAS PIPELINES (PRE-MITIGATION) – NEGLIGIBLE – The hazards will not exist for the Natural Gas Pipelines during the construction phase

Box 8.2 *Land Use Planning Impact: Construction Phase: Propane Generator Installations*

Impact Magnitude – Low

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 239 m. The largest land use restriction extends 140 m to the west and 60 m to the north of the CCGT site boundary, centred on the Propane generator.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**.

Receptor Sensitivity – The LUP receptor sensitivity has been categorised as **low** as there are no inhabited areas.

LUP IMPACT SIGNIFICANCE DURING CONSTRUCTION PHASE FOR PROPANE GENERATOR (PRE-MITIGATION) – NEGLIGIBLE – As the majority of the land surrounding the CCGT power plant is unused and uninhabited the impact from hazards is unlikely to have large offsite effects.

Location Specific Individual Risk Impact: Construction Phase: Natural Gas Pipelines and Propane Generator Installations

Impact Magnitude – High

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 239 m. The largest LSIR contours extend 360 m to the west, 320 m to the north and 80 m to the east of the CCGT site boundary, centred on the Propane generator. The area considered intolerable for the general public extends 60 m to the north of the CCGT site boundary. An area centred on the Propane generator is considered intolerable for workers.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**. As stated, no hazards for the Natural Gas pipelines will be realised during the construction phase.

Receptor Sensitivity – The LSIR receptor sensitivity has been categorised as **medium** for the general public as they can access these areas but do not inhabit them and **low** for workers involved in the construction of the project as they are aware and prepared for the risks.

LSIR IMPACT SIGNIFICANCE DURING CONSTRUCTION PHASE FOR NATURAL GAS PIPELINES AND PROPANE GENERATOR (PRE-MITIGATION) – MODERATE – As the general public and workers are not exposed to LSIR that is considered intolerable.

Land Use Planning Impact: Operation Phase: Natural Gas Pipelines

Impact Magnitude – Low

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 676 m. The largest land use restriction extends 140 m from the pipeline due to proposed bends which increase the risk in these areas. Risk transects indicate the normal pipeline area restrictions extend 68 m from the centre of the Natural Gas pipelines' servitude.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**.

Receptor Sensitivity – The LUP receptor sensitivity has been categorised as **low** as there are no inhabited areas.

LUP IMPACT SIGNIFICANCE DURING OPERATION PHASE FOR NATURAL GAS PIPELINES (PRE-MITIGATION) – NEGLIGIBLE – As the majority of the land surrounding the Natural Gas Pipelines' servitude is unused and uninhabited the impact from hazard is unlikely to have large offsite effects. Areas within the Port are understood to be reserved for industrial land use.

Land Use Planning Impact: Operation Phase: Propane Generator Installations

Impact Magnitude – Low

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 239 m. The largest land use restriction extends 120 m to the west and 60 m to the north of the CCGT site boundary, centred on the Propane generator.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**.

Receptor Sensitivity – The LUP receptor sensitivity has been categorised as **low** as there are no inhabited areas.

LUP IMPACT SIGNIFICANCE DURING OPERATION PHASE FOR PROPANE GENERATOR (PRE-MITIGATION) – NEGLIGIBLE – As the majority of the land surrounding the CCGT power plant is unused and uninhabited the impact from hazards is unlikely to have large offsite effects.

Location Specific Individual Risk Impact: Operation Phase: Natural Gas Pipelines and Propane Generator Installations

Impact Magnitude – High

- **Type:** The type of impact would be described as **direct negative** due to nature of the hazards.
- **Duration:** The duration would be **temporary** as such hazards would be of short duration and only happen occasionally, if at all.
- **Extent:** The extent for the impact is **local** as the impact of the worst case scenario impact would extend beyond the boundaries of the CCGT power plant site.
- **Scale:** The largest hazard effects to Dangerous Dose are 676 m. The largest LSIR contours extend 110 m to the west and 240 m to the north of the CCGT site boundary, centred on the Propane generator.

Likelihood – If facilities and equipment are designed to the prescribed specifications the likelihood of such an event occurring is considered **unlikely**.

Receptor Sensitivity – The LSIR receptor sensitivity has been categorised as **medium** for the general public as they can access these areas but do not inhabit them and **low** for workers involved in the construction of the project as they are aware and prepared for the risks.

