Western Cape Government

BETTER TOGETHER.

Environmental screening study for a proposed LNG terminal at Saldanha and associated pipeline infrastructures to Atlantis and Cape Town, Western Cape, South Africa.

APPENDICES

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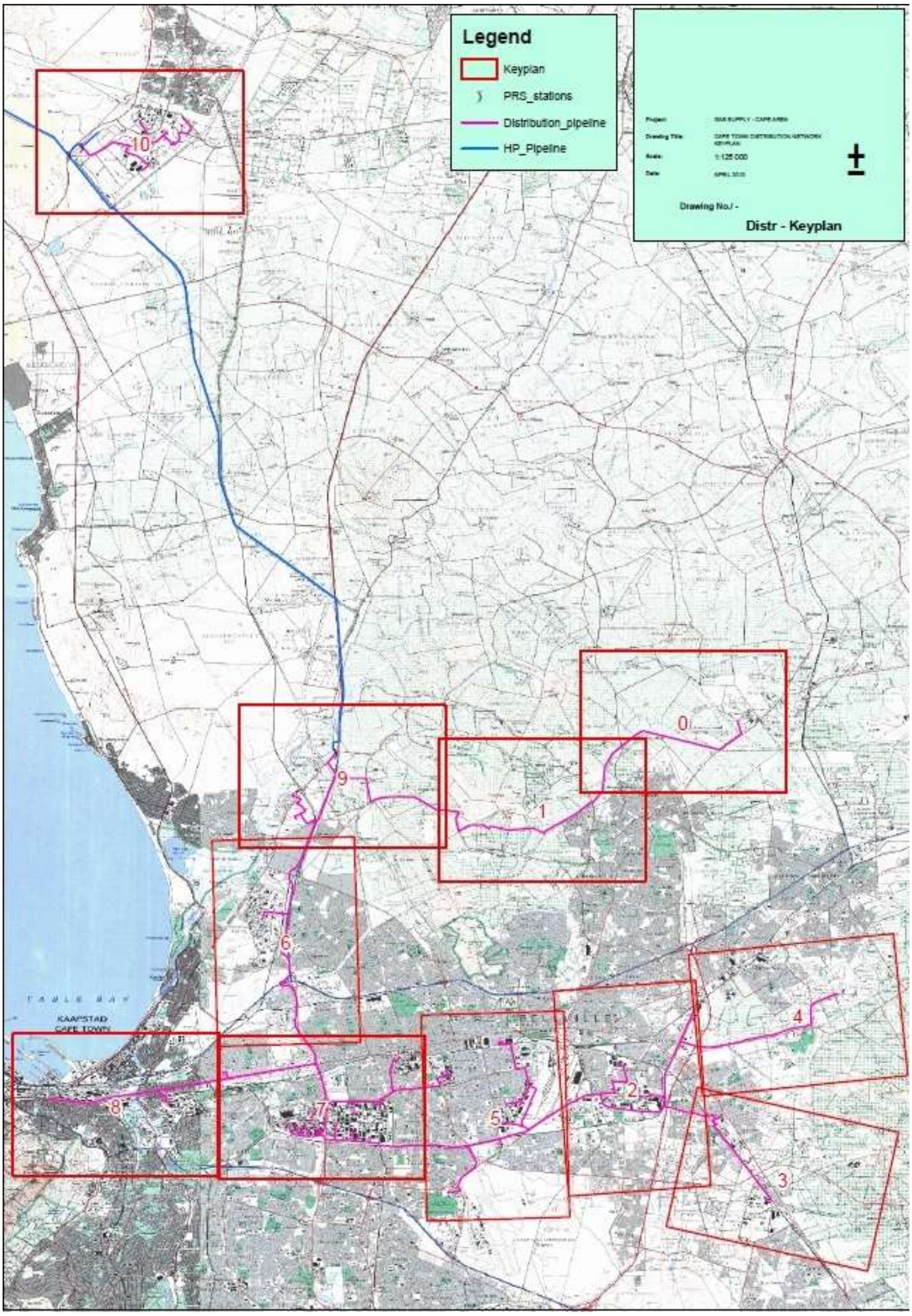
APPENDIX 1: MAPPING OF THE STAGE 2 COMMERCIAL AND DOMESTIC DISTRIBUTION PIPELINE NETWORK EXPANSION, AND PIPELINE SPECIFICATIONS

1. MAPS

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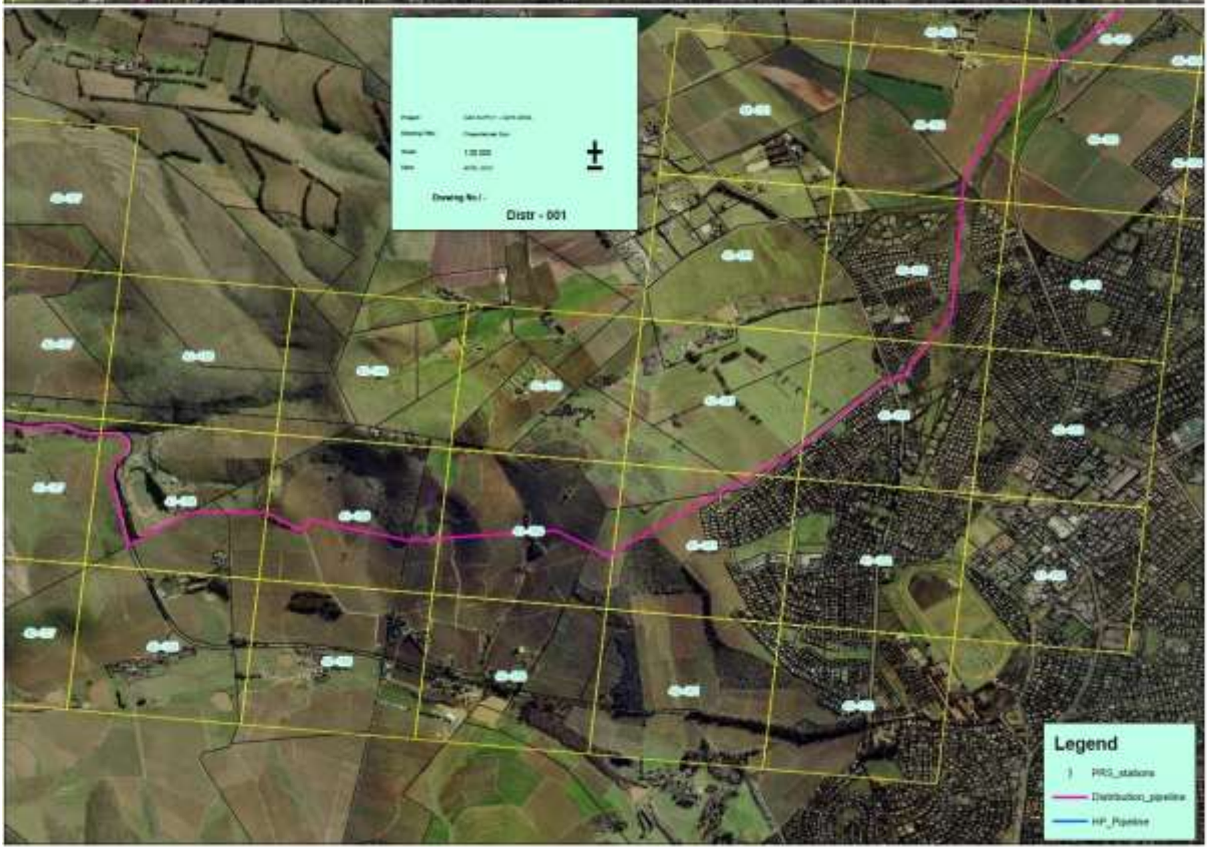
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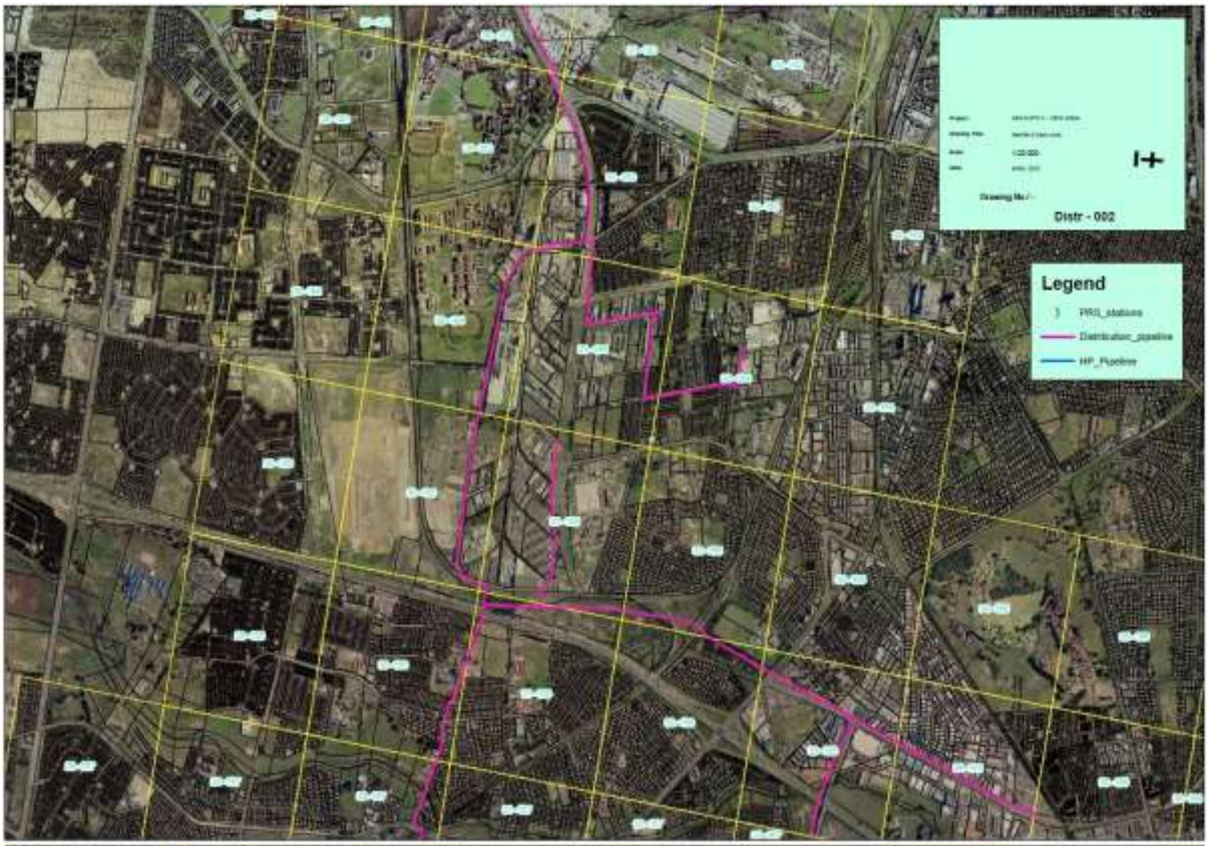
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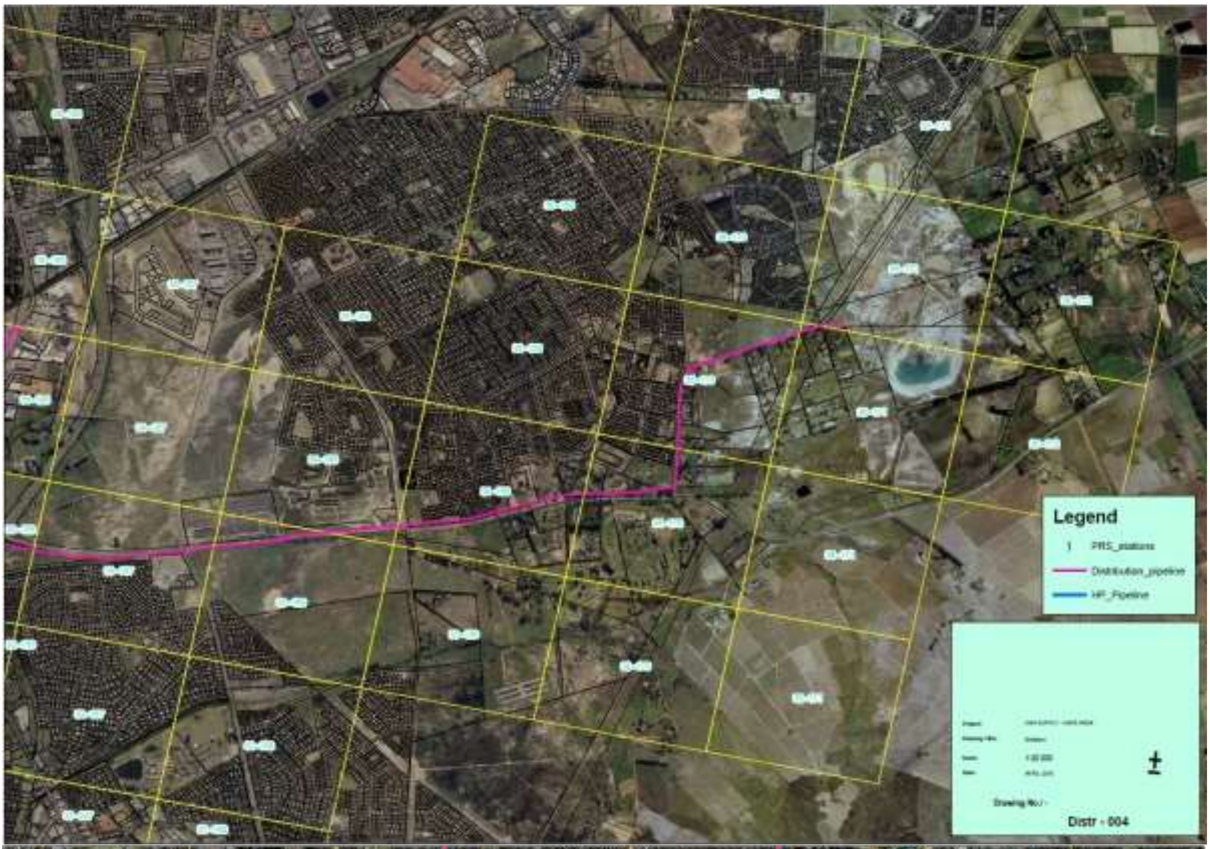
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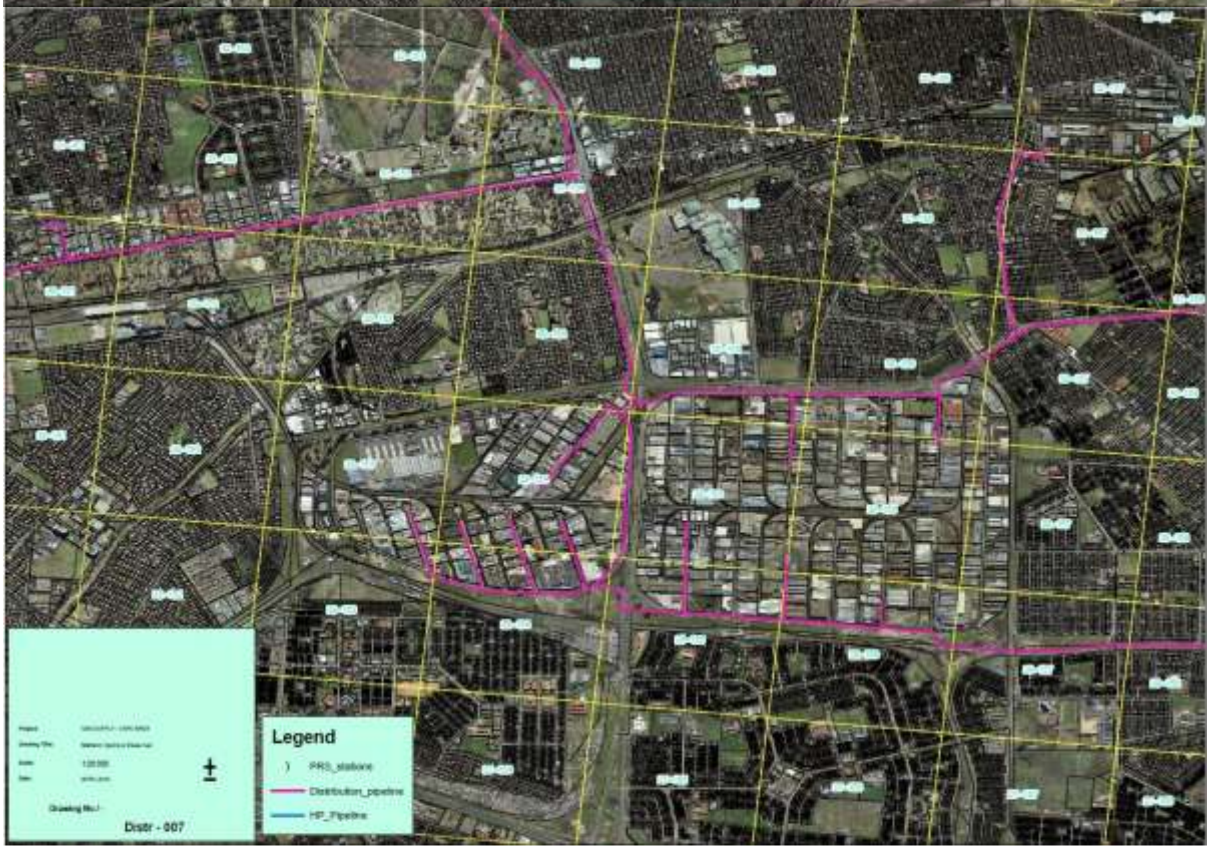
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Legend
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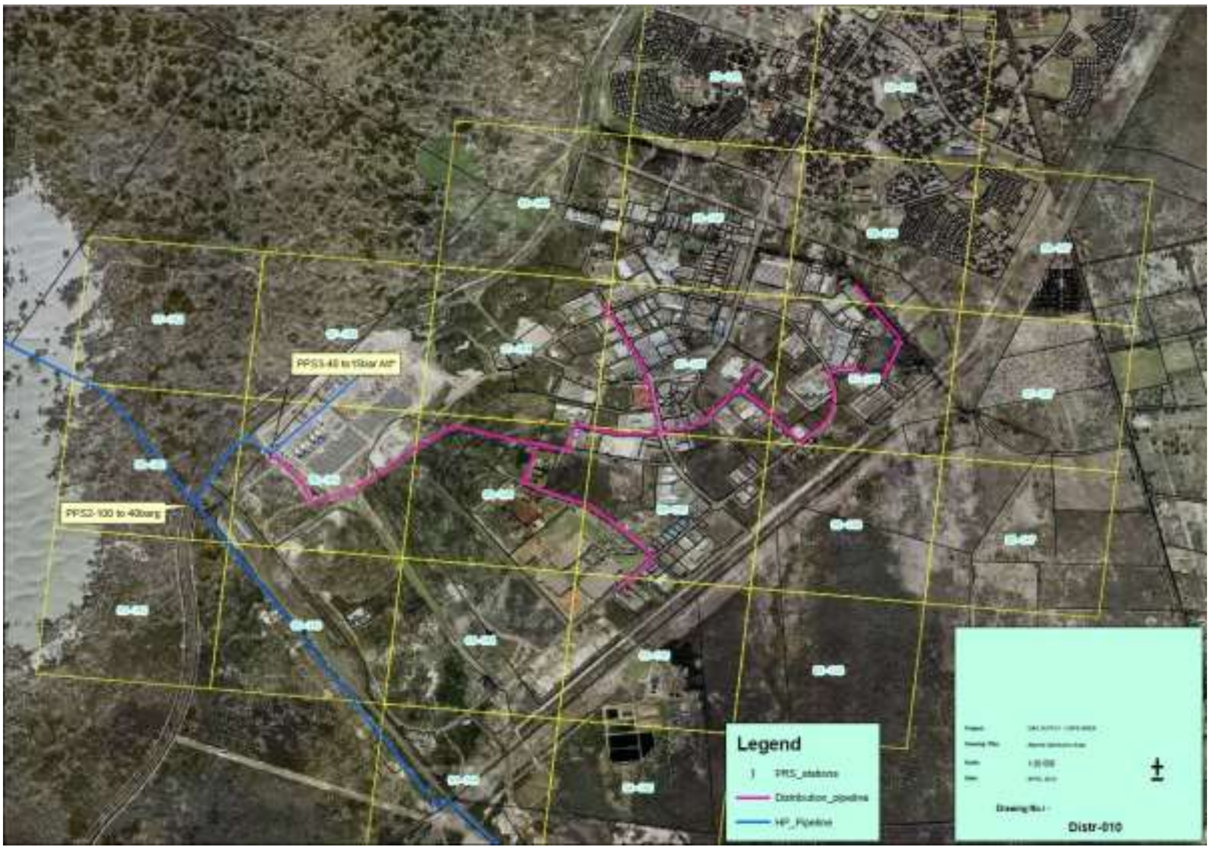
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2. DISTRIBUTION AREAS – PHASE 1