LSIR IMPACT SIGNIFICANCE DURING CONSTRUCTION PHASE FOR NATURAL GAS PIPELINES AND PROPANE GENERATOR (PRE-MITIGATION) – MODERATE – As no areas which are considered intolerable for the general public or workers exists.

Mitigation

Mitigation objective

To avoid or minimise the risk of an incident (i.e. fire or explosion) occurring from a loss of containment of Natural Gas or Propane from pipelines, facilities or ancillary equipment at the proposed Natural Gas pipelines or Propane electricity generator.

Mitigation measure(s) for the proposed Natural Gas Pipelines

The following proposed engineering design features that reduce risks should be implemented:

- The pipelines should be designed to an international standard such as:
 - BS EN 14161: Petroleum and natural gas industries – Pipeline transportation systems;
 - ASME B31.8 Gas Transmission and Distribution Piping Systems; or
 - Other internationally recognised standards.
- The pipelines' wall thickness should be designed to accommodate the maximum operating pressure of 90 barg with a suitable safety factor;
- Isolation valves should be located at least at either end of the pipelines but ideally at intervals such that in the event of a leak only small amounts of Natural Gas would be released;
- Leak prevention systems such as cathodic protection and pipeline coatings suitable for the ground conditions should be implemented;
- The pipelines should include an emergency shutdown system that will shut emergency isolation valves and depressurise the pipelines safely;
- Areas of road crossing shall include specific protection measures to account for the weight from road traffic;
- A Leak detection system should be considered for the pipelines;
- The installation of non-return valves on the pipelines should be considered;
- Depth of burial of the pipelines along their length should be equal to, or greater than the minimum depth of burial specified;
- Potential other risk reduction measures include concrete sheathing, tiles above pipelines, marker tape above pipelines, route marker posts etc; and
- Emergency response plan for the pipeline must be compiled with the user of the pipelines and the Local Authority together.

The following protective measures should be put in place to reduce the risks:

- Third party interference protection measures should be included. These should differentiate between accidental interference (which can be protected against with safety marker tape, regular aboveground pipeline markers, etc) and deliberate interference (which can be protected against with regular pipeline surveys, ground disturbance early warning systems, etc);
- All Natural Gas processing areas should be equipped with gas detectors with appropriate logic that can initiate emergency shutdown of Natural Gas operations and even the pipelines if necessary;
- All of the automatic safety systems shall be designed so that they can also be manually activated;

Specific mitigation measures identified by the specialist include:

- Ensuring compliance with all statutory requirements (i.e. pipeline designs);
- Ensuring compliance with applicable South African National Standards (i.e. SANS 10087, etc.);
- Incorporating applicable guidelines or equivalent international recognised codes of good design and practice into the designs;
- Completing recognised processes of hazard analysis processes (HAZOP, FMEA, SIL, LOPA etc.) for the proposed CCGT power plant prior to construction to ensure design and operational hazards have been identified and adequate mitigation has been considered;
- Ensure any amendments to the current design specifications are captured in amendments to the EIA and relevant specialist studies; and
- Ensuring a Major Hazard Installation (MHI) risk assessment is carried out for the facility after detailed designs have been completed for the pipelines and CCGT power plant in accordance with the Major Hazard Installation regulations;

Mitigation measure(s) for the proposed Propane generator installations on the CCGT power plant site

The following proposed engineering design features that reduce risks should be implemented:

- The installation must comply with all the requirements of SANS 10087-3:2015 *The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations Part 3:*

Liquefied petroleum gas installations involving storage vessels of individual water capacity exceeding 500 L;

- The Propane storage vessel shall be fitted with pressure relief valves, which would only lift when the vessel has reached its maximum operating pressure or level;
- All piping shall be rated to accommodate the required operating pressure of the system and allow for pressure relief to a safe area;
- All pressure relief systems should vent away from the generator air intake system;
- The Propane vessel shall be fitted with sparge pipes in the vapour space to limit reverse flow to the off-loading point as well as preventing vessel stresses due to uneven temperature;
- All instrumentation and electrical equipment shall be specified in accordance to the Hazardous Area classification as per SANS 10108;
- Off-loading of Propane shall be done on a fully-automated system to prevent overfilling;
- Pull away prevention systems such as wheel chocks should be utilised during Propane offloading;
- Off-loading safety systems such as earthing of the road tanker are required;
- Off-loading of Propane shall be done using hoses with breakaway couplings;
- Emergency shutdown (ESD) shall be provided that would automatically shut down systems such as feed or off-loading pumps and emergency shut off valves in the event of an emergency;
- Emergency shutdown should be initiated by local operators, CCGT control room operators as well as by gas detectors where appropriate;
- Multiple pull away prevention measures must be implemented for the Propane road tanker offloading operations. These include wheel chocks, interlock brakes, interlock barriers, etc.; and
- Pull away mitigation measures that stop flow in the event of a pull away must be put in place for the Propane road tanker offloading operations. These include dry break couplings, automatic shutoff valves, etc.

The following protective measures should be put in place to reduce the risks:

- Active or passive fire protection on the Propane storage bullet in line with SANS 10087-3:2015;
- Propane road tanker offloading deluge system to cool equipment in the event of a fire if required by SANS 10087-3:2015;
- Gas detectors with appropriate logic which can initiate emergency shutdown;
- All of the automatic safety systems shall be designed so that they can also be manually activated;
- Procedures should ensure at least one person be present during Propane offloading;

Specific mitigation measures identified by the specialist include:

- Ensuring compliance with applicable South African National Standards (i.e. SANS 10087-3:2015, etc.);
- Incorporating applicable guidelines or equivalent international recognised codes of good design and practice into the designs;
- Completing recognised processes of hazard analysis processes (HAZOP, FMEA, SIL and LOPA etc.) for the proposed CCGT power plant prior to construction to ensure design and operational hazards have been identified and adequate mitigation has been considered;
- Ensure any amendments to the current design specifications are captured in amendments to the EIA and relevant specialist studies; and
- Ensuring a Major Hazard Installation (MHI) risk assessment is carried out for the facility after detailed designs have been completed for the pipelines and CCGT power plant in accordance with the MHI regulations.

Residual

If mitigation measures as described above are implemented, the residual impact significance will change to for the construction phase as described in *Table 8.1* as the only receptors will be workers involved in the construction and operation of the CCGT power plant and their sensitivity is classed as **low**. The residual risk from the operation phase will remain the same.

Table 8.1 Pre- and Post- Mitigation Significance: Quantitative Risk Assessment

Phase and Assessment	Pre- and Post- Mitigation Significance:	Residual Significance (Post-mitigation)
Construction Phase, Natural Gas Pipelines, LUP Assessment	NEGLIGIBLE	NEGLIGIBLE
Construction Phase, Propane Generator, LUP Assessment	NEGLIGIBLE	NEGLIGIBLE
Construction Phase, Natural Gas Pipelines and Propane Generator, LSIR Assessment	MODERATE	MODERATE
Operation Phase, Natural Gas Pipelines, LUP Assessment	NEGLIGIBLE	NEGLIGIBLE
Operation Phase, Propane Generator, LSIR Assessment	NEGLIGIBLE	NEGLIGIBLE
Operation Phase, Natural Gas Pipelines and Propane Generator, LSIR Assessment	MODERATE	MODERATE

8.1.2 Impact Statement

The findings of the Quantified Risk Assessment for the Saldanha Steel Independent Gas-fired Power Plant indicate that the Project will have negative impacts on the immediate areas around the developments by increasing the risk of a major accident. However the risk levels from the developments are not considered intolerable according to the criteria utilised for this assessment. In addition these risks can be managed through the implementation of the mitigation measures outlined in this QRA, the EIR and other specialist reports

It is, therefore, recommended that the Project be supported subject to the implementation of the mitigation measures outlined in this QRA, the EIR and other specialist reports.

A (QRA) was carried out for the proposed construction of the Saldanha Steel Combined Cycle Gas Turbine (CCGT) power plant. This project includes the construction of two Natural Gas pipelines and a Propane backup electricity generator. The study has shown that the operations have the potential to adversely affect the health and safety of the general public as well as workers within the Saldanha Port area and those workers involved in the construction and operation of the CCGT power plant.

The potential hazards from the proposed project include jet fires, flash fires, vapour cloud and gas cloud explosions, boiling liquid evaporating vapour explosions and fireballs. The risk from these hazards was assessed according to the location specific individual risks (LSIR) of fatality as well as Land Use Planning (LUP) methodologies. An impact assessment was also carried out according to ERM's impact assessment methodology.