Cape Town Distribution Pipeline Network - Stage 1

Material	*Diameter (mm)*	*Wall thickness (mm)*	*Length (m)*	*Max Pressure (barg)*	*Ave Op Pressure (barg)*	*Area*	*Capacity committed (Nm^3/h)*
API 5L X42	60.3	2.80	215	15	12	Atlantis	84 Nm^3/h
API 5L X42	60.3	2.80	662	15	12	Atlantis	87 Nm^3/h
API 5L X42	60.3	2.80	1093	15	12	Atlantis	171 Nm^3/h
API 5L X42	60.3	2.80	1237	15	12	Atlantis	45 Nm^3/h
API 5L X42	88.9	3.10	287	15	12	Atlantis	681 Nm^3/h
API 5L X42	88.9	3.10	322	15	12	Atlantis	1 127 Nm^3/h
API 5L X42	88.9	3.10	1608	15	12	Atlantis	552 Nm^3/h
API 5L X42	114.3	3.00	848	15	12	Atlantis	2 441 Nm^3/h
API 5L X42	168.0	4.80	1895	15	12	Atlantis	3 068 Nm^3/h
API 5L X42	88.9	3.10	2543	15	12	Airport	290 Nm^3/h
API 5L X42	60.3	2.80	242	15	12	Beaconvale & Elsies River	54 Nm^3/h
API 5L X42	88.9	3.10	2207	15	12	Beaconvale & Elsies River	584 Nm^3/h
API 5L X42	88.9	3.10	2429	15	12	Beaconvale & Elsies River	390 Nm^3/h
API 5L X42	88.9	3.10	1083	15	12	Bellville	477 Nm^3/h
API 5L X42	88.9	3.10	1365	15	12	Bellville	625 Nm^3/h
API 5L X42	114.3	3.00	6278	15	12	Bottelary Spur	474 Nm^3/h
API 5L X42	323.0	4.80	1269	15	12	Contermanskloof	4 068 Nm^3/h
API 5L X42	60.3	2.80	1423	15	12	Crammix Bottlary spur	87 Nm^3/h
API 5L X42	114.3	3.00	2299	15	12	Crammix Bottlary spur	917 Nm^3/h
API 5L X42	168.0	4.80	379	15	12	Crammix Bottlary spur	2 691 Nm^3/h
API 5L X42	406.4	11.20	1024	15	12	Distr Main line	25 578 Nm^3/h
API 5L X42	406.4	11.20	1103	15	12	Distr Main line	25 946 Nm^3/h
API 5L X42	406.4	11.20	1743	15	12	Distr Main line	25 946 Nm^3/h
API 5L X42	406.4	11.20	2676	15	12	Distr Main line	20 498 Nm^3/h
API 5L X42	406.4	11.20	2858	15	12	Distr Main line	21 494 Nm^3/h
API 5L X42	406.4	11.20	3313	15	12	Distr Main line	26 235 Nm^3/h
API 5L X42	559.0	12.70	2962	15	12	Distr Main line	53 438 Nm^3/h
API 5L X42	559.0	12.70	3977	15	12	Distr Main line	57 506 Nm^3/h
API 5L X42	559.0	12.70	6820	15	12	Distr Main line	52 684 Nm^3/h
API 5L X42	457.0	12.70	107	15	12	Distr Main line Epping	49 037 Nm^3/h
API 5L X42	457.0	12.70	110	15	12	Distr Main line Epping	49 037 Nm^3/h
API 5L X42	457.0	12.70	1233	15	12	Distr Main line Epping	48 467 Nm^3/h
API 5L X42	457.0	12.70	1539	15	12	Distr Main line Epping	51 766 Nm^3/h
API 5L X42	60.3	2.80	178	15	12	Epping	303 Nm^3/h

API 5L X42	60.3	2.80	438	15	12	Epping	303 Nm^3/h
API 5L X42	60.3	2.80	523	15	12	Epping	384 Nm^3/h
API 5L X42	88.9	3.10	276	15	12	Epping	267 Nm^3/h
API 5L X42	88.9	3.10	541	15	12	Epping	570 Nm^3/h
API 5L X42	88.9	3.10	547	15	12	Epping	1 180 Nm^3/h
API 5L X42	88.9	3.10	636	15	12	Epping	504 Nm^3/h
API 5L X42	88.9	3.10	768	15	12	Epping	490 Nm^3/h
API 5L X42	114.3	3.00	488	15	12	Epping	1 215 Nm^3/h
API 5L X42	114.3	3.00	1175	15	12	Epping	917 Nm^3/h
API 5L X42	168.0	4.80	915	15	12	Epping	2 729 Nm^3/h
API 5L X42	323.0	4.80	300	15	12	Epping	19 418 Nm^3/h
API 5L X42	323.0	4.80	311	15	12	Epping	20 598 Nm^3/h
API 5L X42	323.0	4.80	473	15	12	Epping	18 928 Nm^3/h
API 5L X42	457.0	12.70	73	15	12	Epping	20 726 Nm^3/h
API 5L X42	60.3	2.80	561	15	12	Killarney Gardens	351 Nm^3/h
API 5L X42	88.9	3.10	339	15	12	Killarney Gardens	51 Nm^3/h
API 5L X42	88.9	3.10	752	15	12	Killarney Gardens	654 Nm^3/h
API 5L X42	88.9	3.10	853	15	12	Killarney Gardens	885 Nm^3/h
API 5L X42	60.3	2.80	228	15	12	Kuilsriver & Blackheath	43 Nm^3/h
API 5L X42	168.0	4.80	1899	15	12	Kuilsriver & Blackheath	3 122 Nm^3/h
API 5L X42	168.0	4.80	4081	15	12	Kuilsriver & Blackheath	3 025 Nm^3/h
API 5L X42	60.3	2.80	1123	15	12	Montague Gardens	49 Nm^3/h
API 5L X42	60.3	2.80	252	15	12	Parrow	24 Nm^3/h
API 5L X42	60.3	2.80	833	15	12	Parrow	129 Nm^3/h
API 5L X42	88.9	3.10	251	15	12	Parrow	368 Nm^3/h
API 5L X42	88.9	3.10	2762	15	12	Parrow	225 Nm^3/h
API 5L X42	114.3	3.00	587	15	12	Parrow	1 694 Nm^3/h
API 5L X42	114.3	3.00	640	15	12	Parrow	1 718 Nm^3/h
API 5L X42	168.0	4.80	64	15	12	Parrow	2 307 Nm^3/h
API 5L X42	168.0	4.80	873	15	12	Parrow	3 955 Nm^3/h
API 5L X42	168.0	4.80	1214	15	12	Parrow	4 084 Nm^3/h
API 5L X42	323.0	4.80	17342	15	12	Phesantekraal	2 988 Nm^3/h
API 5L X42	114.3	3.00	104	15	12	Sack Circle	1 074 Nm^3/h
API 5L X42	114.3	3.00	995	15	12	Sack Circle	1 397 Nm^3/h
API 5L X42	60.3	2.80	354	15	12	Saltriver, Ndebeni & Maitland	276 Nm^3/h
API 5L X42	60.3	2.80	386	15	12	Saltriver, Ndebeni & Maitland	333 Nm^3/h
API 5L X42	88.9	3.10	571	15	12	Saltriver, Ndebeni & Maitland	447 Nm^3/h
API 5L X42	88.9	3.10	3992	15	12	Saltriver, Ndebeni & Maitland	157 Nm^3/h
API 5L X42	114.3	3.00	4988	15	12	Saltriver, Ndebeni & Maitland	2 441 Nm^3/h

3. LEGISLATION, OPERATING AND TECHNICAL STANDARDS, CODES AND SPECIFICATIONS

Pipeline Protection and Cathodic Protection System:	
SANS 10121	Cathodic Protection of Buried and Submerged Structures
Gas Transmission and Distribution Piping System:	
ASME B31	American Society of Mechanical Engineers Code for Pressure Piping
ASME B31.3 (2002 Edition)	Process Piping Aboveground
ASME B31.8 (1999 Edition)	Gas Transmission and Distribution Piping Systems
SANS 1200 DB-1999	Earthworks (Pipe Trenches)
SANS 1200 LG-1983	Pipe Jacking
SANS 1200 GA-1983	Concrete (Small Works)
API 6D	American Petroleum Institute Standard for Pipeline Valves
API 5L	American Petroleum Institute Standard for Pipes
API Standard 1104	American Petroleum Institute Standard for Field Welding of Pipelines
DIN 54-109-10/16 for Steel	Image Quality Indicator
ISO 13628-2	Flexible Pipe Systems for Subsea and Marine Applications
ISO 13628-7.2	Design and Operation of Subsea Production Systems
BS PD 8010 Part 2	British Standard Code of Practice for Subsea Pipelines
SANS 10199	The Design and Installation of an Earth Electrode Specifications
SANS 15589	Natural Gas Industries: Cathodic Protection of Pipeline Transportation Systems
ASTM A518	American Standard Test Method Specification for Corrosion Resistant High Silicon Iron Castings
ASTM D149	Standard Test Method for Dielectric Breakdown Voltage
ASTM D1248	Polyethylene Plastic Moulding and Extrusion Materials
ASTM D3222	Standard Specification for Unmodified Poly-Vinylidene Fluoride (PVDF) Moulding Extrusion and Coating Material
ASTM E186	Standard Reference Radiographs for Heavy Walled (51 to 114 mm) Steel Castings
ASTM G57	Method for Field Measurement of Soil Resistivity Using the Wenner Four Electrode Method
NACE RP0169	National Association of Corrosion Engineers Control of External Corrosion on Underground or Submerged, Metallic Piping Systems
NACE RP0177	Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
NACE RP0286	Electrical isolation of Cathodically Protected Pipelines
NACE RP0572	Design, Installation, Operation and Maintenance of Impressed Current Deep Ground Beds
NACE Pub10A190	Measurement Techniques Related to Criteria for CP of Underground or Submerged Steel Piping Systems
BS 7361	British Standard: Cathodic Protection Part 1: Code of Practice for Land and Marine Applications
DIN 50929	Probability of Corrosion of Metallic Materials when Subject to Corrosion from the Outside
ASTM D2200-67	American Society for Testing of Materials, Standard Pictorial Surface Preparation Standards for Painting Steel Surfaces
Electrical Installations:	

SANS 10142-1	The Wiring of Premises Part 1: Low-Voltage Installations
SANS 10108	The Classification of Hazardous Locations and the Selection of Apparatus for Use in Such Locations
SANS 10089-2	The Petroleum Industry Part 2: Electrical installations in the Distribution and Marketing Sector
SANS 1411-1	Materials of Insulated Electric Cables and Flexible Cords Part 1: Conductors
SANS 1411-2	Materials of Insulated Electric Cables and Flexible Cords Part 2: Polyvinyl Chloride (PVC)
SANS 1411-3	Materials of Insulated Electric Cables and Flexible Cords Part 3: Elastomers
SANS 1411-4	Materials of Insulated Electric Cables and Flexible Cords Part 4: Cross-linked Polyethylene (XLPE)
SANS 1411-5	Materials of Insulated Electric Cables and Flexible Cords Part 5: Halogen-free, Flame-Retardant Materials
SANS 1411-6	Materials of Insulated Electric Cables and Flexible Cords Part 6: Armour
SANS 1507-1	Electric Cables with Extruded Solid Dielectric Insulation for Fixed Installations (300/500 V to 1900/3300 V) Part 1: General
SANS1507-2	Electric Cables with Extruded Solid Dielectric Insulation for Fixed Installations (300/500 V to 1900/3300 V) Part 2: Wiring Cables
SANS 1507-3	Electric Cables with Extruded Solid Dielectric Insulation for Fixed Installations (300/500 V to 1900/3300 V) Part 3: PVC Distribution Cables
SANS 1507-4	Electric Cables with Extruded Solid Dielectric Insulation for Fixed Installations (300/500 V to 1900/3300 V) Part 4: XLPE distribution cables
SANS 1507-5	Electric cables with extruded solid dielectric insulation for fixed installations (300 / 500 V to 1900 / 3300 V) Part 5: Halogen-free Distribution Cables
SANS 1507-6	Electric Cables with Extruded Solid Dielectric Insulation for Fixed Installations (300/500 V to 1900/3300 V) Part 6: Service Cables
SANS 549	Intrinsically Safe Electrical Apparatus
SANS 555	Unused and Reclaimed Mineral Insulating Oils for Transformers and Switchgear
SANS 767	Earth Leakage Protection Units
SANS 60745-1	Safety of Handheld Motor Operated Electrical Tools Part 1. General Requirements
General Standards:	
BS 6001(ISO 2859-1)	Sampling Procedures for Inspection by Attributes Part 1: Specification for Sampling Plans Indexed by Acceptable Quality Levels (AQL) for Lot-by-Lot Inspection
SANS 10105	The Classification, Use and Routine Maintenance of Fire-Fighting Appliances
SANS 1125	Room Air Conditioners and Heat Pumps
SANS 1186	Symbolic Safety Signs
SANS 10328	Methods for Environmental Noise Impact Assessments
ISO 14001	Environmental Management Systems: Specifications with Guidance for Use
ISO 14004	Environmental Management Systems: General Guidelines and Principles, Systems and Supporting Techniques
OHSAS 18001	Health and Safety Management Systems
ISO 9001	Quality Management Systems Standards
SANS 29001: 2009	Natural Gas Industries: Sector Specific Quality Management Systems: Requirements for Product and Service Supply Organizations
ANS 14520: 2008	Gaseous Fire-Extinguisher Systems

APPENDIX 2: RISK ASSESSMENT

1. NOTIFICATION OF MAJOR HAZARD INSTALLATION

Prior to the assessment of the potential impact of the various accidental spills, reference needs to be made to the legislation, regulations and guidelines governing the operation of the development.

Section 1 of the Occupational Health and Safety Act (OHS Act; Act No. 85 of 1993) defines a "*major hazard installation*" to mean an installation:

" (a) *Where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily;*

(b) *Where any substance is produced, processed, used, handled or stored in such a form and quantity that it has the potential to cause a major incident (our emphasis).* "

It should be noted that if either (a) or (b) is satisfied, the Major Hazard Installation (MHI) regulations will apply. The prescribed quantity of a chemical can be found in Section 8(1) of the General Machinery Regulation 8.

A major incident is defined as: "*an occurrence of catastrophic proportions, resulting from the use of plant and machinery or from activities at a workplace*". Catastrophic in this context means loss of life and limbs or severe injury to employees or members of the public, particularly those who are in the immediate vicinity.

It is important to note that the definition refers to an occurrence, whereas Section 1b) refers to the potential to cause a major incident. If the potential to cause a major incident exists, then the OHS Act and the Major Hazard Installation regulations will apply (our emphasis).

On the 16th of January 1998, the MHI regulations were promulgated under the OHS Act (Act No. 85 of 1993), with a further amendment on the 30th of July 2001. The provisions of the regulations apply to installations that have on their premises a certain quantity of a substance that can pose a significant risk to the health and safety of employees and the public.

The scope of application given in Section 2 of the MHI regulations is as follows:

" (1) *Subject to the provisions of Subregulation (3) these regulations shall apply to employers, self-employed persons and users, who have on their premises, either permanently or temporarily, a major hazard installation or a quantity of a substance which may pose a risk that could affect the health and safety of employees and the public (our emphasis);*

(2) *These regulations shall apply to local governments, with specific reference to Regulation 9.* "

It is important to note that the regulations refer to a substance, and furthermore the regulations are applicable to risks posed by the substance and **NOT** merely the potential consequences (our emphasis).

The regulations essentially consist of six parts, namely:

1. Duties for notification of a Major Hazard Installation (existing or proposed), including:
   a. Fixed (see List 1);
   b. Temporary installations;
2. The minimum requirements for a quantitative risk assessment (see List 2);
3. The requirements of an on-site emergency plan (see List 3);
4. The reporting steps of risk and emergency occurrences (see List 4);
5. The general duties required of suppliers;
6. The general duties required of local government.

Notification of installation (List 1) indicates that:

- Applications need to be made in writing to the relevant local authority and the provincial director for permission:
  - To erect any Major Hazard Installation;
  - Prior to the modification of any existing installation that may significantly increase the risk related to it (e.g. an increase in the storage or production capacity or alteration of the process);
- Applications need to include the following information:
  - Physical address of installation;
  - Complete material safety data sheets of all hazardous substances;
  - Maximum quantity of each substance envisaged to be on the premises at any one time;
  - The risk assessment of the installation (see List 2);
  - Any further information that may be deemed necessary by an inspector in the interests of health and safety to the public;
- Applications need to be advertised in at least one newspaper serving the surrounding communities and by way of notices posted within these communities.

The risk assessment (List 2):

- Is the process of collecting, organising, analysing, interpreting, communicating and implementing information in order to identify the probable frequency, magnitude and nature of any major incident which could occur at a Major Hazard Installation and the measures required to remove, reduce or control the potential causes of such an incident;
- Needs to be undertaken at intervals not exceeding 5 years and needs to be submitted to the relevant local emergency services;
- Must be made available in copies to the relevant health and safety committee and 60 days must be given to comment thereon and ensure that the results of the assessment be made available to any relevant representative or committee to comment thereon;
- Should be undertaken by competent person(s) and include the following:
    - A general process description;
    - A description of major incidents associated with this type of installation and the consequences of such incidents (including potential incidents);
    - An estimation of the probability of a major incident;
    - The on-site emergency plan;
    - An estimation of the total result in the case of an explosion;
    - An estimation of the effects of thermal radiation in the case of fire;
    - An estimation of concentration effects in the case of a toxic release;
    - Potential effects of a major incident on an adjacent major hazard installation or part thereof;
    - Potential effects of a major incident on any other installation, members of the public (including all persons outside the premises) and on residential areas;
    - Meteorological tendencies;
    - Suitability of existing emergency procedures for the risks identified;
    - Any requirements laid down in terms of the Environmental Conservation Act of 1989 (Act No. 73 of 1989);
    - Any organisational measures that may be required;
    - The employer shall ensure that the risk assessment is of an acceptable standard and shall be reviewed should:
        - It be suspected that the preceding assessment is no longer valid;
        - Changes in the process that affect hazardous substances;
        - Changes in the process that involve a substance that resulted in the installation being classified a Major Hazard Installation or in the methods, equipment or procedures for the use, handling or processing of that substance;
        - Incidents that have brought the emergency plan into operation and may affect the existing risk assessment;
- Must be made available at a time and place and in a manner agreed upon between parties for scrutiny by any interested person that may be affected by the activities.

Requirements related to the on-site emergency plan (List 3) are:

- After submission of the notification, the following shall be established:
  - An on-site emergency plan must be made available and must be followed inside the premises of the installation or the part of the installation classified as a Major Hazard Installation, in consultation with the relevant health and safety representative or the relevant health and safety committee;
  - The on-site emergency plan must be discussed with the relevant local government, taking into consideration any comment on the risk related to the health and safety of the public;
  - The on-site emergency plan must be reviewed and where necessary updated, in consultation with the relevant local government, at least once every three years;
  - A copy of the on-site emergency plan must be signed in the presence of two witnesses, who shall attest the signature;
  - The on-site emergency plan must be readily available at all times for implementation and use;
  - All employees must be conversant with the on-site emergency plan;
  - The on-site emergency plan must be tested in practice at least once a year, and a record must be kept of such testing;
- Any employer, self-employed person and user owning or in control of a pipeline that could pose a threat to the general public shall inform the relevant local government and shall be jointly responsible with the relevant local government for the establishment and implementation of an on-site emergency plan.

In reporting of risk and emergency occurrences (List 4):

- Following an emergency occurrence, the user of the installation shall:
  - Subject to the provisions of Regulation 6 of the General Administrative Regulations, within 48 hours by means of telephone, facsimile or similar means of communication inform the chief inspector, the provincial director and relevant local government of the occurrence of a major incident or an incident that brought the emergency plan into operation or any near miss;
  - Submit a report in writing to the chief inspector, provincial director and local government within seven days;
  - Investigate and record all near misses in a register kept on the premises, which shall at all times be available for inspection by an inspector and local government representatives.

The duties of the supplier refer specifically to:

- The supplying of material safety data sheets for the hazardous substances employed or contemplated in the installation;
- Assessment of the circumstances and substance involved in an incident or potential incident and the informing all persons being supplied with that substance of the potential dangers surrounding it;

- Provision of a service that shall be readily available on a 24-hour basis to all employers, self-employed persons, users, relevant local government and any other body concerned to provide information and advice in the case of a major incident with regard to the substance supplied.

The duties of local government are summarised as follows:

" 9. (1) *Without derogating from the provisions of the National Building Regulations and Building Standards Act of 1977 (Act No. 103 of 1977), no local government shall permit the erection of a new major hazard installation at a separation distance less than that which poses a risk to:*

(a) Airports;

(b) Neighbouring independent major hazard installations;

(c) Housing and other centres of population; or,

(d) Any other similar facility…

Provided that the local government shall permit new property development only where there is a separation distance which will not pose a risk (our emphasis) in terms of the risk assessment: Provided further that the local government shall prevent any development adjacent to an installation that will result in that installation being declared a major hazard installation.

(2) Where a local government does not have facilities available to control a major incident or to comply with the requirements of this regulation that local government shall make prior arrangements with a neighbouring local government, relevant provincial government or the employer, self-employed person and user for assistance…

(3) All off-site emergency plans to be followed outside the premises of the installation or part of the installation classified as a major hazard installation shall be the responsibility of the local government… "

2. HISTORY OF INCIDENTS IN THE LNG INDUSTRY

Design requirements set forth by the US National Fire Protection Association address the protection of facilities from earthquakes. No LNG storage tank failures have occurred due to seismic activity. This is true even in Japan, which relies on LNG to meet all of its natural gas needs and is one of the most seismically active areas in the world.

In 2011 the largest earthquake and tsunami recorded in Japanese history, from the Great East Japan Earthquake, was the first seismic event to damage a Japanese LNG receiving facility, the Sendai City Gas Bureau Minato Works (Takei 2012). The facility was constructed according to seismic design requirements and the actual earthquake did almost no damage. Flooding by the tsunami did most of the damage, but there were no fatalities, LNG leaks or secondary hazards due to LNG. As a result new standards are being developed to safeguard LNG facilities against tsunami damage.

Due to the properties of LNG, explosions are highly unlikely. According to the US Federal Energy Regulatory Commission (FERC), although a large amount of energy is stored in LNG, it cannot be released rapidly enough to cause the overpressures associated with an explosion. LNG vapours consisting mainly of methane mixed with air are not explosive in an unconfined environment. However, it should be noted that the safety of LNG facilities and marine transport vessels over the decades has been a product of advanced technology, well-trained professionals, a thorough understanding of LNG risks, virtually fail-safe safety systems and procedures and rigidly adhered to standards, codes and regulations.