The current land uses are considered tolerable from a risk perspective for the proposed development. Future land use around the pipelines' servitude and power plant site should adhere to the restrictions set about by the UK HSE. As the Propane consumption at the power plant site is understood to be highest in the second year of construction, the surrounding land use during this period will be the most restricted.

The location specific individual risk of fatality for persons located indoors and outdoors has also been calculated for the proposed pipelines as well as the proposed Propane generator. During the construction and operational phases of the CCGT power plant project the risks are not considered intolerable. Due to the LSIR level on the CCGT power plant site as well as the area surrounding the site and along the pipelines' servitude, the risk can only be considered tolerable if it can be demonstrated by the site that the risks are As Low As Reasonably Practicable (ALARP).

As the detailed design of the CCGT power plant is not complete at this stage of the project, a risk assessment of the gas receiving station was not completed. However in the event of a release from this equipment a flammable gas cloud explosion was considered possible. This was modelled and found to extend 57m from the centre of the gas receiving area to a dangerous dose overpressure end point. This does not extend beyond the proposed power plant site boundary.

The impact assessment concluded that the pre-mitigation impact significance from a land use planning perspective was **negligible** for the Natural Gas Pipelines and the Propane Generator during both the construction phase and operation phase. The location specific individual risk was **moderate** for the construction phase and **moderate** for the operation phase. The impact significance of the construction and operation phases remained **moderate**

post-mitigation as the impact magnitude remains **high** during both construction and operation.

Claire Alborough
Senior Consultant
ERM Southern Africa (Pty) Ltd
Tel: +27 21 681 5400
Fax: +27 21 686 0736

19 July 2016

Dear Madam,

RE: REVIEW OF THE QUANTITATIVE RISK ASSESSMENT OF JULY 2016 COMPILED BY ERM CONSULTANTS FOR THE SUPPLY OF NATURAL GAS TO A CCGT AND PROPANE TO A POWER GENERATOR FOR SALDANHA STEEL

1. INTRODUCTION

ISHECON have been approached to review the QRA conducted by ERM on the natural gas supply to a CCGT and the propane supply to a propane power generator to be located in Saldanha Bay providing power to Saldanha Steel. ERM is conducting the EIA for the CCGT project and the authorities have requested an external review of all specialist studies conducted internally by ERM. A quantitative risk assessment has been compiled by ERM for the natural gas supply pipelines from the port and for the offloading, storage and vapourization of propane for the alternative power generation systems.

The review has been specifically asked to address the following questions:

1. Is the ToR acceptable for this specialist study within the context of the proposed project and site location?
2. Is the methodology clearly explained and acceptable?
3. Are the findings acceptable, and scientifically defensible (review data evidence)?
4. Are the mitigation measures and recommendation measures appropriate?
5. Is the literature referenced in the report appropriate?
6. Is the article well-written and easy to understand?
7. Are there any shortcoming to this study? If yes, please describe.

These questions are addressed in detail in the table in ATTACHMENT B and the conclusions of the review are summarized below.

ISHECON is an Approved Inspection Authorities for Major Hazard Installations (See ATTACHMENT A) and Explosives and we are therefore familiar with QRAs and are competent to review these types of studies.

2. CONCLUSIONS OF THE QRA REVIEW

ISHECON is of the opinion that (refer to ATTACHMENT B for details):

Ref No	Requirements Against the Risk Assessment	Evaluation - Overall Suitability of Technical Analysis
1	Is the ToR acceptable for this specialist study within the context of the proposed project and site location?	<p>GAS PIPELINES The risks posed by the pipeline are in the tolerable range. This means that all reasonably practicable risk reduction measures should be implemented. There is an extensive list of mitigation measures suggested and these could be considered adequate. Totally adequate.</p> <p>PROPANE STORAGE INSTALLATION The risk results are in the intolerable range within the “restrict access mitigation measure” suggested by ERM. ISHECON would suggest reviewing the risk calculations to ensure ERM have not been overly conservative resulting in the 10 e-4 going off site etc. Also see item 4 below. Requires additional input.</p>
2	Is the methodology clearly explained and acceptable?	<p>The methodology follows conventional QRA methodologies. Totally adequate.</p> <p>Possible domino effects from one gas pipeline to the other should be addressed in some manner. Requires additional input.</p> <p>Internal ERM Impact assessment cannot be judged. Requires additional input.</p>
3	Are the findings acceptable, and scientifically defensible (review data evidence)?	<p>The findings are all defensible. Totally adequate.</p>
4	Are the mitigation measures and recommendation measures appropriate?	<p>GAS PIPELINES Mitigation measures suggested are extensive and they could be considered adequate. Totally adequate.</p> <p>PROPANE STORAGE FACILITY It is the opinion of this reviewer that the mitigation measure “to prevent or reduce access to these areas” is not an acceptable solution to a high risk problem. More technical options should be offered or systematically eliminated if not possible. Requires additional input.</p>
5	Is the literature referenced in the report appropriate?	<p>All the literature reference is typical for this type of QRA. Totally adequate.</p>
6	Is the article well-written and easy to understand?	<p>The report is well written and well presented. Totally adequate.</p> <p>The internal ERM risk matrix used to derive the assessment evaluation of High, Moderate etc. is not included in the report and hence this section is technically not understandable. Requires additional input.</p>
7	Are there any shortcoming to this study? If yes, please describe.	<p>The current assessment excludes the on-site CCGT and propane power generation systems. However, when information become available, the installations need to be included in the QRA to ensure employees risk levels are within the Location Specific Individual Risk criteria. Requires additional input when design information becomes available.</p>