In the early years of the liquid natural gas (LNG) industry three incidents occurred at onshore facilities which resulted in fatalities. The outcome was the institutionalisation of more stringent operational and safety regulations in the industry. The East Ohio Gas Company built the first commercial liquefaction LNG facility in Cleveland in 1941. As stainless steel alloys were scarce due to the Second World War, a large new tank was constructed out of steel with low nickel content. Shortly after going into service the tank failed and LNG spilled into the street and stormwater system. 128 people were killed, 225 people were injured and about 30 acres were devastated due to the resultant fire. Factors that were relevant to the incident developing was the incompatible nature of the material used to build the vessel, the absence of adequate bonding, the proximity of the facility to the residential area and the release from a second vessel due to the inadequate fire insulation of its support structure (US Bureau of Mines 1946). Within the United States, proper precautions have been common place in all the LNG facilities built and placed in service since the Cleveland incident. In the second incident, one of the concrete LNG storage tanks the Texas Eastern Transmission Corporation (TETCO) collapsed killing 37 construction workers inside. This commonly misunderstood to be an LNG incident; however, the subsequent investigation by the New York City Fire Department (1973) concluded that it was a construction accident. The third and final incident to produce a fatality in the US occurred in October 1979 at an electrical substation at Cove Point Terminal in Maryland. LNG leaked through an inadequately tightened pump seal and vaporised. The vapours travelled a distance through an underground electrical conduit and entered the substation where no gas detectors were installed. The subsequent explosion resulted in one fatality, one severe injury and very severe damages to the substation. This incident resulted in three major design code changes which are applicable to entire industry (National Transportation Safety Board 1980). As of 2014, no death or serious accident involving an LNG facility has occurred in the United States in 35 years.
Two other incidents are worth noting. In March 2014 an explosion and fire occurred at Northwest Pipeline LNG facility in Plymouth, Washington. One person was injured, the facility was damaged, including one of the LNG storage vessels, and the surrounding area was evacuated as a precaution to secondary incidents (The Williams Companies 2014). There were no fatalities. The cause of the incident is still under investigation. Another is the explosion at the LNG facility in Skikda, Algeria, in January 2004 that resulted in the death of 27 people, injured about 80 others and resulted in extensive damage to the facility and even to neighbouring facilities. A boiler exploded setting off a chain reaction. The ultimate cause of the incident is still under investigation, but there is some speculation that siting, design, operational and management aspects could have played significant roles (The Pipeline & Gas Journal 2004). The LNG storage vessels themselves remained intact.

Ocean-going tanker transportation of liquefied natural gas (LNG) has a long record of safe operation. Only a few incidents have occurred since the first converted vessel delivered a cargo of LNG to the United Kingdom originating from Lake Charles, Louisiana, in January 1959. According to the US Department of Energy (2002) over the life of the industry eight marine incidents worldwide have resulted in spillage of LNG, with some hulls damaged due to cold fracture, but no cargo fires have occurred. Seven incidents were recorded not involving spillage, with two from groundings, but none of these had significant cargo loss. Furthermore, there have been no LNG fatalities related to shipping.

1.1 Historical trends and failures of overland pipelines

Pipeline failures, for many years, have been either reported by law and made public (as in the USA) or reported by law but under conditions of confidentiality (as in some European countries). The US Department of Transport (DOT) regularly publishes statistics of oil and gas pipeline failures. Two groups, namely the European Gas Pipeline Incident Group (EGIG) and the European oil companies

(CONCAWE), record European experiences. These results are summarised below, with the addition of incident statistics in Australia.

It is known that transport through pipelines has created the safest mode of transportation today, surpassing road, rail, air and water. Figure 2-1 is a clear illustration of this situation in the USA. This record has been achieved and maintained with the use of redundant safety systems, round-the-clock monitoring and extensive inspection and maintenance to keep the pipelines operating in top condition.

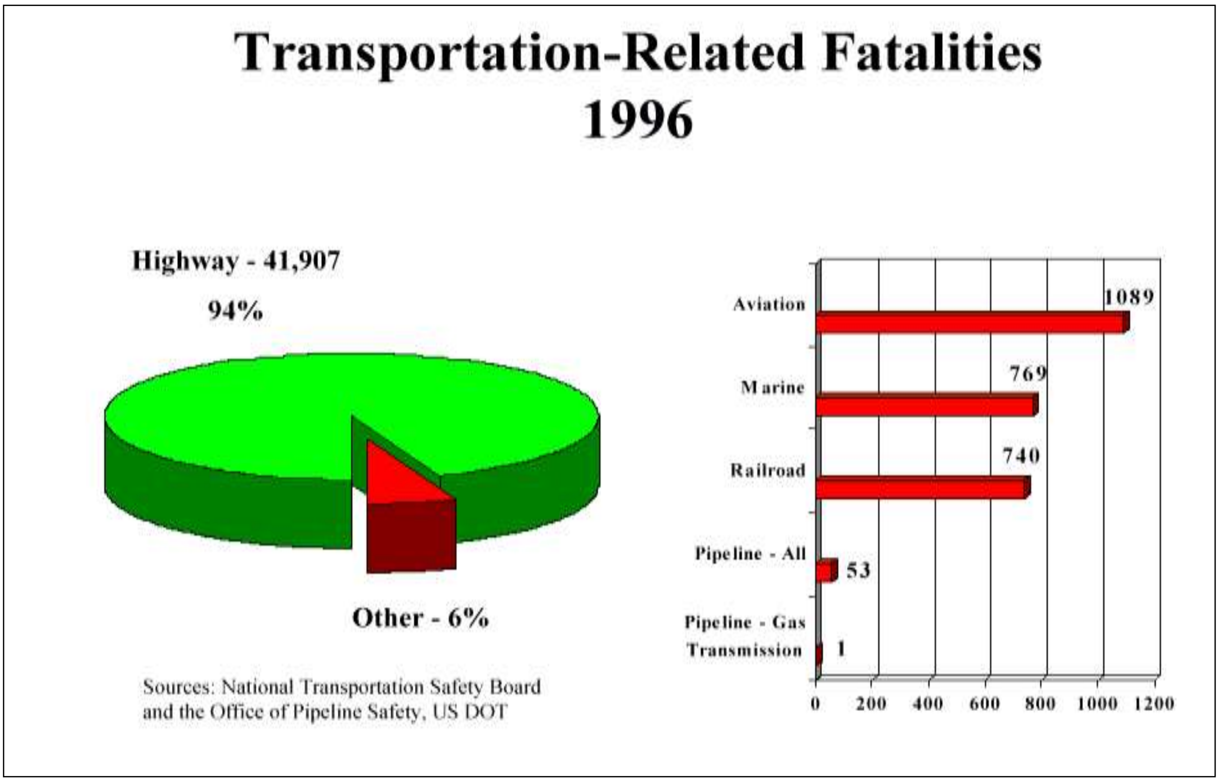


Figure 2-1: Statistical comparison of transportation fatalities in the USA

In this investigation, a review of historical pipeline spillage records from the USA, Europe, Australia and New Zealand forms the basis for establishing generic accident and failure rates. The leak and spill history for these pipelines will be discussed in the following section. For the purposes of risk assessment, both USA and European pipeline accident databases were consulted for the development of historical pipeline failure rates, including the event frequency data and causes of leaks and spills.

Most studies of pipeline failures have identified a range of causes and possible sizes of holes. A failure occurs when there is a loss in the integrity in the pipeline, either in the pipe wall itself or in a weld where sections of the pipeline have been joined together. Damage may be due to corrosion or mechanical impact damage, whilst more severe failures may occur due to ground movement, over-pressurization of the pipe or construction faults.

The European Gas Pipeline Incident Data Group, comprising gas institutions from nine European countries, has collected data since 1970 about the performance of onshore transmission gas pipelines in Western Europe. The data have been analysed (EGIG 1999) to record the reported-on pipeline system development over time, quantify environmental performance and reveal trends in causes of spillages. The two most important causes of spillages are third-party accidents and mechanical failure, with corrosion in third place and operational and natural hazards making minor contributions.

Third-party interference is the most important mechanism of pipeline damage in terms of likelihood and volume spilled. This term means that someone other than the pipeline operator (a 'third-party') damages the pipeline. This type of accident is normally a consequence of digging operations with mechanical excavators or, occasionally, by driving metal or wooden stakes into the ground. The result may be an immediate leak or a weakened part in the pipeline that might fail at some point in the future.

Mechanical failures are essentially unrehearsed failures of the pipe wall or welds. This may, for example, occur when the pipeline is used continuously at a pressure considerably higher than the designed specification; this may lead to material fatigue. Alternatively, a weld may split open at a weak point (e.g. inclusion of a piece of slag or simply a thin portion). Although very uncommon, a pipe may fail due to stress on the steel, which would typically occur as a result of an incorrect installation.

Corrosion of a pipeline can be either external or internal. Where the pipe wall or a weld has been corroded away, the corrosion usually forms a very small hole or pinhole. Corrosion can be the result of electrochemical differences between the soil and pipeline surface or the result of an existing weak point on the pipe or weld. This is generally difficult to predict or pinpoint since large holes from corrosion are very rare.

Natural hazards include flooding, landslides, earthquakes and sinkholes (undermining). The latter event is possibly the only significant natural hazard anticipated along the proposed pipeline route.

Operation failures cover operator error and malfunction of the pressure control and protection systems.

The best collection of cross-country pipeline performance data in the European petrochemical industry is that compiled by the CONCAWE Oil Pipeline Management group (Larivé et al 2007).

According to the statistical summary of reported spillages by the CONCAWE Oil Pipeline Management group, there were 14 incidents recorded in which reportable spillages occurred. In total, 789 000 000 m^3 of crude oil and refined products were transported through the pipeline system of approximately 348 000 km. The occurrence of these spillages amounts to approximately 0.3 spills per year per 1 000 km. There were no associated fires or injuries reported.

Over the 35 reporting years there have been a total of 14 fatalities in five separate incidents. All but one of the fatalities occurred when people were caught up in a fire following a spillage. The single non-fire fatality was a person engaged in a theft attempt who was unable to escape from a pit which he had dug to expose and drill into the pipeline. This caused a leak that filled the pit with product in which the person drowned.

In the 13 fire-related fatalities the ignition was a delayed event, hours or days after the detection and demarcation of the spillage area had taken place. In just one case, fire ensued almost immediately when a bulldozer doing construction work hit and ruptured a gasoline pipeline. A truck driver engaged in the works received fatal injuries. There has been no reported fatality or injury since 1999.

Comparing the results for 2005 with the 35-year performance statistics, significant progress on pipeline spillage performance in the oil industry was illustrated. Figure 2-2 demonstrates the reduction of the spillage frequency per unit length of pipeline over the time. The figure shows the overall frequency trend, broken down into the major cause categories and projected as pipeline spills per 1000 km by year. The frequency of spillages has been progressively reduced from about 1.2 per year per 1000 km to about 0.3 over the 35 years, resulting in a reduction of approximately two thirds of what it started out in 1970.

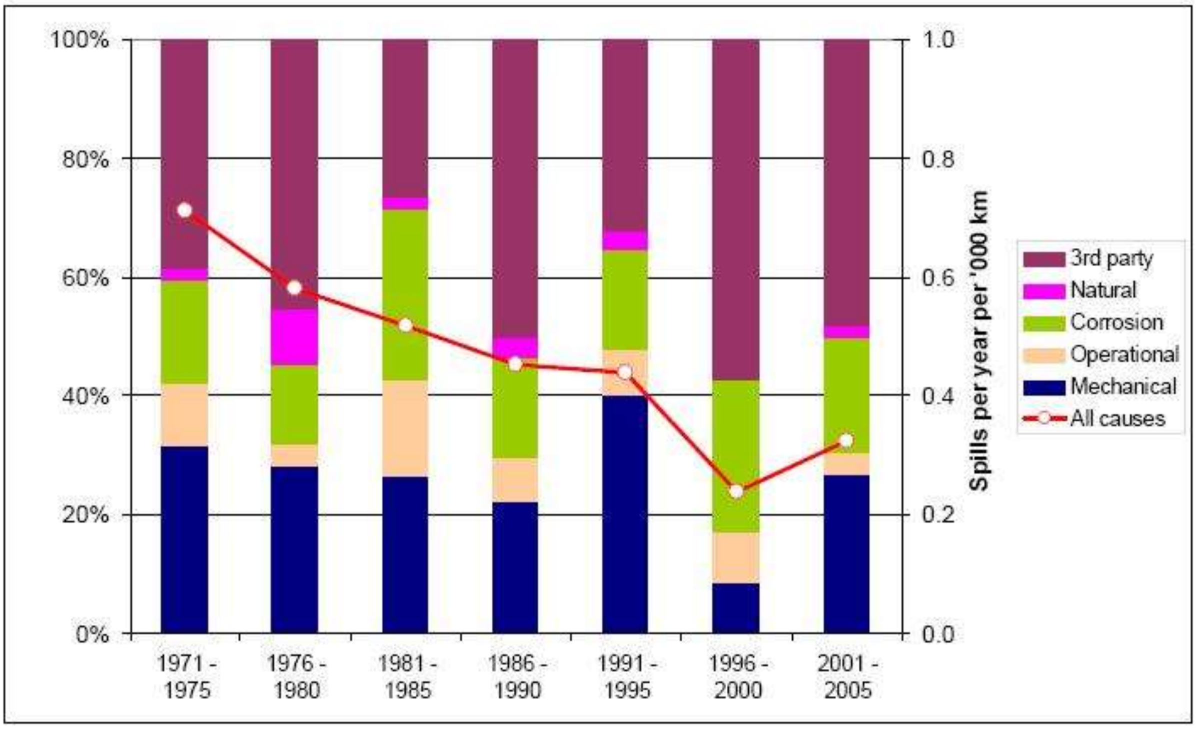


Figure 2-2: Oil spillage frequency trend by major cause category (Larivé et al 2007, p. 18)

CONCAWE classifies spill causes into five major categories: mechanical failure, operational, corrosion, natural hazard and third party, themselves being divided into subcategories. The major cause of spills is third party and the most minor cause is natural hazards (see Figure 2-3).

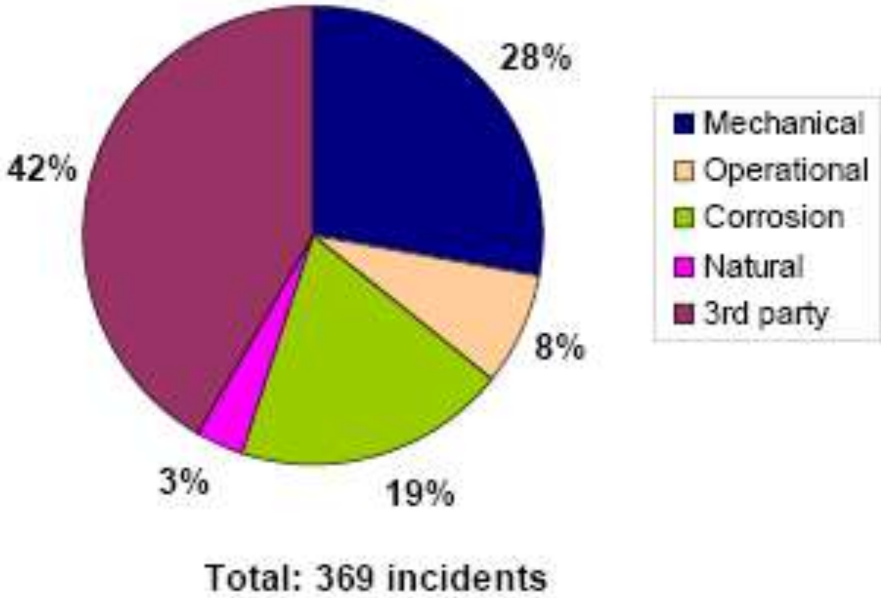


Figure 2-3: Oil spillage frequency by major cause category (Larivé et al 2007, p. 28)

Most studies of pipeline failures have identified a range of possible sizes of holes. It is typical to categorise these sizes into small leaks, significant leaks, large leaks and full-bore ruptures. Small leaks are normally due to corrosion and have a nominal diameter of 6 mm and less. Significant leaks would typically result from excavation work. A nominal size of 12 mm represents the lower end and 50 mm the upper end of such leaks. Catastrophic pipe failures are considered as full-bore ruptures. Table 2-1 is a summary of release frequencies as estimated from the data compiled by CONCAWE.

Table 2-1: Oil spillage frequencies (per million km-years) determined from European experience (Larivé et al 2007)

Cause	Small Leak	Significant Leak	Rupture
Third Party	32.0	79.9	22.8
Mechanical Failure	111.2	47.7	8.0
Corrosion	81.8	1.6	0
Other	35.3	8.1	1.5
TOTAL	**260.3**	**137.3**	**32.3**

The CONCAWE study also found a direct relationship between pipeline diameter and spillage occurrence - smaller pipeline diameters were found to be strongly correlated to higher vulnerability (see Figure 2-4).

Pipe sizes below 8” are approximately 2.5 times more vulnerable than the average, whilst pipes larger than 30” sustained only about one tenth of the average frequency of incidents. Unfortunately, inadequate data prevented an estimate of the risk reduction by deeper coverage - it is not recorded if larger pipelines have greater coverage than small ones.

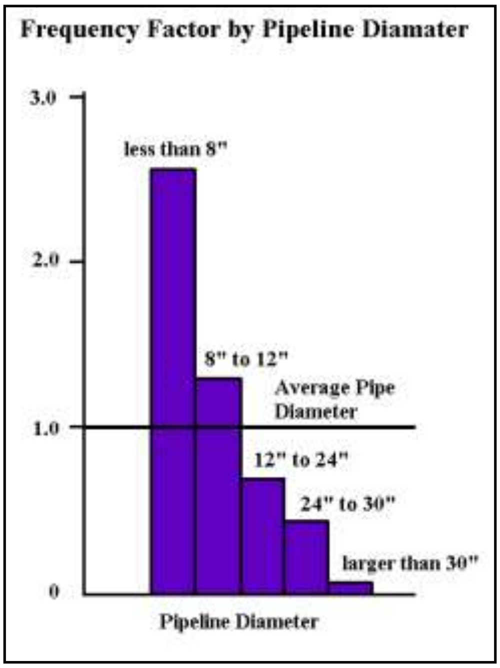


Figure 2-4: Third-party accidental spillages: measure of the vulnerability as a function of pipeline size (Larivé et al 2007, p. 35)

CONCAWE differentiates between failures occurring either in a pipeline proper or in pumping stations and also record the type of land use in the area. Not surprisingly, most incidents (86%) occur in the pipeline themselves. The type of location has been reported for a total of 353 spillages, as seen in Table 2-2.

Table 2-2: Location of spillage incidents (Larivé et al 2007, p. 25)

Type	Pipeline		Pump Station / Manifold	
	Number	%	Number	%
Commercial/Industrial	69	24	52	78
Residential	15	5	2	3
Agricultural	198	69	13	19
Forest/Mountain	5	2	0	0
Surface water	0	0	0	0
Sub-total	287		67	
Unspecified	76		6	
TOTAL	**363**		**73**	

It should be noted that CONCAWE does not have statistics of the length of pipeline installed for each land use type and thus failures frequencies per land use cannot be accurately determined. It is clear that the number of spillages in commercial and industrial areas is much higher than would be expected from consideration of installed length alone. Evidently, the vulnerability of the pipelines is significantly increased in such areas by a factor of possibly as much as ten compared to other areas. The bulk of the spillages from pump stations occur in industrial areas simply because their location is mostly classified as such.

The ground area (m^2) affected by spillages after 1983 are shown in Figure 2-5, together with the average spill size for each category. Over the whole period, the average recovery of the spilled oil is 56% leaving an average net loss of oil to the environment of 73 m^3 per spill.

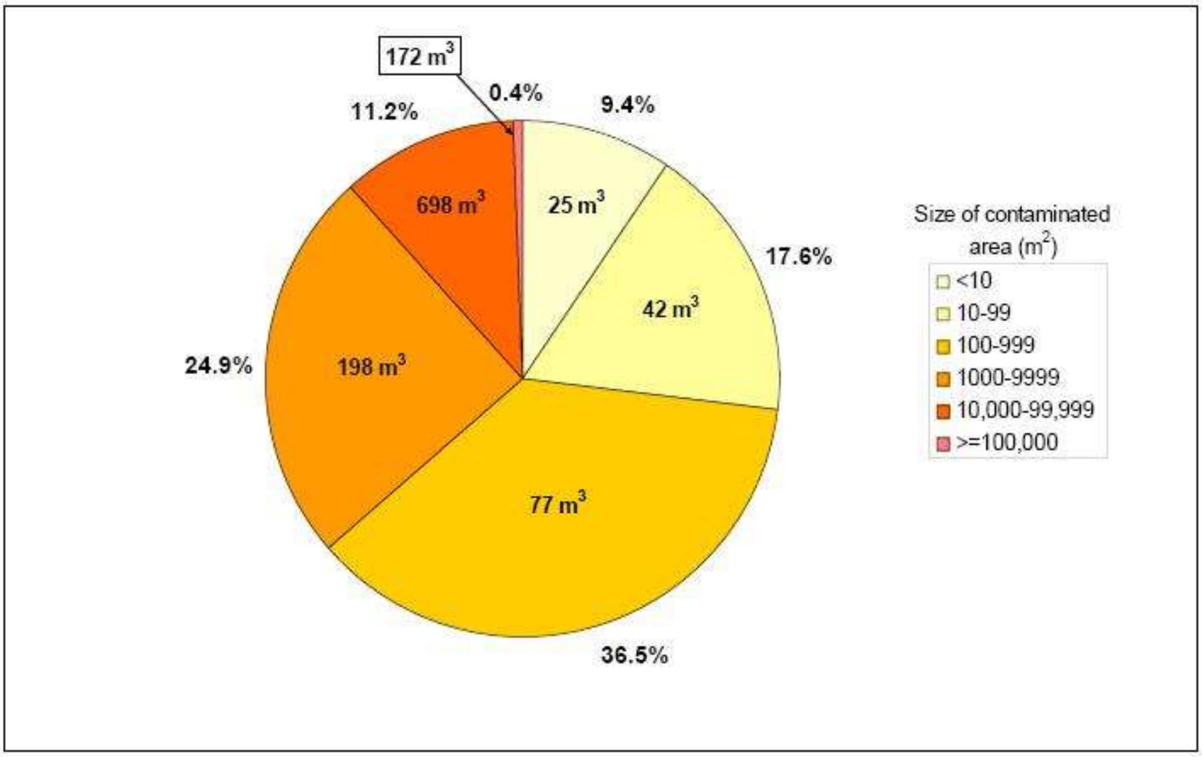


Figure 2-5: Ground area (m^2) affected by spillages (% of number reporting) (Larivé et al 2007, p. 26)

This factor tends to be more prevalent in the smaller area ranges. Other smaller spillages can be spread over larger areas by the influence of groundwater or surface water flows. This is the main mechanism by which relatively small spillages can affect very large areas. Conversely, comparatively large spillages, particularly those that occur over extended periods of time and in the lower quadrants of the pipeline circumference, can have their main effect underground with relatively little impact on the surface. Porous ground and hot arid conditions can also lead to the surface consequences being limited.

The spillage reports record the incidents where oil pollution of the water table and underground aquifers and surface watercourses has had consequences for the abstraction of potable water. Some 14 spillages, representing 3.2% of the total, have had some effect. It is believed that all of these effects have been temporary. For the last five years, impacts on other types of water have been reported. In the years 2001 to 2005, of the 57 reported spillages, 10have affected surface water, 8 have affected ground water but only 2 have impacted potable water supplies.

REFERENCES

BARTINEV, A. M. et al. (1996). Statistical Analysis of Accidents on the Middle Asia Centre Gas Pipelines. *Journal of Hazardous Materials,* 46, pp. 57-69.

BERRY, K. G. et al. (1999). *Performance of Cross-Country Oil Pipelines in Western Europe. Statistical Summary of Reported Spillages 1998*. Brussels: CONCAWE.

EGIG. (2008). *7th EGIG-Report 1970-2007: Gas Pipeline Incidents*. European Pipeline Incident Data Group Report (EGIG).

EISENBERG, N. A. *et al.* (1975). *Vulnerability Model. A Simulation System for Assessing Damage Resulting from Marine Spills.* U. S. Department of Transportation, U. S. Coast Guard, and Office of Research and Development

LARIVÉ, J-F. et al. (2007) *Performance of European Cross-country Oil Pipelines Statistical Summary of Reported Spillages in 2005 and Since 1971*. Brussels: CONCAWE.

LYONS, D. (1998). *Western European Cross-Country Oil Pipelines 25-year Performance Statistics.* Brussels: CONCAWE.

MARTIN, D. E. (1998). *Methods of Prevention, Detection And Control Of Spillages In European Oil Pipelines*. Brussels: CONCAWE.

MARTIN, D. E. (1999). *European Downstream Oil Industry Safety Performance*. Brussels: CONCAWE.

3. APPROACH AND METHODOLOGY

As mentioned in the introduction, the Major Hazard Installation (MHI) regulations give instruction to the owner regarding the requirements of the risk assessment but stop short on giving the methodologies and criteria that must be used for such studies.

As an approved inspection authority (AIA), RISCOM uses the methodologies and criteria described in the internationally recognised CPR 18E (Purple Book) and RIVM (2009) as documentation with which conformance can be measured. This is a requirement of accreditation and implies that similar results should be obtained by independent risk assessors compliant to the aforementioned documents. Furthermore, CPR 18E (Purple Book) and RIVM (2009) are legal requirements for conducting quantitative risk assessments (QRAs) in the Netherlands and forms the basis of the commercially available software.

The evaluation of the acceptability of the risks is extended to the ALARP criteria of the UK Health and Safety Executive (HSE) that covers land use based on the determined risks (see Subsection 0).

The QRA process is summarised with the following steps:

1. The identification of components that are flammable, toxic, reactive or corrosive and that have the potential to result in a major incident from fires, explosions or toxic releases;
2. The development of accidental loss-of-containment scenarios for equipment containing hazardous components (including the release rate, location and orientation of release);
3. For each incident developed in Step 2, the determination of the consequences (thermal radiation, domino effects, toxic-cloud formation, etc.);
4. For scenarios with off-site consequences (i.e. greater than 1% fatality off-site), the calculation of the maximum individual risk (MIR), taking into account all generic failure rates, initiating events (such as ignition), meteorological conditions and lethality.

3.1 Hazard identification

The first step in any risk assessment is to identify all hazards. The merit of including a hazard for further investigation is then determined by how significant it is, normally by using a cut-off or threshold value.

Once a hazard has been identified, it is necessary to assess it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequence should be considered but there are occasions where, if either the probability or the consequence can be shown to be sufficiently low or sufficiently high, decisions can be made based on just one factor.

During the hazard identification component of the report, the following considerations are taken into account:

- Chemical identities;
- Location of on-site installations that use, produce, process, transport or store hazardous components;
- The type and design of containers, vessels or pipelines;
- The quantity of material that could be involved in an airborne release;
- The nature of the hazard most likely to accompany hazardous materials spills or releases, e.g. airborne toxic vapours or mists, fires or explosions, large quantities in storage and certain handling conditions of processed components.

The evaluation methodology assumes that the facility will perform as designed in the absence of unintended events such as component and material failures of equipment, human errors, external events and process unknowns.

3.1.1 Notifiable substances

The General Machinery Regulation 8 and its Schedule A on notifiable substances requires any employer who has a substance equal to or exceeding the quantity as listed in the regulation to notify the divisional director. A site is classified as a Major Hazard Installation if it contains one or more notifiable substances or if the off-site risk is sufficiently high. The latter can only be determined from a quantitative risk assessment.

Methane (compressed) is listed as a notifiable substance at a threshold value of 15 t. The schedule does not specifically mention LNG. To this end LNG would not be classified as a notifiable substance.

However, if the design changes so that more than 15 t of CNG would be contained in a single container, the CNG would be classified as a notifiable substance and the facility would automatically be classified as a Major Hazard Installation.

3.1.2. Substance hazards

Chemical Properties

Natural gas consists mainly of methane (92.6 mol. %) with minor concentrations of ethane, propane, nitrogen of higher chained alkanes.

Given the flammable and potentially explosive nature of natural gas, fires and vapour cloud explosions represent the primary hazards associated with the transfer of the gas. The gas is a fire and explosion hazard when it is exposed to heat and flame. The lower explosive limit (LEL) of natural gas is 5% v/v (meaning 5% gas to 95% air, measured by volume) and the upper explosive limit (UEL) is 15% v/v. In unconfined atmospheric conditions the likelihood of an explosion is expected to be small.

Natural gas is not compatible with strong oxidants and could result in fires and explosions in the presence of such materials. It is nontoxic and is to be considered as an asphyxiant only. Chronic and long-term effects are not significant and are not listed. At atmospheric temperatures and pressures natural gas is in gaseous form. Economical transportation of natural gas would require either liquefying the gas so that would occupy less volume per weight. The liquefied natural gas (LNG) has a low temperature of -162°C (at atmospheric pressure).

Another economical form of transportation, particularly in pipelines, is to compress the gas to reduce the density. The critical pressure of methane is 46 bar and thus compressed natural gas (CNG) above the critical pressure would be a supercritical gas having a density similar to that of the liquid form.

Flammable and Combustible Components

Flammable and combustible components are those that can ignite and give a number of possible hazardous effects, depending on the nature of the component and conditions. These effects may include pool fires, jet fires and flash fires as well as explosions and fireballs.

The flammable and combustible components to be stored on site are listed in Table 3-3. These components have been analysed for fire and explosion risks.

Table 3-3: Flammable and combustible components to be stored on site

Component	Flashpoint (°C)	Boiling Point (°C)	LFL (vol. %)	UFL (vol. %)
Natural gas	Flammable gas	Flammable gas	5	15

3.1.3 Physical Properties

For this study, certain components are modelled as pure components, as given in Table 3-4. The physical properties used in the simulations were based on the DIPPR[1] data base and modelled on DNV's PHAST v. 6.7.

Table 3-4: Representative components

Component	Modelled as
LNG	Methane
CNG	

3.1.4 Software

The physical consequences were calculated with DNV's PHAST v. 6.7 and the data derived was entered into TNO's RISKCURVES v. 9.0.21. All calculations were performed by Mr M P Oberholzer.

3.1.5 Physical and Consequence Modelling

In order to establish the impacts following an accident, it is necessary first to estimate: the physical process of the spill (i.e. rate and size); the spreading of the spill; the evaporation from the spill; the subsequent atmospheric dispersion of the airborne cloud; and, in the case of ignition, the burning rate and resulting thermal radiation from a fire and the overpressures from an explosion.

1 Design Institute for Physical Properties

The second step is then to estimate the consequences of a release on humans, fauna, flora and structures. This merely illustrates the significance and the extent of the impact in the event of a release. The consequences would be due to toxic and asphyxiant vapours, thermal radiation or explosion overpressures. The consequences may be described in various formats. The simplest methodology follows a comparison of predicted concentrations (or thermal radiation or overpressures) to short-term guideline values. In a different, but more realistic fashion, the consequences may be determined by using a dose-response analysis. Dose-response analysis aims to relate the intensity of the phenomenon that constitutes the hazard to the degree of injury or damage that it can cause. Probit analysis is possibly the method mostly used to estimate probability of death, hospitalisation or structural damage. The probit is a lognormal distribution and represents a measure of the percentage of the vulnerable resource that sustains injury or damage. The probability of injury or death (i.e. risk level) is in turn estimated from this probit (risk characterisation).

The consequence modelling gives an indication of the extent of the impact for selected events and is used primarily for emergency planning. A consequence that would not cause irreversible injuries would be considered insignificant, and no further analysis would be required. The effects from major incidents are summarised in the following subsections.

3.1.6 Multiple Consequence Scenarios

A particular scenario may produce more than one major consequence. In such cases, the consequences are evaluated separately and assigned failure frequencies in the risk analysis. Some of these phenomena are described in the subsections that follow.

Scenarios for Release of a Pressurised Liquefied Gas

The nature of the release of a liquefied gas from a pressurised vessel is dependent on the position of the hole.

A hole above the liquid level will result in a vapour release only, and the release rate would be related to the size of the whole and internal pressure of the tank. Over a period of time, the bulk temperature reduces, with an associated decrease in the vapour release rate.

A hole below the liquid level will result in a release of a liquid stream. With the reduced pressure of the atmosphere, a portion of the liquid will vaporise at the normal boiling point. This phenomenon is called flashing, as shown in Figure 3-6. The pool, formed after flashing, then evaporates at a rate proportional to the pool area, surrounding temperature and wind velocity.

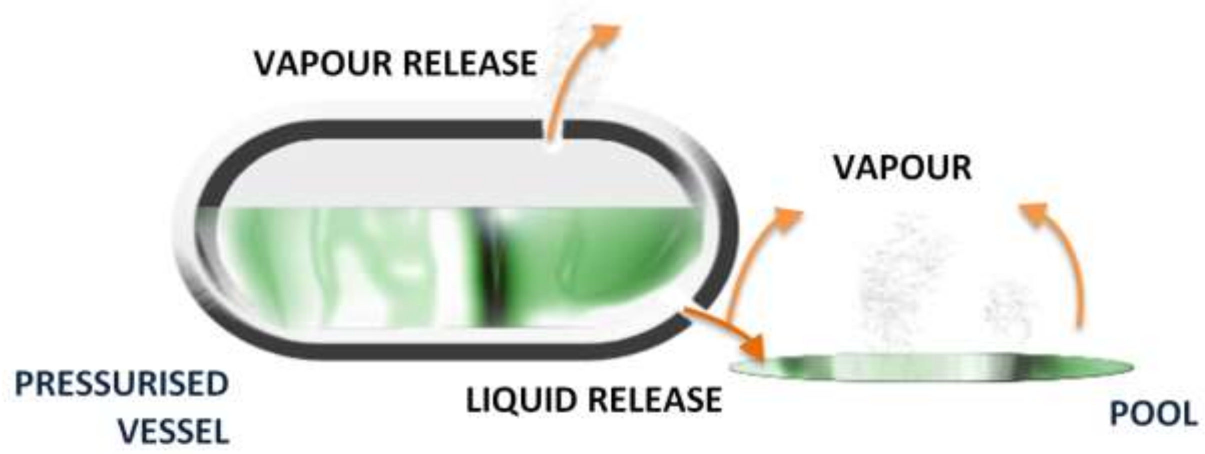


Figure 3-6: Airborne vapours from a loss of containment of liquefied gas stored in a pressurised vessel

Instantaneous Release of a Liquefied Flammable Gas

An instantaneous loss of containment of a liquefied flammable gas could result in the consequences given in the event tree of Figure 3-7. The probabilities of the events occurring are dependent on a number of factors and are determined accordingly. All the scenarios of shown in the figure are determined separately and reported in the relevant subsections of the report.

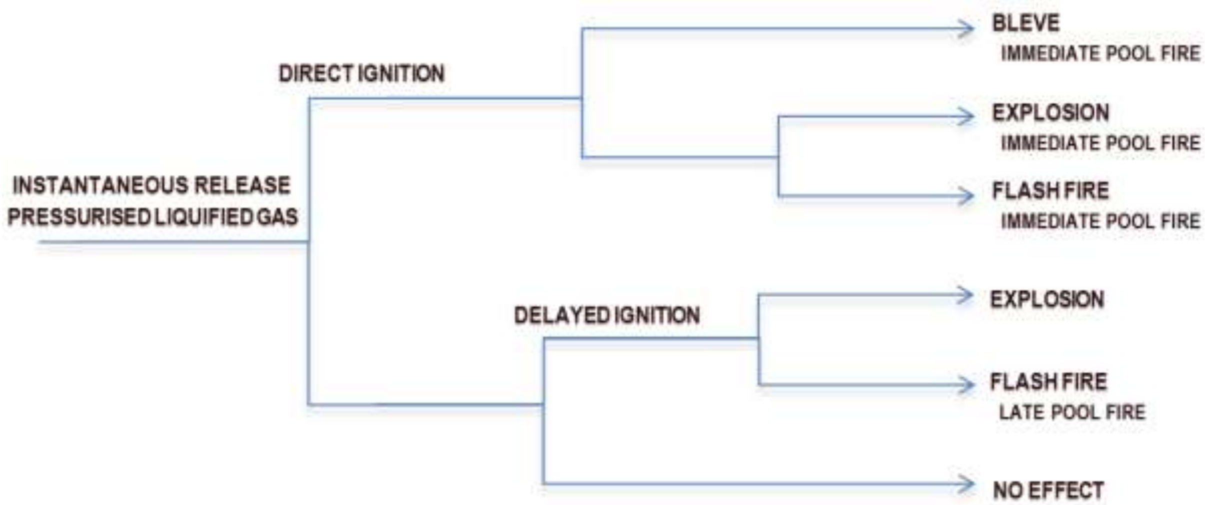


Figure 3-7: Event tree for an instantaneous release of a pressurised flammable gas

Continuous Release of a Pressurised Liquefied Flammable Gas

A continuous loss of containment of a liquefied flammable gas could result in the consequences given in the event tree of Figure 3-8. The probabilities of the events occurring are dependent on a number of factors and are determined accordingly. All the scenarios shown in the figure are determined separately and reported in the relevant subsections of the report.

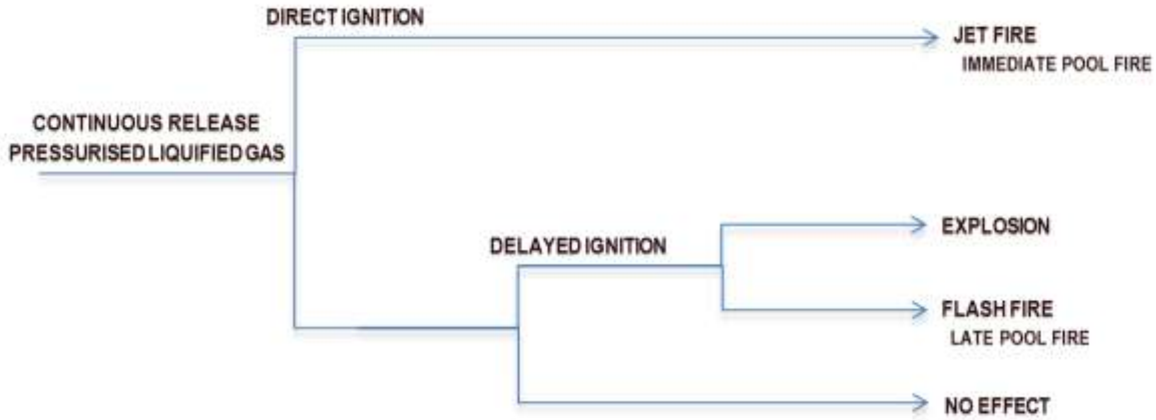


Figure 3-8: Event tree for a continuous release of a pressurised flammable gas

Continuous Release of a Flammable Liquid

A continuous loss of containment of flammable liquids could result in the consequences given in the event tree of Figure 3-9. The probabilities of the events occurring are dependent on a number of factors and are determined accordingly. All the scenarios shown in the figure are determined separately and reported in the relevant subsections of the report.

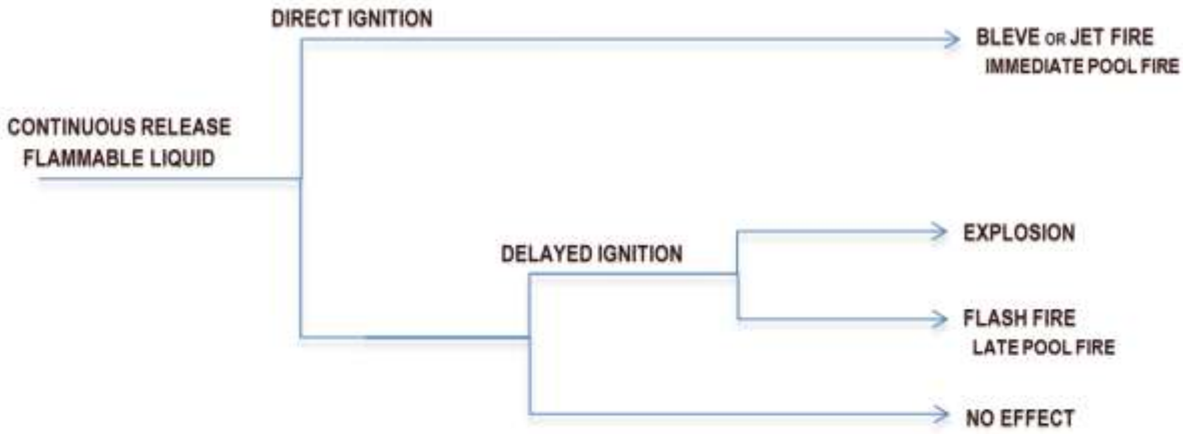


Figure 3-9: Event tree for a continuous release of a flammable liquid

3.1.7 Fires

Combustible materials within their flammable limits may ignite and burn if exposed to an ignition source of sufficient energy. On process plants this normally occurs as a result of a leakage or spillage. Depending on the physical properties of the material and the operating parameters, the combustion of material may take on a number of forms, i.e. pool fires, jet fires and flash fires.

Thermal Radiation

The effect of thermal radiation is very dependent on the type of fire and duration exposed to the thermal radiation. Certain codes, such as API 520 and API 2000, suggest the maximum heat absorbed by vessels for adequate relief designs to prevent the vessel from failure due to overpressure. Other codes, such as API 510 and BS 5980, give guidelines for the maximum thermal-radiation intensity that act as a guide to equipment layout, as given in Table 3-5.

The effect of thermal radiation on human health has been widely studied, relating injuries to the time and intensity of the radiation exposure.

Table 3-5: Thermal radiation guidelines (BS 5980 1990)

Thermal Radiation Intensity (kW/m^2)	Limit
1.5	Will cause no discomfort for long exposure
2.1	Sufficient to cause pain if unable to reach cover within 40 seconds
4.5	Sufficient to cause pain if unable to reach cover within 20 seconds
12.5	Minimum energy required for piloted ignition of wood and melting of plastic tubing
25	Minimum energy required to ignite wood at indefinitely long exposures
37.5	Sufficient to cause serious damage to process equipment

For pool fires, jet fires and flash fires CPR 18E suggests the following thermal radiation levels be reported:

- 4 kW/m^2, the level that glass can withstand, preventing the fire entering a building, and that should be used for emergency planning;
- 10 kW/m^2, the level that represents the 1% fatality for 20 seconds of unprotected exposure and at which plastic and wood may start to burn, transferring the fire to other areas;
- 35 kW/m^2, the level at which spontaneous ignition of hair and clothing occurs, with an assumed 100% fatality, and at which initial damage to steel may occur.

Thermal radiation guideline levels for continuous and emergency flaring is given in the API 521 (2007) standard. More specifically, the acceptable radiation at ground level for LNG flaring can be found in BS EN 1473 (2007) and NFPA 59A (2013). The BS EN 1473 (2007) standard is slightly more conservative and more detailed and was adopted for this study. These values are given in Table 3-6 and Table 3-7.

Table 3-6: Allowable thermal radiation flux excluding solar radiation inside the boundary (BS EN 1473 2007)

Equipment Inside Boundary	Maximum Thermal Radiation Flux (kW/m^2)	
Flow rate (defined in the standard)	Normal	Accidental
Peak within the sterile area (defined in the standard)	5	9
Outer edges of the restricted (sterile) area	N/A	5
Roads and open areas	3	5
Tanks and process areas	1.5	5
Control rooms, maintenance workshops, laboratories, warehouses, etc.	1.5	5
Administrative buildings	1.5	5

Table 3-7: Allowable thermal radiation flux excluding solar radiation outside the boundary (BS EN 1473 2007)

Outside Boundary	Maximum Thermal Radiation Flux (kW/m^2)	
Flow rate (defined in the standard)	Normal	Accidental
Remote area[1]	3	5
Critical area[2]	1.5	1.5
Other areas[3]	1.5	3

Bund and Pool Fires

Pool fires, either tank or bund fires, consist of large volumes of liquid flammable material at atmospheric pressure burning in an open space. The flammable material will be consumed at the burning rate, depending on factors including the prevailing winds. During combustion heat will be released in the form of thermal radiation. Temperatures close to the flame centre will be high but will reduce rapidly to tolerable temperatures over a relatively short distance. Any building or persons close to the fire or within the intolerable zone will experience burn damage with the severity depending on the distance from the fire and the time exposed to the heat of the fire.