ISHECON trusts that this letter provides a clear review of the QRA.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Debra Mitchell', is written over a light blue horizontal line.

Debra Mitchell Pr.Eng
ISHECON Risk Assessor (See AIA certificate ATTACHMENT A)



ATTACHMENT A – AIA Certificate



CERTIFICATE OF ACCREDITATION

In terms of section 22(2) (b) of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006), read with sections 23(1), (2) and (3) of the said Act, I hereby certify that:-

ISHECON CC
Co. Reg. No.: 1999/029022/23
MODDERFONTEIN

Facility Accreditation Number: **MHI0008**

is a South African National Accreditation System accredited Inspection Body to undertake **TYPE A** inspection provided that all SANAS conditions and requirements are complied with

This certificate is valid as per the scope as stated in the accompanying schedule of accreditation, Annexure "A", bearing the above accreditation number for

THE ASSESSMENT OF RISK ON MAJOR HAZARD INSTALLATIONS

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17020:1998

The accreditation demonstrates technical competency for a defined scope and the operation of a quality management system

While this certificate remains valid, the Accredited Facility named above is authorised to use the relevant SANAS accreditation symbol to issue facility reports and/or certificates


Mr R Josias
Chief Executive Officer

Effective Date: 13 June 2013
Certificate Expires: 12 June 2017

This certificate does not, on its own confer authority to act as an Approved Inspection Authority as contemplated in the Major Hazard Installation Regulations. Approval to inspect within the regulatory domain is granted by the Department of Labour.

ANNEXURE A

SCHEDULE OF ACCREDITATION

Facility Number: MH10008

TYPE A

Permanent Address: ISHECON CC H4 Pinelands Anteen Road Modderfontein 1645 Tel: (011) 997-7945 Fax: (011) 808-2000 E-mail: rademeyerd@ishecon.co.za		Postal Address: P O Box 320 Modderfontein 1645 Issue No.: 06 Date of Issue: 03 April 2014 Expiry Date: 12 June 2017
Nominated Representative: Mr DJE Rademeyer	Quality Manager: Ms DC Mitchell Technical Manager: Mr DJE Rademeyer	Technical Signatories: Mr DJE Rademeyer Ms DC Mitchell Mr NN Coni
Field of Inspection	Service Rendered	Codes and Regulations
Regulatory: The supply of services as an inspection authority for Major Hazard Risk Installation as defined in the Major Hazard Risk Installation Regulations, Government Notice No. R892 of 30 July 2001	1) Explosive chemicals 2) Gases: i) Flammable Gases ii) Non-flammable, non-toxic gases (asphyxiants) iii) Toxic gases 3) Flammable liquids 4) Flammable solids, substances liable to spontaneous combustion, substances that on contact with water release flammable gases 5) Oxidizing substances and organic peroxides 6) Toxic liquids and solids	MHI regulation par. 5 (5) (b) i) Frequency/Probability Analysis ii) Consequence Modelling iii) Hazard Identification and Analysis iv) Emergency planning reviews Risk Analysis in the Process Industries, IChemE 1985 Guidelines for Chemical Process Quantitative Risk Analysis, Second Ed. 2000 Guideline for Quantitative Risk Assessment "Purple Book" CPR 18E, First Ed. 1999 A Guide for the Control of Major Accident Hazard Regulations 1999, UK HSE

Original Date of Accreditation: 13 June 2005

Page 1 of 1

ISSUED BY THE SOUTH AFRICAN NATIONAL ACCREDITATION SYSTEM


Field Manager

ATTACHMENT B – Tabular Evaluation

Table Evaluating the Report against the Requirement of the Review

Ref No	Requirements Against the Risk Assessment	Evaluation - Overall Suitability of Technical Analysis
1	Is the ToR acceptable for this specialist study within the context of the proposed project and site location?	<p>GAS PIPELINES</p> <p>When compared to QRA results from ISHECON studies of similar high pressure natural gas systems, the risk results are comparable, i.e. 10 e-6 extending a few tens of meters on either side and the 10 e-7 extending about 100 – 150 m. The risk results therefore seem overall technically correct.</p> <p>The risks posed by the pipeline are in the tolerable range. This means that all reasonably practicable risk reduction measures should be implemented. There is an extensive list of mitigation measures suggested and these could be considered adequate.</p> <p>Totally adequate.</p> <p>PROPANE STORAGE INSTALLATION</p> <p>When compared to QRA results from ISHECON studies of similar LPG gas offloading and storage systems, the results are comparable.</p> <p>The impact zone of 150m or so for jet fires/fire balls is comparable, as is the flash fire range of about 500m.</p> <p>The risk results generated by ERM are, if anything, conservative with the 10 e-6 risk contour extending 500m. ISHECON would likely have found lower risks with the 10 e -6 extending 200m at most. However, ISHECON would have insisted on excess flow valves, ROSOVS etc. in the design and taken credit for these in the risk calculation by adjusting both the magnitude and frequency of events. This is possibly the reason for the more conservative ERM results. With high turnovers of gas and no specific hose isolation features, a 10 e -3 risk contour on site is expected and ISHECON would have generate comparable results.</p> <p>Conservative results at this stage are no concern to the project except that it means the risk results come out as intolerably high and mitigation needs to be specified. See item 4 below for further discussion. ISHECON would suggest reviewing the risk calculations to ensure ERM have not been overly conservative resulting in the 10 e-4 going off site etc.</p> <p>Requires additional input.</p>

Ref No	Requirements Against the Risk Assessment	Evaluation - Overall Suitability of Technical Analysis
2	Is the methodology clearly explained and acceptable?	<p>The methodology for determining Location Specific Individual Risk and for assessing Land Use Planning implications are well explained and follow conventional QRA methodologies. Totally adequate.</p>
		<p>There is no mention of possible domino effects from one gas pipeline to the other. It would appear that the plan is that they will never be in use at the same time. However, this should be stated as a limitation of the application of the QRA, or domino effects should be included in the frequency analysis and possibly the consequence analysis. Requires additional input.</p>
		<p>The section on the Internal ERM Impact assessment does follow a typical risk matrix type approach but in the absence of the original matrix criteria cannot be judged. See item 6 below. Requires additional input.</p>
3	Are the findings acceptable, and scientifically defensible (review data evidence)?	<p>The findings are all defensible, as the methodology used for the calculations is internationally accepted good practice and the criteria used to judge the calculations are also internationally accepted good practice. Totally adequate.</p>
4	Are the mitigation measures and recommendation measures appropriate?	<p>GAS PIPELINES Mitigation measures suggested are extensive, and given that the risks in the ALARP range, they could be considered adequate. Totally adequate.</p> <p>PROPANE STORAGE FACILITY The list of technical and management systems mitigation measures is extensive and they should be applied as most of them are standard requirements for any propane installation.</p> <p>However, the ERM calculation of location specific individual risks results in the conclusion that both on site and off site risks are in tolerably high. ERM then concludes that a suitable further mitigation measure is to prevent or reduce access to these areas.</p> <p>It is the opinion of this reviewer that this mitigation measure is not an acceptable solution to a high risk problem.</p> <p>The risk assessment should at least indicate the technical reasons for the high risks and home in on specific equipment. Probably it is due either the hose failure frequency due to high delivery rate, or possibly the vaporizer with its high failure</p>