In the event of a pool fire, the flames will tilt according to the wind speed and direction. The flame length and tilt angle affect the distance of thermal radiation generated.

Jet Fires

Jet fires occur when flammable material of a high exit velocity ignites. In process industries this may be due to design (such as flares) or due to accidental releases. Ejection of flammable material from a vessel, pipe or pipe flange may give rise to a jet fire and in some instances the jet flame could have substantial 'reach'. Depending on wind speed, the flame may tilt and impinge on other pipelines, equipment or structures. The thermal radiation from these fires may cause injury to people or damage equipment some distance from the source of the flame.

Flash Fires

A loss of containment of flammable materials would mix with air and form a flammable mixture. The cloud of flammable material would be defined by the lower flammable limit (LFL) and the upper flammable limit (UFL). The extent of the flammable cloud would depend on the quantity of released material, physical properties of the released gas, wind speed and weather stability. An ignition within a flammable cloud can result in an explosion if the front is propagated by pressure. If the front is propagated by heat, then the fire moves across the flammable cloud at the flame velocity and is called a flash fire. Flash fires are characterised by low overpressure, with injuries caused by thermal radiation.

1 As defined in BS EN 1473 (2007), an area only infrequently occupied by small numbers of persons, e.g. moor land, farmland, desert.

2 As defined in BS EN 1473 (2007), this is either an unshielded area of critical importance where people without protective clothing can be required at all times, including during emergencies, or a place difficult or dangerous to evaluate at short notice, e.g. hospitals, retirement houses, sports stadiums, schools, outdoor theaters).

3 As defined in BS EN 1473 (2007), other areas typically include urban and industrial areas not under control of the operator or occupier of the LNG facility.

The effects of overpressure due to an exploding cloud are covered in the subsection dealing with vapour cloud explosions (VCEs).

A flash fire would extend to the lower flammable limit; however, due to the formation of pockets, it could extend beyond this limit to the point defined as the ½ LFL. It is assumed that people within the flash fire would experience lethal injuries while people outside of the flash fire would remain unharmed. The ½ LFL is used for emergency planning to evacuate people to a safe distance in the event of a release.

Explosions

An explosion may give rise to any of the following effects:

- Blast damage;
- Thermal damage;
- Missile damage;
- Ground tremors;
- Crater formation;
- Personal injury.

Obviously, the nature of these effects depends on the pressure waves and the proximity to the actual explosion. Of concern in this investigation are the 'far distance' effects, such as limited structural damage and the breakage of windows, rather than crater formations.

Table 3- and Table 3- give a more detailed summary of the damage produced by an explosion due to various overpressures.

CPR 18E (1999) suggests the following overpressures be determined:

- 0.03 bar overpressure, corresponding to the critical overpressure causing windows to break;
- 0.1 bar overpressure, corresponding to 10% of the houses being severely damaged and a probability of death indoors equal to 0.025 (no lethal effects are expected below 0.1 bar overpressure on unprotected people in the open);
- 0.3 bar overpressure, corresponding to structures being severely damaged and a probability of death equal to 1.0 for unprotected people in the open;
- 0.7 bar overpressure, corresponding to an almost entire destruction of buildings and 100% fatality for people in the open.

Vapour Cloud Explosions (VCEs)

A release of flammable material into the atmosphere could result in the formation of a flash fire, as described in the subsection on flash fires, or a vapour cloud explosion (VCE).

The concentration of the combustible component would decrease from the point of release to below the lower explosive limits (LEL), at which concentration the component can no longer ignite. The material contained in the vapour cloud between the higher explosive limits (HEL) and the lower explosive limit (LEL), if it ignites, could form a flash fire or a fireball. The sudden detonation of the explosive mass of material would cause overpressures that can result in injury or damage to property.

Table 3-8: Summary of consequences of blast overpressure (Clancey 1972)

Pressure (Gauge)		Damage
Psi	kPa	
0.02	0.138	Annoying noise (137 dB), if of low frequency (10 – 15 Hz)
0.03	0.207	Occasional breaking of large glass windows already under strain
0.04	0.276	Loud noise (143 dB); sonic boom glass failure
0.1	0.69	Breakage of small under strain windows
0.15	1.035	Typical pressure for glass failure
0.3	2.07	'Safe distance' (probability 0.95; no serious damage beyond this value); missile limit; some damage to house ceilings; 10% window glass broken
0.4	2.76	Limited minor structural damage
0.5–1.0	3.45–6.9	Large and small windows usually shattered; occasional damage to window frames
0.7	4.83	Minor damage to house structures
1.0	6.9	Partial demolition of houses, made uninhabitable
1.0–2.0	6.9–13.8	Corrugated asbestos shattered; corrugated steel or aluminium panels, fastenings fail, followed by buckling; wood panels (standard housing) fastenings fail, panels blown in
1.3	8.97	Steel frame of clad building slightly distorted
2.0	13.8	Partial collapse of walls and roofs of houses
2.0–3.0	13.8–20.7	Concrete or cinderblock walls (not reinforced) shattered
2.3	15.87	Lower limit of serious structural damage
2.5	17.25	50% destruction of brickwork of house
3.0	20.7	Heavy machines (1.4 t) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations
3.0–4.0	20.7–27.6	Frameless, self-framing steel panel building demolished
4.0	27.6	Cladding of light industrial buildings demolished
5.0	34.5	Wooden utilities poles (telegraph, etc.) snapped; tall hydraulic press (18 t) in building slightly damaged
5.0–7.0	34.5–48.3	Nearly complete destruction of houses
7.0	48.3	Loaded train wagons overturned
7.0–8.0	48.3–55.2	Brick panels (20 – 30 cm) not reinforced fail by shearing or flexure
9.0	62.1	Loaded train boxcars completely demolished
10.0	69.0	Probable total destruction buildings; heavy (3 t) machine tools moved and badly damaged; very heavy (12 000 lb. / 5443 kg) machine tools survived
300	2070	Limit of crater lip

Boiling Liquid Expanding Vapour Explosions (BLEVEs)

A boiling liquid expanding vapour explosion (BLEVE) can occur when a flame impinges on a pressure cylinder, particularly in the vapour space region where cooling by evaporation of the contained material does not occur. The cylinder shell would weaken and rupture with a total loss of the contents, and the issuing mass of material would burn as a massive fireball.

The major consequences of a BLEVE are the intense thermal radiation from the fireball, a blast wave and fragments from the shattered vessel. These fragments may be projected to considerable distances. Analyses of the travel range of fragment missiles from a number of BLEVEs suggest that the majority land within 700 m from the incident. A blast wave from a BLEVE is fairly localised but can cause significant damage to immediate equipment.

A BLEVE occurs sometime after the vessel has been engulfed in flames. Should an incident occur that could result in a BLEVE, people should be evacuated to beyond the 1% fatality line.

Table 3-9: Damage caused by overpressure effects of an explosion (Stephens 1970)

Equipment	Overpressure (psi)																								
	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	12	14	16	18	20
Control house steel roof	A	C	V				N																		
Control house concrete roof	A	E	P	D			N																		
Cooling tower	B			F			O																		
Tank: cone roof		D				K							U												
Instrument cubicle			A			LM						T													
Fire heater				G	I					T															
Reactor: chemical				A				I				P						T							
Filter				H					F									V			T				
Regenerator						I				IP					T										
Tank: floating roof						K							U												D
Reactor: cracking							I							I							T				
Pine supports							P					SO													
Utilities: gas meter									Q																
Utilities: electric transformer									H					I						T					
Electric motor										H								I							V
Blower										Q										T					
Fractionation column											R			T											
Pressure vessel horizontal												PI						T							
Utilities: gas regulator												I								MQ					
Extraction column													I							V	T				
Steam turbine															I						M	S			V
Heat exchanger															I			T							
Tank sphere																I						I	T		
Pressure vessel vertical																					I	T			
Pump																					I		Y		

A	Windows and gauges break
B	Louvers fall at 0.3–0.5 psi
C	Switchgear is damaged from roof collapse
D	Roof collapses
E	Instruments are damaged
F	Inner parts are damaged
G	Bracket cracks
H	Debris-missile damage occurs
I	Unit moves and pipes break
J	Bracing fails
K	Unit uplifts (half filled)
L	Power lines are severed
M	Controls are damaged
N	Block wall fails
O	Frame collapses
P	Frame deforms
Q	Case is damaged
R	Frame cracks
S	Piping breaks
T	Unit overturns or is destroyed
U	Unit uplifts (0.9 filled)
V	Unit moves on foundations

4. RISK ANALYSIS

4.1 Background

It is important to understand the difference between hazard and risk. A hazard is anything that has the potential to cause damage to life, property and the environment. Furthermore, it has constant parameters (of petrol, chlorine, ammonia, etc.) that pose the same hazard wherever present.

Risk, on the other hand, is the probability that a hazard will actually cause damage along with how severe that damage will be (consequence). Risk is therefore the probability that a hazard will manifest itself. For instance, the risks of a chemical accident or spill depends upon the amount present, the process the chemical is used in, the design and safety features of its container, the exposure, the prevailing environmental and weather conditions and so on.

Risk analysis consists of a judgement of probability based on local atmospheric conditions, generic failure rates and the severity of consequences, based on the best available technological information.

Risks form an inherent part of modern life. Some risks are readily accepted on a day-to-day basis, while certain hazards attract headlines even when the risk is much smaller, particularly in the field of environmental protection and health. For instance, the risk of one-in-ten-thousand chance of death per year associated with driving a car is acceptable to most people, whereas the much lower risks associated with nuclear facilities (one-in-ten-million chance of death per year) are deemed unacceptable.

A report by the British Parliamentary Office of Science and Technology (POST), titled 'Safety in Numbers? Risk Assessment and Environmental Protection', explains how public perception of risk is influenced by a number of factors in addition to the actual size of the risk. These factors were summarised as follows in Table 4-10.

Table 4-10: The influence of public perception of risk on the acceptance of that risk, based on the POST report

Control	People are more willing to accept risks they impose upon themselves or they consider to be 'natural' than to have risks imposed upon them
Dread and Scale of Impact	Fear is greatest where the consequences of a risk are likely to be catastrophic rather than spread over time
Familiarity	People appear more willing to accept risks that are familiar rather than new risks
Timing	Risks seem to be more acceptable if the consequences are immediate or short term, rather than if they are delayed (especially if they might affect future generations)
Social Amplification and Attenuation	Concern can be increased because of media coverage, graphic depiction of events or reduced by economic hardship
Trust	A key factor is how far the public trusts regulators, policy makers or industry; if these bodies are open and accountable (being honest as well as admitting mistakes and limitations and taking account of differing views without disregarding them as emotive or irrational), then the public is more likely consider them credible

A risk assessment should be seen as an important component of ongoing preventative actions, aimed at minimising or hopefully avoiding accidents. Reassessments of risk should therefore follow at regular intervals and after any changes that could alter the nature of the hazard, so contributing to the overall prevention programme and emergency response plan of the plant. Risks should be ranked in decreasing severity and the top risks reduced to acceptable levels.

Procedures for predictive hazard evaluation have been developed for the analysis of processes when evaluating very low probability accidents with very high consequences (for which there is little or no experience) as well as more likely releases with fewer consequences (for which there may be more information available). These address both the probability of an accident as well as the magnitude and nature of undesirable consequences of that accident. Risk is usually defined as some simple function of both the probability and consequence.

4.1.1 Predicted Risk

The physical and consequence modelling (Section 5) addresses the impact of a release of hazardous materials without taking into account the probability of occurrence. This merely illustrates the significance and the extent of the impact in the event of a release. Section 5 also contains an analysis of the possibility of cascading or knock-on effects due to incidents in the facility and the surrounding industries and suburbs. In Section 6 the likelihood of various incidents is assessed, the consequences calculated and finally the risk for the facility is determined.

Generic Equipment Failure Scenarios

In order to characterise the various failure events and assign a failure frequency, fault trees were constructed starting with a final event and working from the top down to define all initiating events and frequencies. The analysis was completed using published failure rate data. Equipment failures can occur in tanks, pipelines and other items handling hazardous materials. These failures may result in:

- Release of combustible, flammable and explosive materials with fires or explosions upon ignition;
- Release of toxic or asphyxiant materials.

Storage Tanks

Incidents involving storage tanks include catastrophic failure leading to product leakage into the bund and a possible bund fire. A tank-roof failure could result in a possible tank fire. A fracture of the tank nozzle or the transfer pipeline could also result in product leakage into the bund and a possible bund fire.

Typical failure frequencies for atmospheric tanks and pressure vessels are listed, respectively, in Table 4- 11 and Table 4-12.

Table 4-11: Failure frequencies for atmospheric tanks

Event	Leak Frequency (per item per year)
Small leaks	1×10^{-4}
Severe leaks	3×10^{-5}
Catastrophic failure	5×10^{-6}

Table 4-12: Failure frequencies for pressure vessels

Event	Failure Frequency (per item per year)
Small leaks	1×10^{-5}
Severe leaks	5×10^{-7}
Catastrophic failure	5×10^{-7}

Transport and Process Piping

Piping may fail as a result of corrosion, erosion, mechanical impact damage, pressure surge (water hammer) or operation outside the design limitations for pressure and temperature. Failures caused by corrosion and erosion usually result in small leaks, which are detected and corrected early. For significant failures, the leak duration may be from 10–30 minutes before detection.

The generic data for leak frequency for process piping is generally expressed in terms of the cumulative total failure rate per year for a 10 m section of pipe and each pipe diameter. Furthermore, the failure frequency normally decreases with increasing pipe diameter. The scenarios and failure frequencies for a pipeline apply to pipelines with connections, such as flanges, welds and valves.

The failure data given in Table 4-13 represents the total failure rate, incorporating all failures of whatever size and due to all probable causes. These frequencies are based on an environment where no excessive vibration, corrosion, erosion or thermal cyclic stresses are expected. For potential risk causing significant leaks (e.g. corrosion) the failure rate will be increased by a factor of 10.

Table 4-13: Failure frequencies for process pipes

Description	Frequencies of Loss of Containment for Process Pipes (per meter per year)	
	Full Bore Rupture	Leak
Nominal diameter < 75 mm	1×10^{-6}	5×10^{-6}
75 mm < nominal diameter < 150 mm	3×10^{-7}	2×10^{-6}
Nominal diameter > 150 mm	1×10^{-7}	5×10^{-7}

For scenarios and failure frequencies no distinction is made between process pipes and transport pipes, the materials from which a pipeline is made, the presence of cladding, the design pressure of a pipeline or its location on a pipe bridge. However, a distinction is made between aboveground pipes and underground pipes. The scenarios for aboveground pipes are given in Table 4-14 and those for underground pipes are given in Table 4-15.

Transport pipelines aboveground can be compared, under certain conditions, with underground pipes in a pipe bay. The necessary conditions for this are external damage being excluded, few to no flanges and accessories present and the pipe is clearly marked. In very specific situations the use of a lower failure frequency for transport pipes aboveground can be justified.

Table 4-14: Failure frequencies for aboveground transport pipelines

Description	Frequency (per meter per annum)		
	Nominal Diameter < 75 mm	75 mm > Nominal Diameter > 150 mm	Nominal Diameter > 150 mm
Full bore rupture	$1x10^{-6}$	$3x10^{-7}$	$1x10^{-7}$
Leak with an effective diameter of 10% of the nominal diameter, up to a maximum of 50 mm	$5x10^{-6}$	$2x10^{-6}$	$5x10^{-7}$

Table 4-15: Failure frequencies for underground transport pipelines

Description	Frequency (per meter per annum)		
	Pipeline in Pipe Lane[5]	Pipeline Complies with NEN 3650	Other Pipelines
Full bore rupture	$7x10^{-9}$	$1.525x10^{-7}$	$5x10^{-7}$
Leak with an effective diameter of 20 mm	$6.3x10^{-8}$	$4.575x10^{-7}$	$1.5x10^{-6}$

Ignition Probability of Flammable Gases and Liquids

The estimation of the probability of an ignition is a key step in the assessment of risk for installations where flammable liquids or gases are stored. There is a reasonable amount of data available relating to characteristics of ignition sources and the effects of release type and location.
The probability of ignition for stationary installations is given in Table 4-16 (along with the classification of flammable substances in Table 4-17). These can be replaced with ignition probabilities related to the surrounding activities. For example, the probability of a fire from a flammable release at an open flame would increase to a value of 1.

Table 4-16: The probability of direct ignition for stationary installations (RIVM 2009)

Substance Category	Source-Term Continuous	Source-Term Instantaneous	Probability of Direct Ignition
Category 0 Average to high reactivity	< 10 kg/s 10 – 100 kg/s > 100 kg/s	< 1000 kg 1000 – 10 000 kg > 10 000 kg	0.2 0.5 0.7
Category 0 Low reactivity	< 10 kg/s 10 – 100 kg/s > 100 kg/s	< 1000 kg 1000 – 10 000 kg > 10 000 kg	0.02 0.04 0.09

5 A pipeline located in a 'lane' is a pipeline located in a group of pipelines on a dedicated route. Losses of containment frequencies for this situation are lower because of extra preventive measures.

Substance Category	Source-Term Continuous	Source-Term Instantaneous	Probability of Direct Ignition
Category 1	All flow rates	All quantities	0.065
Category 2	All flow rates	All quantities	0.0043[6]
Category 3 Category 4	All flow rates	All quantities	0

Table 4-17: Classification of flammable substances

Substance Category	Description	Limits
Category 0	Extremely flammable	Liquids, substances and preparations that have a flashpoint lower than 0°C and a boiling point (or the start of the boiling range) less than or equal to 35°C Gaseous substances and preparations that may ignite at normal temperature and pressure when exposed to air
Category 1	Highly flammable	Liquids, substances and preparations that have a flashpoint of below 21°C
Category 2	Flammable	Liquids, substances and preparations that have a flashpoint equal to 21°C and less than 55°C
Category 3		Liquids, substances and preparations that have a flashpoint greater than 55°C and less than or equal to 100°C
Category 4		Liquids, substances and preparations that have a flashpoint greater than 100°C

4.1.2 Risk Calculations

Maximum Individual Risk Parameter

Standard individual risk parameters include: average individual risk; weighted individual risk; maximum individual risk; and, the fatal accident rate. The latter parameter is more applicable to occupational exposures. Only the maximum individual risk (MIR) parameter will be used in this assessment. For this parameter the frequency of fatality is calculated for an individual who is presumed to be present at a specified location. This parameter (defined as the consequence of the event multiplied by the likelihood of the event) is not dependent on knowledge of the population at risk. So, it is an easier parameter to use in the predictive mode than the average individual risk and weighted individual risk. The unit of measure is risk of fatality per person per year.

6 This value is taken from the CPR 18E (1999). RIVM (2009) gives the value of delayed ignition as zero. RISCOM believes the CPR 18E is more appropriate for warmer climates and is a conservative value.

Acceptable Risks

The next step, after having characterised a risk and obtained a risk level, is to recommend whether the outcome is acceptable. In contrast to the employees in a plant, who may be assumed to be healthy, the adopted exposure assessment applies to an average population group that also includes sensitive subpopulations. Sensitive subpopulation groups are those people that for reasons of age or medical condition have a greater than normal response to contaminants. Health guidelines and standards used to establish risk normally incorporate safety factors that address this group.

Among the most difficult tasks of risk characterisation is the definition of acceptable risk. In an attempt to account for risks in a manner similar to those used in everyday life, the UK Health and Safety Executive (HSE) developed the risk ALARP triangle. Applying the triangle involves deciding:

- Whether a risk is so high that something must be done about it;
- Whether the risk is or has been made so small that no further precautions are necessary;
- If a risk falls between these two states that it has been reduced to levels as low as reasonably practicable (ALARP).

ALARP stands for 'as low as reasonably practicable' (Figure 4-10). As used in the UK, it is the region between that which is intolerable, at $1x10^{-4}$ per year, and that which is broadly acceptable, at $1x10^{-6}$ per year/ A further lower level of risk of $3x10^{-7}$ per year is applied to either vulnerable or very large populations for land-use planning.

Figure 4-10: UK HSE decision-making framework

Land Use Planning

South Africa does not have specific land use planning (LUP) criteria applicable to major hazard installations. Therefore, in the absence of local LUP criteria, reference is made to the criteria adopted in the UK and the Netherlands. In this instance, RISCOM would only advise on applicable land planning and would require governmental authorities to make final decisions.

The objectives of LUP controls should be based on the potential risk posed by industry on sensitive land uses. Planning guidelines need therefore to have the following objectives in common:

- To discourage inappropriate developments near potentially hazardous installations;
- To attempt to structure growth so that developments with small numbers of less vulnerable members of the public nearby the site are encouraged, while the largest developments involving the most vulnerable and sensitive members of the public are kept further away.

Development categories must represent the full range of different possible developments. This approach would therefore categorise developments according to several factors, which determine the appropriate risk level, such as:

- The inherent vulnerability of the exposed population;
- The proportion of the time and individual spends at the development;
- The size of the facility, in terms of the number of people who may be present;
- Whether they are likely to be indoors or out of doors and, if out of doors, how easily they would be able to seek shelter;
- The ease of evacuation or other emergency measures;
- The construction of the building and the protection available to the harmful agent.

Land development restrictions can be seen as passive mitigation against unnecessary exposure to hazards. This includes the establishment of buffer zones (or separation distances), orientation of buildings and the use of suitable building materials. Land development planning policies must achieve a number of desired outcomes, including the protection of the amenity of residential areas (and other public areas) and the unhindered operation of businesses in industrial and commercial areas.

The land zoning applied in this study follows the HSE (UK) approach of defining the area into three zones, consistent to the ALARP approach (HSE 2011).