Ref No	Requirements Against the Risk Assessment	Evaluation - Overall Suitability of Technical Analysis
		<p>rate. If it is the hose failure rate, then one cannot suggest reducing access when one simultaneously suggests there must be someone present during offloading.</p> <p>If it is not technically possible to reduce the risks with for example higher than normal integrity hoses, excess flow valves, ROSOVS, ASOVS, larger tank and road tanker with lower deliver frequency, electric heater instead of shell and tube vapourizer etc. then the QRA should state that no additional risk reduction measures could be developed and therefore the assessor concludes that the only option is to try and limit access and in that manner all reasonably practicable measures have been implemented.</p> <p>Requires additional input.</p>
5	Is the literature referenced in the report appropriate?	<p>All the literature referenced is typical for this type of QRA. Given the absence of South African standards, the UK HSE systems are applied throughout South Africa, reference to the UK failure data, pipeline guidelines, risk assessment and land use planning methods is therefore entirely appropriate.</p> <p>Totally adequate.</p>
6	Is the article well-written and easy to understand?	<p>The report is well written and well presented.</p> <p>QRA is a highly technical subject and therefore not easy to convey in “layman’s” terms. However, at least the summary should be easily understandable.</p> <p>The Summary and its conclusions section are easy to understand.</p> <p>The technical sections of the report are easily understandable to the reviewer.</p> <p>Totally adequate.</p>
		<p>The Summary section titled impact assessment is not easy to follow (see comment below).</p> <p>The internal ERM risk matrix used to derive the assessment evaluation of High, Moderate etc. is not included in the report and hence this section is technically not understandable. Suggestion – include the matrix with a brief description to allow this QRA document to stand on its own, or at least refer to another EIA document where it is included.</p> <p>Requires additional input.</p>
7	Are there any shortcoming to this study? If yes, please describe.	<p>The current assessment excludes the on-site CCGT and propane power generation systems.</p> <p>The expected worst case explosion scenario for each of these facilities has been modelled and the report indicates that these explosions will not extend offsite. The implication of this is that these installations are unlikely to pose intolerable public risks and that the exclusion of them at this stage is unlikely to become a major offsite risk concern at a later stage. This seems reasonable to the reviewer.</p> <p>However, when information become available, the installations need to be included in the QRA to ensure employees risk</p>

Ref No	Requirements Against the Risk Assessment	Evaluation - Overall Suitability of Technical Analysis
		levels are within the Location Specific Individual Risk criteria. Requires additional input when design information becomes available.

.....The End.....

Ref/Project number 0315829 – EIA for a Gas-fired Independent Power Plant to Support Saldanha Steel and Other Industries in Saldanha Bay

Subject ERM's response to comments from the Independent Peer Review conducted on the quantitative risk assessment (QRA) specialist study

Date 19 July 2016



ERM Southern Africa (Pty) Ltd appointed ISHECON CC to conduct an independent peer review of the Quantitative Risk Assessment (QRA) for a Gas-fired Independent Power Plant to Support Saldanha Steel and Other Industries in Saldanha Bay, as part of the Environmental Impact Assessment (EIA) being conducted for ERM's client (ArcelorMittal).

A limited peer review was provided by ISHECON, in which several points were raised which required additional input within the QRA report (shown below, with the particular peer review question in bold). This memo contains ERM's response to the specific requirements for additional input contained within the peer review report.

1. Is the ToR acceptable for this specialist study within the context of the proposed project and site location?

When compared to QRA results from ISHECON studies of similar LPG gas offloading and storage systems, the results are comparable.

The impact zone of 150m or so for jet fires/fire balls is comparable, as is the flash fire range of about 500m.

The risk results generated by ERM are, if anything, conservative with the 10 e-6 risk contour extending 500m. ISHECON would likely have found lower risks with the 10 e-6 extending 200m at most. However, ISHECON would have insisted on excess flow valves, ROSOVS etc. in the design and taken credit for these in the risk calculation by adjusting both the magnitude and frequency of events. This is possibly the reason for the more conservative ERM results. With high turnovers of gas and no specific hose isolation features, a 10 e-3 risk contour on site is expected and ISHECON would have generate comparable results.

Conservative results at this stage are no concern to the project except that it means the risk results come out as intolerably high and mitigation needs to be specified. ISHECON would suggest reviewing the risk calculations to ensure ERM have not been overly conservative resulting in the 10 e-4 going off site etc.

ERM Response:

ERM have reviewed the Propane offloading hose failure scenarios and incorporated failure data which ensures multiple pullaway prevention and mitigation measures. These measures have also been included in the assumptions as well as the recommendations sections, as the revised risk levels are only relevant when such measures are incorporated.

The resulting risk levels showed a large reduction in the risk contours during the construction phase. As such the LSIR for individuals not involved in the construction and operation of the CCGT power plant was not found to be intolerable. Similarly the LSIR for workers was also not found to be intolerable. These revised results have been incorporated into the risk assessment.

2. Is the methodology clearly explained and acceptable?

There is no mention of possible domino effects from one gas pipeline to the other. It would appear that the plan is that they will never be in use at the same time. However, this should be stated as a limitation of the application of the QRA, or domino effects should be included in the frequency analysis and possibly the consequence analysis.

ERM Response:

ERM have included a section of the report to cater for escalation / domino effects. This section deals with the Natural Gas pipelines and Propane installations separately.

ERM has concluded that for the natural gas pipelines, the escalation effects are unlikely to result in a more severe consequence than the initiating event. For the Propane installations, a prolonged fire could result in a Propane vessel or Propane road tanker boiling liquid evaporating vapour explosion (BLEVE). It is understood the failure data used for the risk assessment includes the consideration of typical equipment found in the vicinity of pressurised flammable vapour vessels. Furthermore recommendations in the report require an operator to be present, as well as require adequate fire detection equipment such that appropriate action can be taken in order to prevent sustained flame impingement on the Propane vessel or road tanker.

3. Is the methodology clearly explained and acceptable?

The section on the Internal ERM Impact assessment does follow a typical risk matrix type approach but in the absence of the original matrix criteria cannot be judged.

ERM Response:

The ERM Risk Matrix appears in the Environmental Impact Assessment report and was distributed to the specialists.

4. Are the mitigation measures and recommendation measures appropriate?

The list of technical and management systems mitigation measures is extensive and they should be applied as most of them are standard requirements for any propane installation.

However, the ERM calculation of location specific individual risks results in the conclusion that both on site and off site risks are in tolerably high. ERM then concludes that a suitable further mitigation measure is to prevent or reduce access to these areas.

It is the opinion of this reviewer that this mitigation measure is not an acceptable solution to a high risk problem.

The risk assessment should at least indicate the technical reasons for the high risks and home in on specific equipment. Probably it is due either the hose failure frequency due to high delivery rate, or possibly the vaporizer with its high failure rate. If it is the hose failure rate, then one cannot suggest reducing access when one simultaneously suggests there must be someone present during offloading.

If it is not technically possible to reduce the risks with for example higher than normal integrity hoses, excess flow valves, ROSOVS, ASOVS, larger tank and road tanker with lower deliver frequency, electric heater instead of shell and tube vapourizer etc. then the QRA should state that no additional risk reduction measures could be developed and therefore the assessor concludes that the only option is to try and limit access and in that manner all reasonably practicable measures have been implemented.

ERM Response

The evaluation of the failure data used in the Propane installation risk assessment and subsequent recommendation for more stringent Propane road tanker offloading pullaway prevention, as stated in Point 1, has the effect of reducing the risk from the Propane installation. The resulting risk is not intolerable to individuals offsite or to workers onsite.

The provision for Propane road tanker offloading pullaway prevention and mitigation measures has been included as a recommendation.

5. Is the article well-written and easy to understand?

Memo

The Summary section titled impact assessment is not easy to follow (see comment below).

The internal ERM risk matrix used to derive the assessment valuation of High, Moderate etc. is not included in the report and hence this section is technically not understandable. Suggestion – include the matrix with a brief description to allow this QRA document to stand on its own, or at least refer to another EIA document where it is included.

ERM Response

The ERM Risk Matrix appears in the Environmental Impact Assessment report and was distributed to the specialists.

6. Are there any shortcoming to this study? If yes, please describe.

The current assessment excludes the on-site CCGT and propane power generation systems.

The expected worst case explosion scenario for each of these facilities has been modelled and the report indicates that these explosions will not extend offsite. The implication of this is that these installations are unlikely to pose intolerable public risks and that the exclusion of them at this stage is unlikely to become a major offsite risk concern at a later stage. This seems reasonable to the reviewer.

However, when information become available, the installations need to be included in the QRA to ensure employees risk levels are within the Location Specific Individual Risk criteria.

ERM Response

ERM have recommended that a further quantitative risk assessment be carried out after detailed design has been completed. These considerations can be more readily accommodated after these details are available.