The three zones are defined as follows: the inner zone (greater than 1×10^{-5} fatalities per person per year); the middle zone (1×10^{-5} fatalities per person per year to 1×10^{-6} fatalities per person per year); and, the outer zone (1×10^{-6} fatalities per person per year to 3×10^{-7} fatalities per person per year). The risks decrease from the inner zone to the outer zone as shown in Figure 4-11 and Figure 4-12.

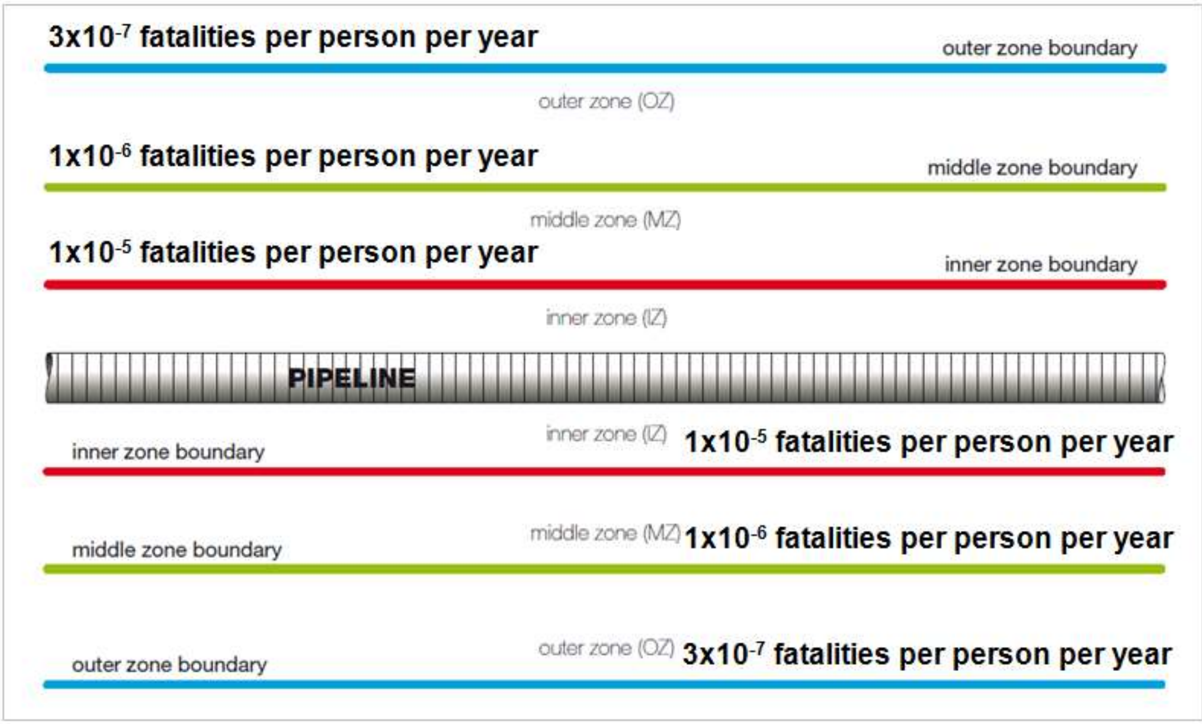


Figure 4-11: Town-planning zones for pipelines

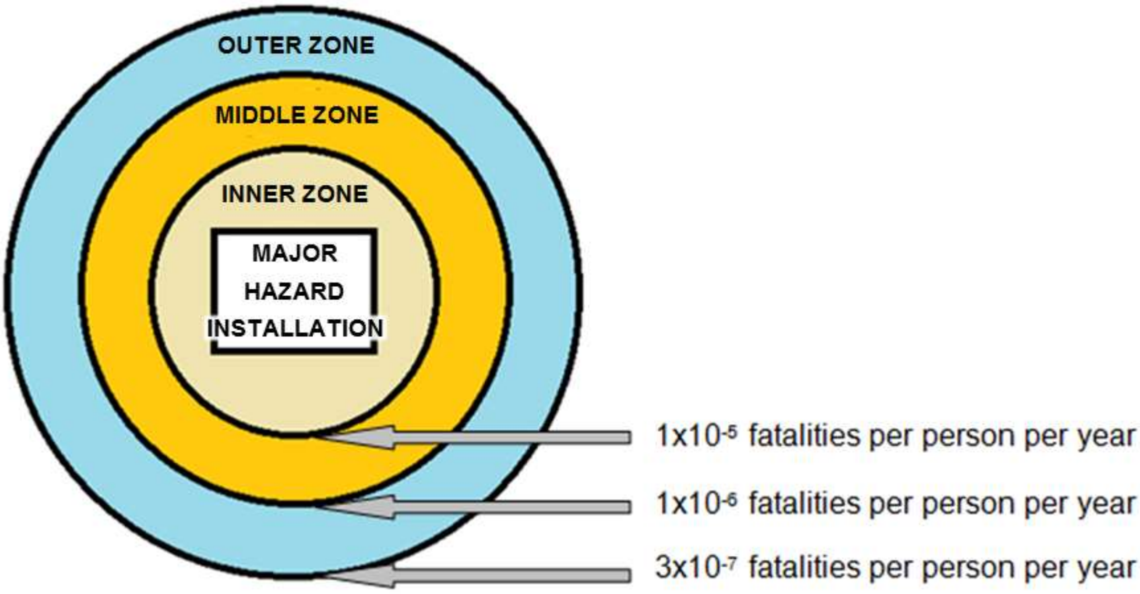


Figure 4-12: Town-planning zones

Once the zones are calculated, the HSE (UK) methodology then determines whether a development in a zone should be categorised as 'advised against' (AA) or as 'don't advise against' (DAA), depending on the sensitivity of the development, as indicated in Table 4-18. There are no land-planning restrictions beyond the outer zone.

Table 4-18: Land-use decision matrix

Level of Sensitivity	Development in Inner Zone	Development in Middle Zone	Development in Outer Zone
1	DAA	DAA	DAA
2	AA	DAA	DAA
3	AA	AA	DAA
4	AA	AA	AA

The sensitivity levels are based on a clear rationale, progressively more severe restrictions are to be imposed as the sensitivity of the proposed development increases.

There are four sensitivity levels, with the sensitivity for housing defined as follows:

- Level 1: based on workers who have been advised of the hazards and trained accordingly;
- Level 2: based on the general public at home and involved in normal activities;
- Level 3: based on the vulnerability of members of the public (e.g. children, those with mobility difficulties or those unable to recognise physical danger);
- Level 4: large examples of Level 2 and of Level 3.

Refer to Section 5 for detailed planning advice for developments near hazardous installations (PADHI) tables. These tables illustrate how the HSE land-use decision matrix, generated using the three zones and the four sensitivity levels, is applied to a variety of development types.

4.1.3 Land based receiving terminal - Consequence Modelling

4.1.3.1 Pool Fires

LNG Ship

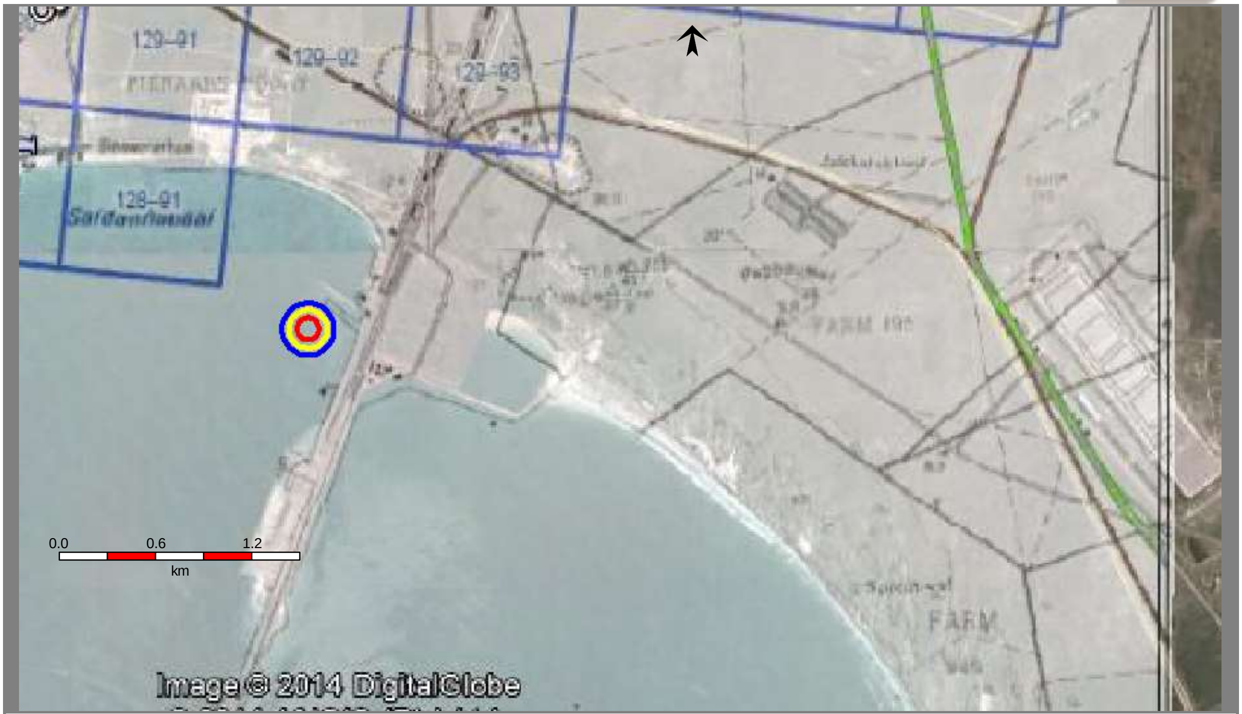
The LNG ship would berth at Saldanha Bay before offloading the LNG to the onshore terminal. It is assumed that the loss of containment of LNG would be at the berthing position.

The potential amount of released material that should be considered as a result of a collision is 126 m^3 in 1800 seconds for a large release (RIVM 2009).

The thermal radiation isopleths from a potential LNG fire from a loss of containment at the berthed ship, at an assumed offloading point, is shown in Figure 4-13.

The 4 kW/m^2 represents the thermal radiation flux people can be exposed for 20 seconds without serious effects. This is usually used for emergency planning. The 10 kW/m^2 represents a 1% fatality while the 35 kW/m2 represents a 100% fatality and the lower limit for steel damage.

The maximum distance to the 1% fatality represented by the 10 kW/m^2 would be 114 m under strong wind conditions.



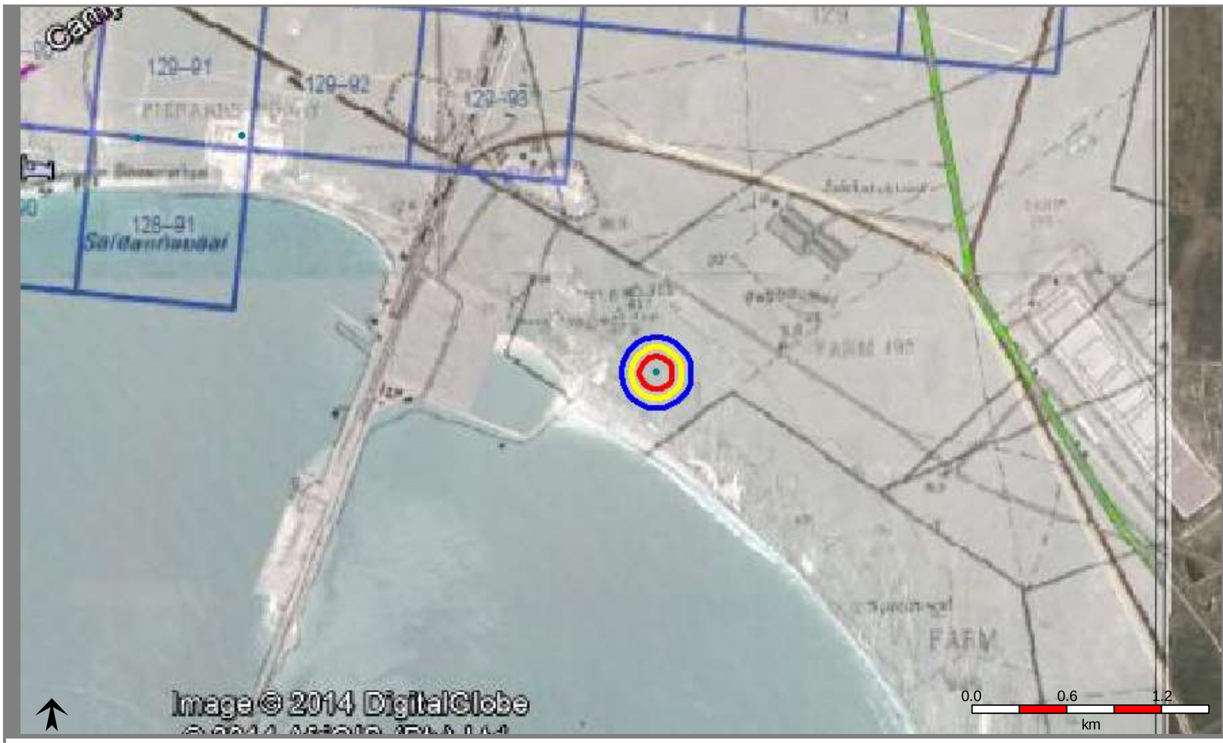
LEGEND	THERMAL RADIATION (kW/m²)
blue line	4
yellow line	10
red line	35

Figure 4-13: Thermal radiation from large LNG pool fires from an assumed offloading point

Onshore Terminal

The maximum effect of pool fires is shown in Figure 4-14. In this instance, the spilt material was assumed to spread evenly to a maximum area of 1500 m^2 (RIVM 2009). The pool would shrink as the fuel is consumed during the fire.

The maximum distance to the 1% fatality represented by the 10 kW/m^2 would be 160 m under strong wind conditions.



LEGEND	THERMAL RADIATION (kW/m^2)
blue line	4
yellow line	10
red line	35

Figure 4-14: Thermal radiation from large LNG pool fires for one of the onshore siting options

Onshore Pipeline

LNG from the ship would be transported to the onshore terminal via a pipeline. A pipeline failure during delivery of LNG would form a pool that would be limited by natural barriers. The maximum pool size is limited to 3000 m^3 (RIVM 2009).

The maximum thermal radiation isopleths from a large pool fire are shown in Figure 4-15. The 10 kW/m2 radius representing 1 % fatality could extend to a maximum distance of 209 m from the centre of the point of release

LEGEND	THERMAL RADIATION (kW/m^2)
blue line	4
yellow line	10
red line	35

Figure 4-15: Thermal radiation from large LNG pool fires for a loss of containment of the pipeline at a single point

4.1.3.2 Jet Fires

A release of CNG under pressure could result in a jet fire. The simulations assume the jet fire to be in the worst orientation i.e. horizontal for pipelines aboveground and vertical for underground pipelines. The most significant scenarios are described in the following subsections.

Full-Bore Pipeline Failure

It is assumed that the facility would have a number of compressors with a combined capacity of $1.7x10^6$ t per annum or 54 kg/s. The outlet from the compressors would be combined into the transmission pipeline at 120 bar. The worst-case release orientation would be in the horizontal plane producing a flame length of 96 m in still air. The edge of the flame would have over 296 kW/m^2 of thermal radiation and could cause severe damage to equipment within a short time as well as result in fatalities within a short distance from the flame. Figure 4-16 gives the thermal radiation from a full-bore rupture of the pipeline, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance.

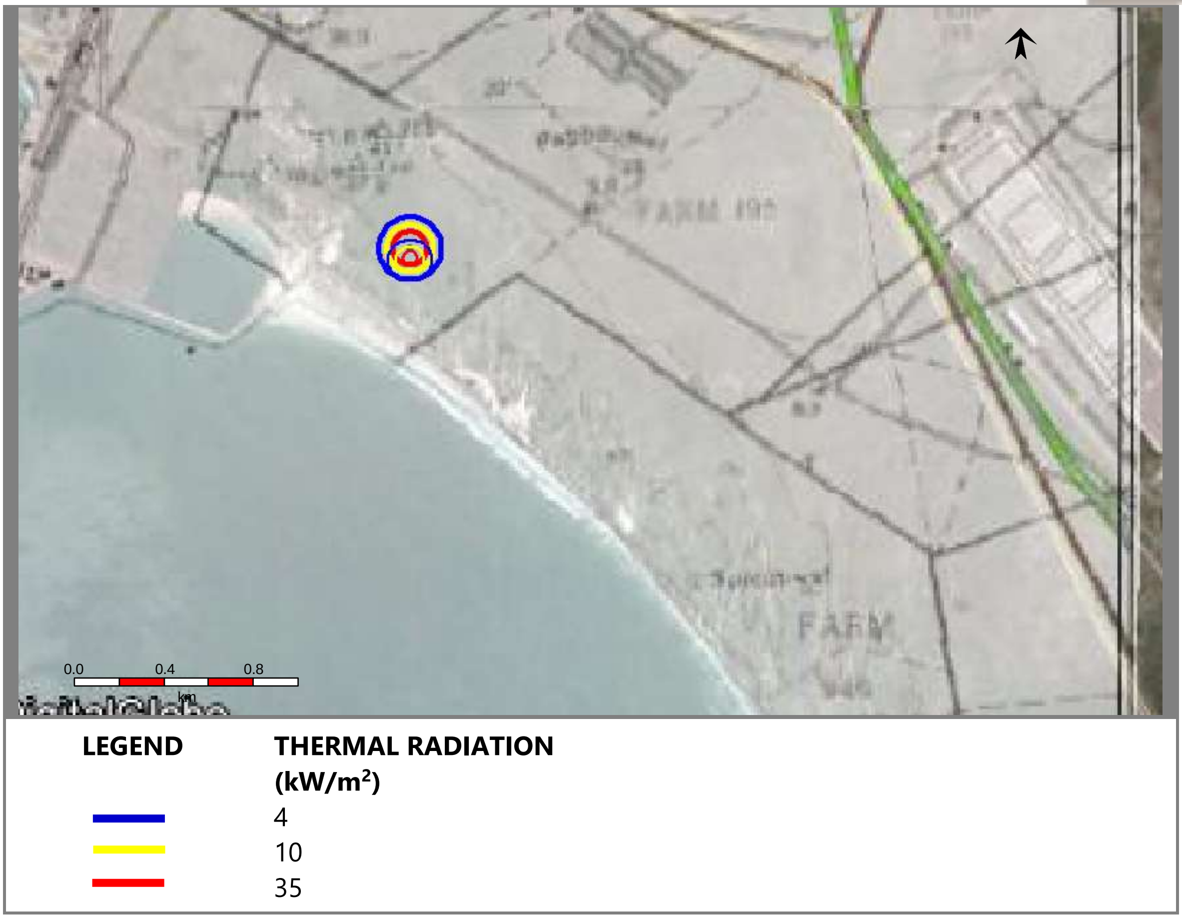


Figure 4-16: Thermal radiation from large CNG jet fires for one of the onshore siting options

An accidental jet fire from the CNG gas pipeline could have substantial reach and, depending on the orientation, on point of release and on the layout, could damage the LNG storage tanks with knock-on effects.

4.1.3.3 Flash Fires

LNG Ship

The maximum extent of a flash fire from a LNG ship release onto the sea was estimated to be 360 m under calm conditions at a low wind speed.

Pipeline

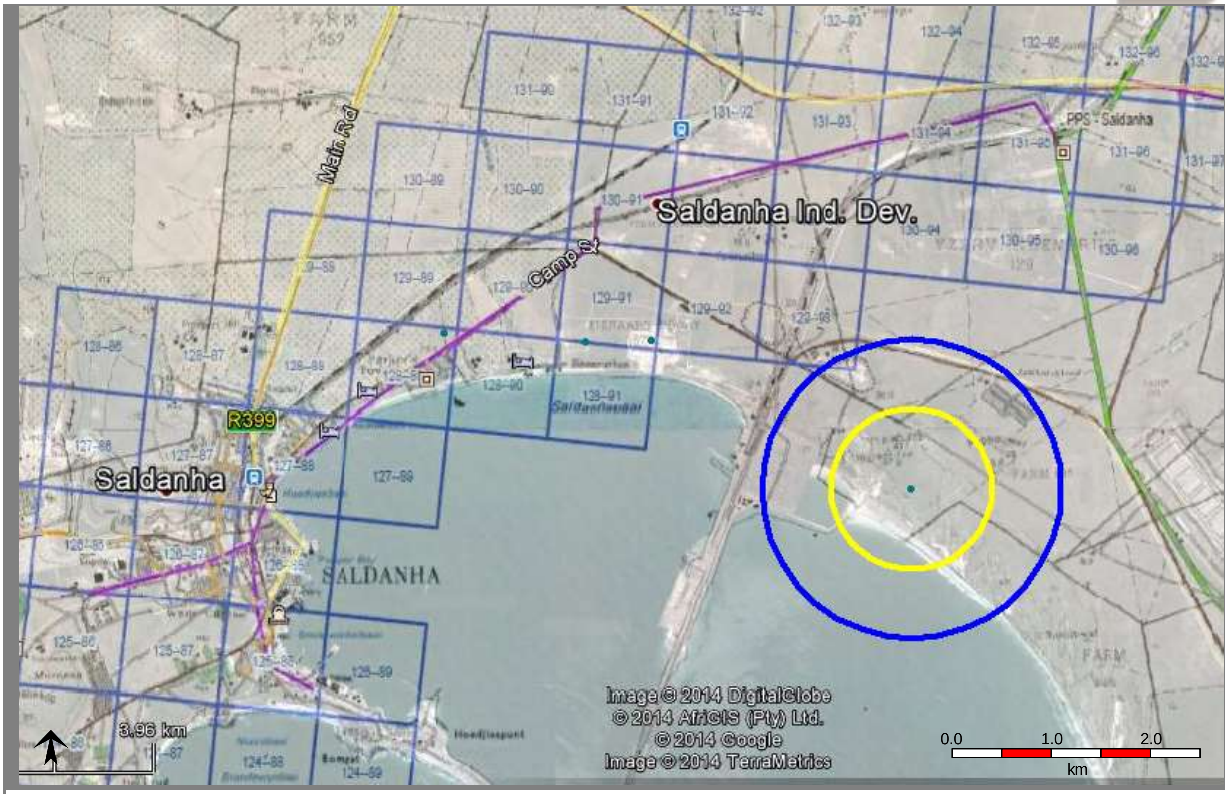
The extent of a flash fire, represented by the LFL, from a large pipeline failure is shown in Figure 4-17 and could extend 476 m downwind of a release.

LEGEND	THERMAL RADIATION (kW/m^2)
(blue line)	½ LFL
(yellow line)	LFL

Figure 4-17: The extent of a LNG flash fire following a large pipeline failure at a single point

Onshore LNG Terminal

In the event of a large release of LNG, a flash fire could extend to the LFL that under low wind speeds could reach 800 m downwind of the release. The extent of the flash fire, represented by the LFL, is shown in Figure 4-18.



LEGEND	THERMAL RADIATION (kW/m^2)
Blue line	½ LFL
Yellow line	LFL

Figure 4-18: The extent of a flash fire from large LNG flash fires for one of the onshore siting options

4.1.3.4 Vapour Cloud Explosions

A loss of containment of LNG with an ignition source could form a flash fire or a vapour cloud explosion. On release, the vapours could drift to an ignition point before detonating, forming a 'late explosion'.

LNG Ship

The maximum extent of a vapour cloud explosion, to the 1% fatality, from a LNG ship release onto the sea was estimated to be 537 m under calm conditions at a low wind speed.

Pipeline

The extent of a vapour cloud explosion from a loss of containment of the LNG pipeline is shown in Figure 4-19 and could extend a maximum 630 m downwind of the release to the 1% fatality represented by the 0.1 bar overpressure.

LEGEND	BLAST OVERPRESSURE (bar)
Blue line	0.03
Yellow line	0.1
Red line	0.3
Green line	0.7

Figure 4-19: Blast overpressures from LNG vapour cloud explosions following a large release from the pipeline

Onshore LNG Terminal

The maximum distances predicted for vapour cloud explosions, are shown in Figure 4-20. The thin lines indicate the overpressures due to vapours drifting from a northerly wind, while the thicker lines show the effect zone due to drifting clouds from all wind directions.

The maximum downwind distance to minor damage was estimated at 1.2 km downwind of the release.

LEGEND	BLAST OVERPRESSURE (bar)
Blue line	0.03
Yellow line	0.1
Red line	0.3
Green line	0.7

Figure 4-20: Blast overpressures from large LNG vapour cloud explosions for one of the onshore siting options

4.1.4 Offshore Terminal - Consequence Modelling

A loss of containment of LNG could occur due to the following reasons:

- Failure of the LNG tanks;
- Failure of FSRU structure;
- Collision with the supply LNG tanker;
- Collision with other ships;
- Failure of the ship transfer pipeline;
- Failure of the regasification units;
- Failure of mooring and drifting of FSRU to shore;
- Bad weather.

A loss of containment of CNG could occur due to the following reasons:

- Pipeline damage from ship anchors;
- Compressor failure.

The potential amount of released material that should be considered as a result of a collision is 126 m^3 in 1800 seconds for a large release (RIVM 2009).

For the filling hose, the material that would be spilt would be equal to a full-bore rupture of the hose (RIVM 2009) that would be equal to 125 000 m^3 in 30 hours.

Pool Fires

Thermal radiation of 10 kW/m^2 represents the 1% fatality for people due to an exposure of 20 seconds. It is also the lower limit of plastic failure and ignition of wood and vegetation. The expected 10 kW/m^2 thermal radiation from LNG pool fires on the ocean are shown in Figure 4-21 and extend to a maximum distance of 366 m with a full-bore failure of the delivery hose.

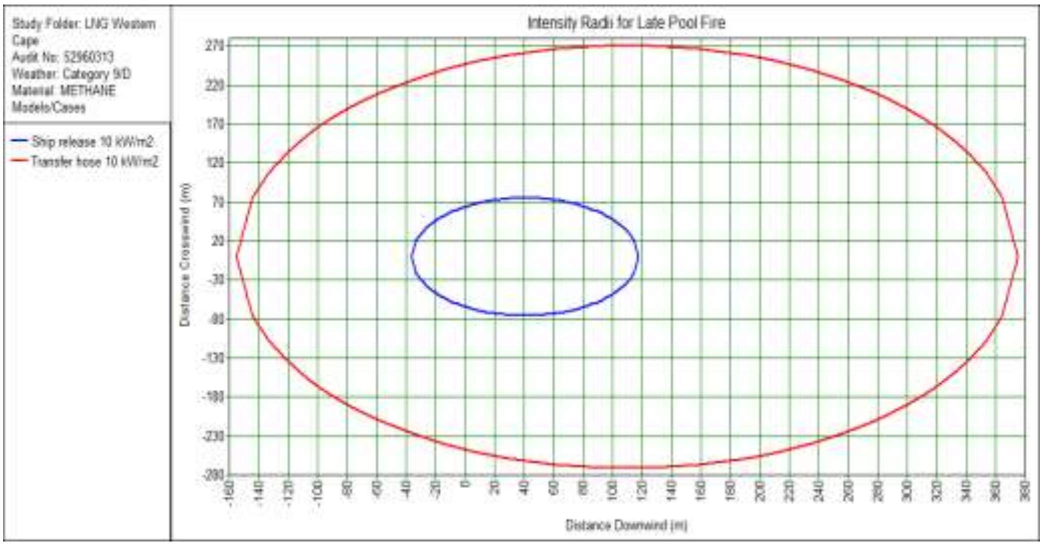


Figure 4-21: Expected distance to the 10 kW/m^2 thermal radiation for worst-case pool fire

Jet Fires

A release of CNG under pressure could result in a jet fire. The simulations assume the jet fire to be in the worst orientation i.e. horizontal for pipelines aboveground and vertical for underground pipelines. The most significant scenario is described in the following subsection.

Full-Bore Pipeline Failure (On Ship)

It is assumed that the ship would have a number of compressors with a combined capacity of 1.7x10^6 t per annum or 54 kg/s. The outlet from the compressors would be combined into the shore-bound transmission pipeline at 120 bar. The worst-case release orientation would be in the horizontal plane producing a flame length of 96 m in still air. The edge of the flame would have over 296 kW/m^2 of thermal radiation and could cause severe damage to equipment within a short time as well as result in fatalities within a short distance from the flame. Figure 4-22 gives the thermal radiation from a full-bore rupture of the pipeline, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance.

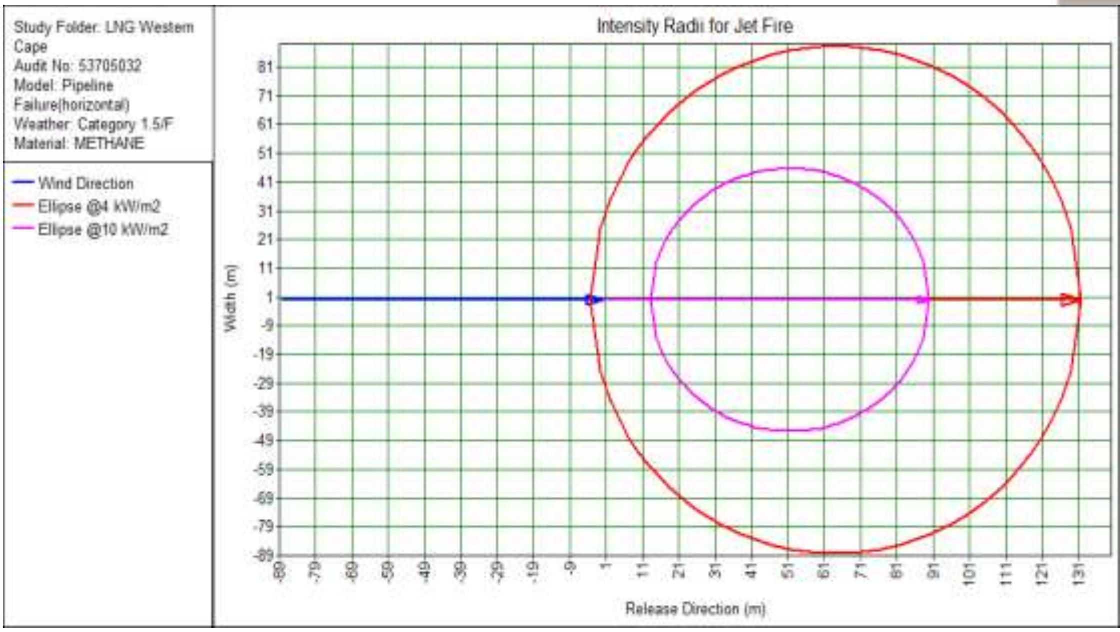


Figure 4-22: Thermal radiation from a jet fire due to a full-bore CNG gas pipeline rupture at 1.0 m above the sea level

An accidental jet fire from the CNG gas pipeline on the ship could have substantial reach and depending on the orientation and point of release. It is assumed that the ship designers would make provision to prevent ship damage from a jet fire. Furthermore, 80 m distance between the loading LNG tanker and the FSRU would be adequate.

Flash Fires

Releases from high pressure CNG pipelines produce a high momentum jet with no significant flash fires. However, the release of LNG onto the ocean surface would produce flash fires, as shown in Figure 4-23 indicated by the LFL..

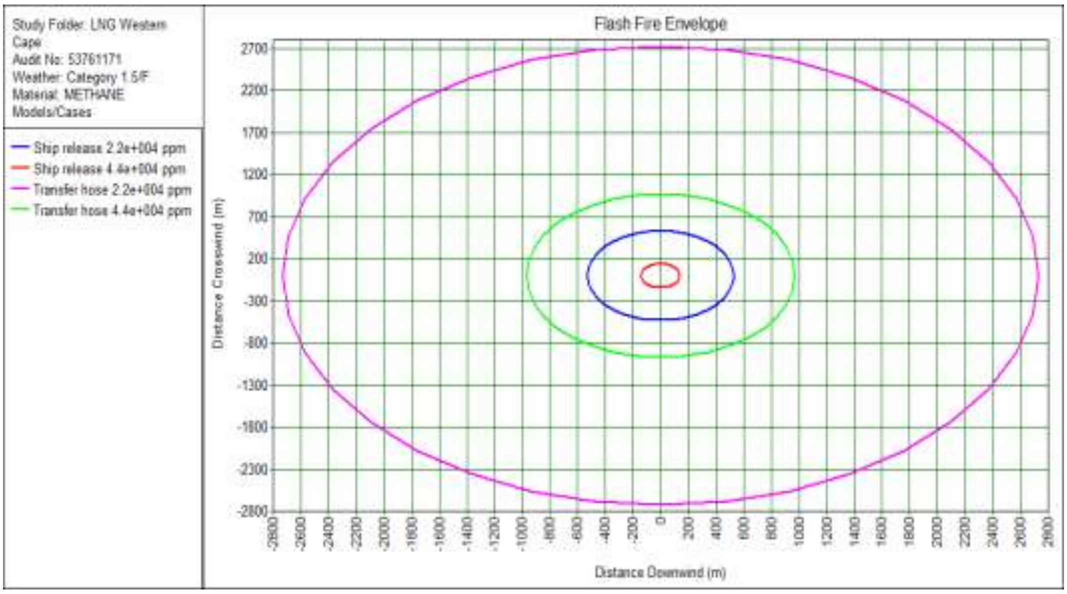


Figure 4-23: The extent of flash fires from LNG releases

Vapour Cloud Explosions

A loss of containment of LNG on the ocean surface with an ignition source could form a flash fire or a vapour cloud explosion. Figure 4-24 indicates the off-site blast overpressures of 0.1 bar from the release of flammable vapours demonstrated in loss of containment scenarios in worst-case meteorological conditions. In these scenarios, the vapours could drift to an ignition point before detonating. This is referred to as a 'late explosion'.

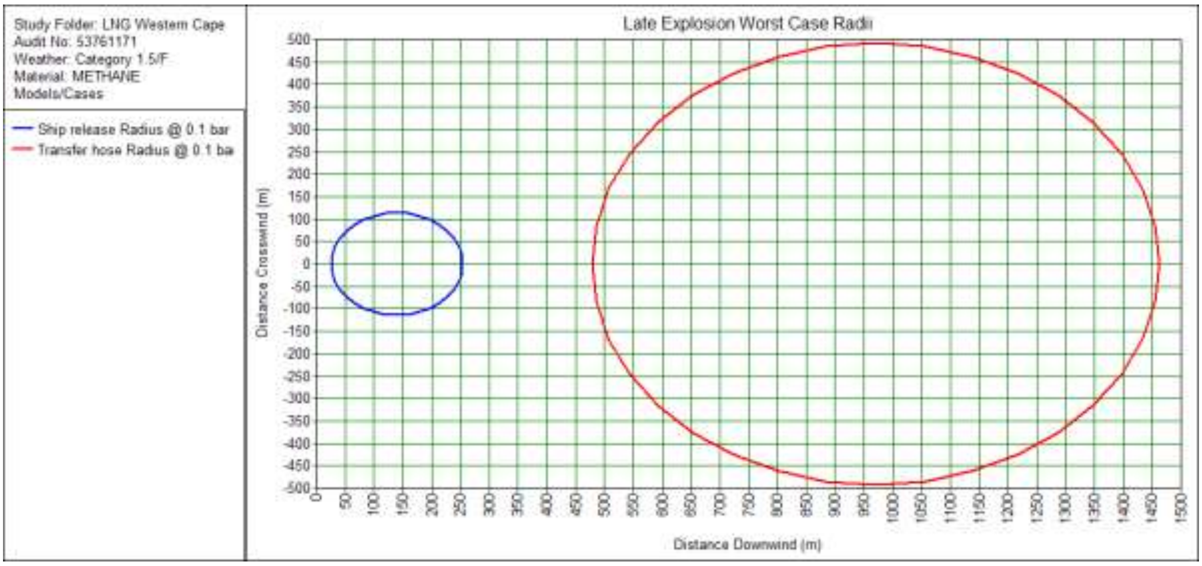


Figure 4-24: Blast overpressures of 0.1 bar from overpressure from LNG releases

In the case where the FSRU would be stationed outside of the Port of Saldanha Bay, risk analysis would be completed using a general basic failure frequency for accidents. This is equal to:

$$6.7 \times 10^{-11} \times T \times t \times N$$

Where T is the total number of ships per annum on the transport route or in the port
t is the average loading time for each ship (in hours)
N is the number of loading operations per annum

Outside of the Saldanha Bay port the basic frequency for accidents would be 3.22×10^{-6} per annum.

Where T = 40 ships per annum
t = 30 hours
N = 40 per annum

4.1.5 Transmission and Distribution Pipelines

Pipeline Failures

- **Wall Thickness**

It is a requirement of the American Society of Mechanical Engineers ASME B31.8 code to increase the strength of the pipeline (related to wall thickness) in areas of high existing and projected population density. Population density is a reasonable index of the possible consequences of a fire or explosion; in densely populated downtown areas, for example, the consequences of a pipeline failure would be significantly greater than in suburban, peri-urban or rural areas.

The ASME B31.8 standard (2010) uses four location classes, based on a population density index. For each location class, the design factor (safety factor) used for determining wall thickness varies.

Table 4.19 Class locations

(Source: ASME B31.8)

Class Location	Description	Design Factor
Class 1, Division 1	A Location Class 1 is any 1-mile (1.6-km) section that has 10 or fewer buildings intended for human occupancy. A Location Class 1 is intended to reflect areas such as wasteland, deserts, mountains, grazing land, farmland, and sparsely populated areas	0.80
Class 1, Division 2		0.72
Class 2	A Location Class 2 is any 1-mile (1.6-km) section that has more than 10 but fewer than 46 buildings intended for human occupancy. A Location Class 2 is intended to reflect areas such as fringe areas around cities and towns, industrial areas, ranch or country estates, etc.	0.60
Class 3	A Location Class 3 is any 1-mile (1.6-km) section that has 46 or more buildings intended for human occupancy except when a Location Class 4 prevails. A Location Class 3 is intended to reflect areas such as suburban housing developments, shopping centres, residential areas, industrial areas, and other populated areas not meeting Location Class 4 requirements	0.50
Class 4	Location Class 4 includes areas where multi-storey buildings are prevalent, where traffic is heavy or dense, and where there may be numerous other utilities underground. Multi-storey means four or more floors above ground including the first or ground floor. The depth of basements or number of basement floors is immaterial.	0.40

In addition to the above criteria the code gives consideration to the possible consequences of a failure near a concentration of people, such as found in churches, schools, multiple dwelling units, hospitals or recreational areas of an organised character in Class 1 or Class 2 locations. If the facility is used frequently, then Class 3 location standards are required. The concentrations of people referred to are not intended to include groups of fewer than 20 people per instance or location but are intended to cover people in outside areas as well as in buildings.

4.1.6 Transmission Pipelines - Consequence Modelling

While the transmission pipeline would have a defined maximum flow rate entering the pipeline defined by the capacity of the regasification units or the high pressure pumps, the transmission pipeline would have a maximum diameter of 509 mm and would extend some distance resulting in a relatively large inventory. In the event of a pipeline rupture, gas would escape at sonic velocity, referred to as choked flow, for some time until the release rate stabilises to the pumped rate. Therefore, this risk assessment evaluated the pipeline releases for a full-bore pipeline release at choked flow defined by the pressure of the material in the pipeline and diameter of the pipeline. While the choked flow rates may be considered conservative, they are still realistic as the choked flow rates exceed 20 seconds, whic**h is the time frame for thermal radiation fatality calculations.**

Jet Fires

A release of CNG from the transmission pipeline could result in a large jet fire with substantial length. Strong winds would tilt the flame, producing the highest thermal radiation effects at the representative height of 1.0 m aboveground.

Figure 4-25 indicates the thermal radiation from jet fires due to CNG releases. For 20 mm hole the thermal radiation of 10 kW/m^2, representing a 1% fatality, would extend about 20 m from the release. The 1% fatality due to a full-bore rupture could extend 380 m downwind of the release.

The 1% fatality would also correspond to the lower limit for ignition of vegetation. One could expect vegetation or bush fires to follow the release of jet fires.

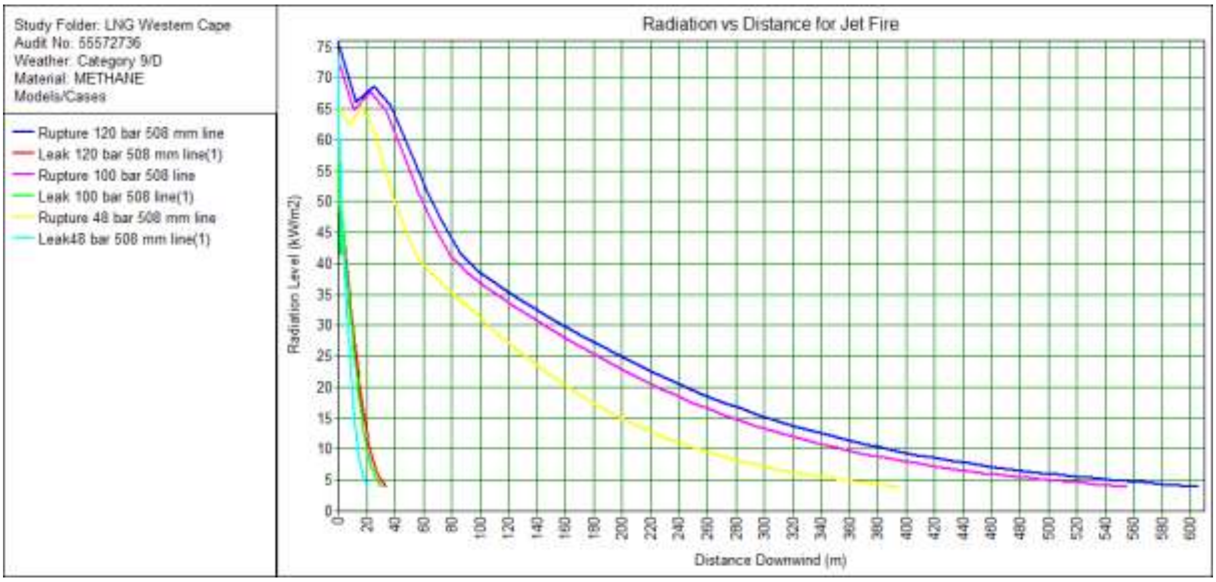


Figure 4-25: The extent of thermal radiation from transmission pipeline jet fires resulting from CNG releases

Flash Fires

A release of CNG from the transmission pipeline was assumed to be in the worst orientation i.e. vertical for an underground release. The momentum of the jet would result in a narrow flammable area close to the ground and would increase with the height of the jet. In a windless environment the jet would remain vertical. Increasing wind strength would tilt the flammable cloud downwind.

For full-bore ruptures, the flammable cloud could extend beyond 140 m aboveground but would be considerably lower for 20 mm holes. Due to the small size of a flash fire at the reference height of 1.0 m aboveground, flash fires would be limited with little injury beyond the flammable limits. Figure 4-26 shows the extent of flash fires limited to the LFL for releases at different pressures at a strong wind speed.

Figure 4-26: The extent of a flash fire due to a release of CNG from the transmission pipeline

Vapour Cloud Explosions

No hazards were predicted from vapour cloud explosions from CNG releases.

5. PADHI LAND-PLANNING TABLES

Development Type Table 1: People at Work, Parking

Development Type	**Examples**	**Development Detail and Size**	**Justification**
DT1.1 Workplaces	Offices, factories, warehouses, haulage depots, farm buildings, nonretail markets, builder's yards	Workplaces (predominantly nonretail), providing for less than 100 occupants in each building and less than 3 occupied storeys (Level 1)	Places where the occupants will be fit and healthy and could be organised easily for emergency action Members of the public will not be present or will be present in very small numbers and for a short time
	Exclusions		
		DT1.1 x1 Workplaces (predominantly nonretail) providing for 100 or more occupants in any building or 3 or more occupied storeys in height (Level 2 except where the development is at the major hazard site itself, where it remains Level 1)	Substantial increase in numbers at risk with no direct benefit from exposure to the risk
	Sheltered workshops, Remploy	DT1.1 x2 Workplaces (predominantly nonretail) specifically for	Those at risk may be especially vulnerable to injury from hazardous events

Development Type	Examples	Development Detail and Size	Justification
		people with disabilities (Level 3)	or they may not be able to be organised easily for emergency action
DT1.2 Parking Areas	Car parks, truck parks, lockup garages	Parking areas with no other associated facilities (other than toilets; Level 1)	
	Exclusions		
	Car parks with picnic areas or at a retail or leisure development or serving a park and ride interchange	DT1.2 x1 Where parking areas are associated with other facilities and developments the sensitivity level and the decision will be based on the facility or development	

Development Type Table 2: Developments for Use by the General Public

Development Type	Examples	Development Detail and Size	Justification
DT2.1 Housing	Houses, flats, retirement flats or bungalows, residential caravans, mobile homes	Developments up to and including 30 dwelling units and at a density of no more than 40 per hectare (Level 2)	Development where people live or are temporarily resident It may be difficult to organise people in the event of an emergency
	Exclusions		
	Infill, back-land development	DT2.1 x1 Developments of 1 or 2 dwelling units (Level 1)	Minimal increase in numbers at risk
	Larger housing developments	DT2.1 x2 Larger developments for more than 30 dwelling units (Level 3)	Substantial increase in numbers at risk
		DT2.1 x3 Any developments (for more than 2 dwelling units) at a density of more than 40 dwelling units per hectare (Level 3)	High-density developments
DT2.2 Hotel or Hostel or Holiday Accommodation	Hotels, motels, guest houses, hostels, youth hostels, holiday camps, holiday homes, halls of residence, dormitories, accommodation centres, holiday caravan sites, camping sites	Accommodation up to 100 beds or 33 caravan or tent pitches (Level 2)	Development where people are temporarily resident It may be difficult to organise people in the event of an emergency
	Exclusions		
	Smaller: guest houses, hostels, youth hostels, holiday homes, halls of	DT2.2 x1 Accommodation of less than 10 beds or 3 caravan or tent	Minimal increase in numbers at risk

	residence, dormitories, holiday caravan sites, camping sites	pitches (Level 1)	
	Larger: hotels, motels, hostels, youth hostels, holiday camps, holiday homes, halls of residence, dormitories, holiday caravan sites, camping sites	DT2.2 x2 Accommodation of more than 100 beds or 33 caravan or tent pitches (Level 3)	Substantial increase in numbers at risk
DT2.3 **Transport Links**	Motorway, dual carriageway	Major transport links in their own right i.e. not as an integral part of other developments (Level 2)	Prime purpose is as a transport link Potentially large numbers exposed to risk but exposure of an individual is only for a short period
	Exclusions		
	Estate roads, access roads	DT2.3 x1 Single carriageway roads (Level 1)	Minimal numbers present and mostly a small period of time exposed to risk Associated with other development
	Any railway or tram track	DT2.3 x2 Railways (Level 1)	Transient population, small period of time exposed to risk Periods of time with no population present

DT2.4 Indoor Use by Public	*Food and drink:* restaurants, cafes, drive-through fast food, pubs *Retail:* shops, petrol filling station (total floor space based on shop area not forecourt), vehicle dealers (total floor space based on showroom or sales building not outside display areas), retail warehouses, super-stores, small shopping centres, markets, financial and professional services to the public *Community and adult education*: libraries, art galleries, museums, exhibition halls, day surgeries, health centres, religious buildings, community centres. adult education, 6th form college, college of FE *Assembly and leisure*: Coach or bus or railway stations, ferry terminals, airports, cinemas, concert or bingo or dance halls, conference centres, sports or leisure centres, sports halls, facilities associated with golf courses, flying clubs (e.g. changing rooms, club house), indoor go kart tracks	Developments for use by the general public where total floor space is from 250 m^2 up to 5000 m^2 (Level 2)	Developments where members of the public will be present (but not resident) Emergency action may be difficult to coordinate
	Exclusions		
		DT2.4 x1 Development with less than 250 m^2 total floor space (Level 1)	Minimal increase in numbers at risk
		DT2.4 x2 Development with more than 5000 m^2 total floor space (Level 3)	Substantial increase in numbers at risk
DT2.5 Outdoor Use by Public	*Food and drink*: food festivals, picnic areas *Retail*: outdoor markets, car boot sales, funfairs *Community and adult education*: open-air theatres and exhibitions *Assembly and leisure*: coach or bus or railway stations, park and ride interchange,	Principally an outdoor development for use by the general public i.e. developments where people will predominantly be outdoors and not more than 100 people will gather at the facility at any one time (Level 2)	Developments where members of the public will be present (but not resident) either indoors or outdoors Emergency action may be difficult to coordinate

	ferry terminals, sports stadia, sports fields or pitches, funfairs, theme parks, viewing stands, marinas, playing fields, children's play areas, BMX or go kart tracks, country parks, nature reserves, picnic sites, marquees		
	Exclusions		
	Outdoor markets, car boot sales, funfairs picnic area, park and ride interchange, viewing stands, marquees	DT2.5 x1 Predominantly open-air developments likely to attract the general public in numbers greater than 100 people but up to 1000 at any one time (Level 3)	Substantial increase in numbers at risk and more vulnerable due to being outside
	Theme parks, funfairs, large sports stadia and events, open air markets, outdoor concerts, pop festivals	DT2.5 x2 Predominantly open-air developments likely to attract the general public in numbers greater than 1000 people at any one time (Level 4)	Very substantial increase in numbers at risk, more vulnerable due to being outside Emergency action may be difficult to coordinate

Development Type Table 3: Developments for Use by Vulnerable People

Development Type	Examples	Development Detail and Size	Justification
DT3.1 Institutional Accommodation and Education	Hospitals, convalescent homes, nursing homes, old people's homes with warden on site or 'on call', sheltered housing, nurseries, crèches, schools and academies for children up to school leaving age	Institutional, educational and special accommodation for vulnerable people or that provides a protective environment (Level 3)	Places providing an element of care or protection Because of age, infirmity or state of health the occupants may be especially vulnerable to injury from hazardous events Emergency action and evacuation may be very difficult
	Exclusions		
	Hospitals, convalescent homes, nursing homes, old people's homes, sheltered housing	DT3.1 x1 24-hour care where the site on the planning application being developed is larger than 0.25 hectare (Level 4)	Substantial increase in numbers of vulnerable people at risk
	Schools, nurseries, crèches	DT3.1 x2 Day care where the site on the planning application being developed is larger than 1.4 hectare (Level 4)	Substantial increase in numbers of vulnerable people at risk
DT3.2 Prisons	Prisons, remand centres	Secure accommodation for those sentenced by court, or awaiting trial, etc. (Level 3)	Places providing detention Emergency action and evacuation may be very difficult

Development Type Table 4: Very Large and Sensitive Developments

Development Type	Examples	Development Detail and Size	Justification
[Note: all Level 4 developments are by exception from Level 2 or 3 and are reproduced in this table for convenient reference]			
DT4.1 Institutional Accommodation	Hospitals, convalescent homes, nursing homes, old people's homes, sheltered housing	Large developments of institutional and special accommodation for vulnerable people (or that provide a protective environment) where 24-hour care is provided and where the site on the planning application being developed is larger than 0.25 hectare (Level 4)	Places providing an element of care or protection Because of age or state of health the occupants may be especially vulnerable to injury from hazardous events Emergency action and evacuation may be very difficult The risk to an individual may be small but there is a larger societal concern
	Nurseries, crèches, schools for children up to school leaving age	Large developments of institutional and special accommodation for vulnerable people (or that provide a protective environment) where day care (not 24-hour care) is provided and where the site on the planning application being developed is larger than 1.4 hectare (Level 4)	Places providing an element of care or protection Because of a the occupants may be especially vulnerable to injury from hazardous events Emergency action and evacuation may be very difficult The risk to an individual may be small but there is a larger societal concern
DT4.2 Very Large Outdoor Use by Public	Theme parks, large sports stadia and events, open air markets, outdoor concerts, pop festivals	Predominantly open air developments where there could be more than 1000 people present (Level 4)	People in the open air may be more exposed to toxic fumes and thermal radiation than if they were in buildings Large numbers make emergency action and evacuation difficult The risk to an individual may be small but there is a larger societal concern

APPENDIX 3: WORKSHOP MEETING NOTES

Environmental Screening Study for the Importation of LNG into the Western Cape

Workshop with key authorities and organs of state

Purpose: Consultation with key authorities and other organs of state with decision-making responsibilities with regards to this project, in order to identify key issues.

Date: 9 June 2014
Venue: Mountain View Seminar Room, CSIR Stellenbsoch.

2 LIST OF ATTENDEES

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1. WELCOME AND INTRODUCTION

Annick Walsdorff welcomes all the attendees, who briefly introduce themselves. The aim of the workshop is to identify key issues with regards to the importation of Liquefied Natural Gas (LNG) into the Western Cape.

2. LNG INITIATIVE AND CAPE-WEST COAST GAS DEVELOPMENT (JIM PETRIE – DEDAT)

Jim Petrie delivers a presentation on the LNG initiative driven by the Western Cape Government. The west coast of South Africa provides opportunities for the importation of LNG for both domestic and industrial applications. This "west coast gas opportunity" has been promoted as one of the priorities from the Gas Utilisation Master Plan (GUMP). GUMP is a joint effort between National Treasury and the Department of Energy (DoE), whilst National Government carries the energy mandate. GUMP considers the national market opportunity for gas importation in the entire South Africa, as well as where gas may be acquired and what the physical infrastructure needs are to drive the gas initiative forward.

A pre-feasibility study for the importation of LNG into the Western Cape delivered desirable results in terms of infrastructural-, market related- and socio-economic opportunities:

- Economic incentives pertaining to servicing existing market demand.
- Supply of gas to Ankerlig power station in Atlantis.
- Transportation sector.
- Industrial hubs in and around Cape Town to convert to gas instead of coal or diesel (also relates to climate change alleviation).
- Port industries in Saldahna Bay Port.
- Supply of LNG to other SADC (Southern African Development Community) nations, thus trading gas at a regional level.

There are currently two options for the delivery of LNG into the Western Cape:

Offshore Floating Storage and Regasification Unit (FSRU)
This option requires no onshore storage and is a quicker technical solution; however ocean conditions may be a constraint.

Onshore LNG storage and regasification facility
This option requires a jetty with a land-based facility for the storage and regasification of the LNG.

The land-based option requires approximately double the total capital than a FSRU. However, the FSRU has nearly double the operational costs. It is therefore important to take into account cumulative economic, social and environmental impacts, as well as the time-frame / life cycle of the project. Furthermore, the cost and selling price of gas is also a key driver for the viability of importation of LNG into the Western Cape.

- **Paul Hardcastle (DEADP):** Does the possibility of indigenous gas (shale gas), which may take another 10 years before it is realised, influence the options (FSRU or onshore facility) that will be considered?

  - **Jim Petrie (DEDAT):** Even if shale gas is available within a short timespan there will still be a shortage of and a need for gas infrastructure (terminal, transmission and distribution pipelines) in South Africa, especially in the Western Cape. If indigenous gas becomes available it will be possible to downscale gas imports and use existing infrastructure for available indigenous gas, thus moving from gas importation to local resources.
- **Paul Hardcastle (DEADP):** Does the possibility of indigenous shale gas favour one of the options (FSRU or onshore facility)?
  - **Jim Petrie (DEDAT):** If shale gas comes from the Karoo, an onshore option would be preferable. However, the market demand is not going to be in the Karoo or Beaufort West where the gas is extracted. There might be a gas power station, but the rest will be transported to the coastal areas.
  - **Johan Visagie (Energy Business):** If large volumes of shale gas are discovered, an importation terminal may be converted into an exportation terminal. In the case of a floating option all the chartered vessels can be redeployed to, for example Coega or wherever there is a need to establish a market demand at the time, realising into a permanent facility.

- **Ryan Lewis (Transnet Group Planning):** Is there a certain level of confidence in the offshore option as being a preferred potential solution?
  - **Jim Petrie (DEDAT):** Apart from the terrestrial Environmental Screening Study (ESS) that CSIR is conducting, the CSIR Marine division is also conducting a study of the metocean conditions both along the coast and within the Port of Saldanha so that the offshore floating options can be verified as viable with a higher level of confidence.

- **Carlo Matthysen (PetroSA):** PetroSA has been looking at LNG importation since 2008. Detailed feasibility studies have been conducted looking at a variety of configurations, locations and technologies. Currently there is a waiting period for coming into alignment with GUMP, which will hopefully assist with the way forward regarding gas related projects.

3. ENVIRONMENTAL SCREENING STUDY (ESS) (ANNICK WALSDORFF – CSIR)

Annick Walsdorff presents on the ESS that is being conducted for the importation of LNG into the Western Cape. The main objective of ESSs is to identify key environmental and safety risks, as well as opportunities and constraints that are mapped at a high level.

For this study three potential onshore locations were considered within Saldanha Bay, two of which is situated in National Defence Force land, and one situated within the Port of Saldanha in an area allocated to bulk liquid oil and gas activities by TNPA. Furthermore, three offshore FSRU options were considered: i) within the Port of Saldanha, where dredging may be required; ii) along the coast between Robben Island and Dassen Island; and iii) along the coast at St. Helena Bay between Baboon Point and Bakkies se Bank.

- **Pat Morant (CSIR):** Regarding the St. Helena Bay FSRU option, a Single-Point-Mooring system (SPM) was investigated for crude oil vessels approximately five years ago. To acquire the appropriate depth without dredging the ships had to moor about 5 km offshore. In summer times this option was very viable with very little down-time, however during the winter North-Western wind was posing a challenge for the vessels, thus creating greater down-time.

- **Selvan Pillay (TNPA):** What are depth requirements for the FSRU options?
  - **Mathabo Masegeba (CSIR):** Within the port a depth of 30 m would be ideal. If no such depth is available, dredging should be localised to the location of the turret.

- **Johan Visagie (Energy Business):** The FSRU corrects to either a turret mooring system (requiring approximately 30 – 50 m of water depth) or to an anchored submerge floating buoy (requiring approximately 30 m of water depth). For this study a Tandem mooring system in being considered where both the FSRU and the shuttle tanker will be able to moor at the same point. Side-by-side offloading has a wave limit of 2.5 m, whilst Tandem mooring can tolerate up to 5.5 m waves, and gas can be transferred to shore at wave height of 12.5 m. Previous studies have indicated 95 – 98% up-time (time when wave conditions are favourable and the vessels are operational).

- **Paul Hardcastle (DEADP):** The results from the PetroSA study for the viability of LNG importation in the Southern Cape indicated that the offshore conditions rendered floating options for the project not viable, but the current findings are indicating that a possible opportunity exists. Why is there a significant difference between the findings?
  - **Carlo Matthysen (PetroSA):** PetroSA had a feasibility study conducted in Mossel Bay with the main focus to transfer the gas to the PetroSA Gas-to-Liquids (GTL) refinery. The engineering contractor suggested that a land-based terminal in Mossel Bay was the preferred option, but due to land availability, steep terrain, and distance between the terminal and the coast the option was not viable. Subsequently FSRU options (single berth, double berth, turret mooring system) were considered. However, the offshore metocean conditions without the construction of a breakwater are too extreme for ship-to-ship transfers in Mossel Bay resulting in acceptable up-time. A breakwater would alleviate conditions whilst mooring, but conditions were too rough to even successfully reaching the jetty. These constraints led to the consideration of an onshore facility in Saldanha Bay, where the feasibility was brought into question based on biodiversity constraints.

- **Paul Hardcastle (DEADP):** What are the main differences between the Southern Cape scenario and the Western Cape scenarios? If the same criteria were considered why would the current Western Cape LNG project be considered a feasible possibility?
  - **Johan Visagie (Energy Business):** The main difference between the Western Cape LNG initiative and the PetroSA Southern Cape initiative is the technology. The Tandem Mooring technology boing considered for this study allows for extra 3 m variability in wave conditions than the Side-by-Side system considered Southern Cape project undertaken by PetroSA.

- **Paul Hardcastle (DEADP):** Is the Tandem mooring technology currently being used in similar conditions elsewhere?
  - **Johan Visagie (Energy Business):** At the moment only Side-by-Side technology is used for LNG at the moment. However, 30 projects are currently in the planning and construction phases, of which 17 % are foreseen to be operating in similar conditions.
  - **Jim Petrie (DEDAT):** It is important to consider that the study being undertaken by the CSIR concerning the metocean conditions needs to provide information on whether any offshore options are viable. Subsequently, in the project development phase it should be determined whether developers are willing to take the risk if the new technology (Tandem mooring) is the best option.

- **Alana Duffell-Canham (CapeNature):** Is there an estimated footprint area for an onshore facility?
  - **Annick Walsdorff (CSIR):** The footprint on an onshore facility is estimated to be 20 – 25 ha.

- **Jessica Courtoreile (PetroSA):** There are a lot of factors to consider for initiatives such as the importation of LNG into the Western Cape. Firstly if the environmental conditionals are favourable but still risky, will you be able to attract a developer that is willing to take that risk. If the risks are taken into account will it still be possible to sell the gas into the market, especially if there is not currently an established existing market.

- **Paul Hardcastle (DEADP):** A main concern for a project like this should be to find the best sustainable solutions considering all the available options (i.e. technology, locations) and all the relevant socio-economic and environmental factors in terms of sustainability. Furthermore, the criteria that is considered to determine the best sustainability options for gas related project in South Africa should be standardised to allow for better alignment in terms of regulatory processes (e.g. Environmental Impact Assessment (EIA)).

- **Selvan Pillay (TNPA):** Within the Port of Saldanha there are three possible land-based locations and also an FSRU option. Can you use a FSRU and the onshore facility in conjunction?
  - **Annick Walsdorff (CSIR):** If there is a FSRU there is no need for an onshore facility.

- **Selvan Pillay (TNPA):** What is the design life of the gas pipeline and the onshore facility?
  - **Johan Visagie (Energy Business):** The pipeline design lifetime is approximately 30 – 50 years under standard pipeline specifications and in conjunction with a maintenance program.

- **Jessica Courtoreile (PetroSA):** What is the leasing period of the FSRU infrastructure?
  - **Johan Visagie (Energy Business):** The FSRU leasing period is approximately between 15 and 30 years
  - **Carlo Matthysen (PetroSA):** In the case that, for example, after five years it is decided to rather convert to an onshore LNG facility and the FSRU has to be redeployed. Does that mean that if there is not a direct overlap between the end of the lease contract of the FSRU and the transfer to an onshore facility, that infrastructure that is not being used will still have to be leased?
  - **Johan Visagie (Energy Business):** It is important to firstly coordinate that property and secondly to have commercial gas in the new infrastructure (in this example the onshore facility) before deployment of the FSRU.

- **Carlo Matthysen (PetroSA):** PetroSA has done another feasibility study at Saldanha and in terms of time-frames there is a 4 month difference between a land-based gas facility and a floating gas facility.
  - **Jim Petrie (DEDAT):** If the feasibility and approvals phases of have been achieved the technical implementation time between an onshore facility and a FSRU will not differ much. However, there may be a difference (which has not yet been determined) in obtaining all the necessary approvals for a land-based option opposed to a floating option, especially considering terrestrial environmental aspects. Therefore, if the regulatory process time-frames are different, then there may be a different outcomes and this should be discussed and considered.

- **Jessica Courtoreile (PetroSA):** It is important to explore the differences between floating and land-based options. From the PetroSA study in Mossel Bay it was expected that people would welcome a floating option – not having more infrastructure built on-land. However, people are not familiar with the floating options and had more reservations towards the technology (almost perceived as a “floating bomb”).

- **Selvan Pillay (TNPA):** If the possibility of indigenous shale gas is realised and South Africa has a local gas reserve there might not necessarily be a need for gas importation. If the gas is not being imported, the infrastructure should have the capacity for gas exportation as well. However, is there a demand at the moment or in the future for South Africa as a gas exporter relating to a more commercial side of the project?

- **Jim Petrie (DEDAT):** A land-based terminal may be reconfigured into an export terminal (with a possible change in the footprint) to adapt to the current gas and market needs and opportunities of South Africa. However, the current scope and priority of the study is the importation of LNG into the Western Cape.

- **Johan Visagie (Energy Business): Jim Petrie (DEDAT):** The project is considering five options at the moment: 2 within the Port of Saldanha and 3 offshore floating options. The reason for this is to give guidance towards what will be best for South Africa incorporated. The development is not aimed to be restricted locally; it should contribute to the Gross Domestic Product (GDP) of the country. Therefore, instead of looking at a preference in isolation, the different options should be sustained by fact which will enable informed responsible decisions.
  - **Paul Hardcastle (DEADP):** The above mentioned is exactly why a strategic (logic) approach is so valuable for projects of this magnitude – it allows options to be logically approached and identified constraints before the EIA process.

- **Paul Hardcastle (DEADP):** There is a lot of industrial land available in the back-of-port area of the Port of Saldanha. Is this land being considered for a land-based facility option?
  - **Annick Walsdorff (CSIR):** The cryogenic pipeline which cannot be buried, but should be placed in an open trench, is a limiting factor from an environmental perspective.
  - **Johan Visagie (Energy Business):** The cryogenic pipeline distance to onshore cryogenic storage tanks should be as short as possible to prevent the regasification of the LNG before it reaches the terminal. If the LNG regasifies before reaching the onshore storage facility, additional energy will be required to cool the liquid back down to -161°C in order to convert it back into liquid, this poses an economic- and time constraint. Therefore, the closer the onshore terminal is to the berthing point, the more viable the project is from a technical and economic perspective.
  - **Carlo Matthysen (PetroSA):** Cryogenic pipelines are extremely expensive to construct. Furthermore, moving the onshore facility further inland will result in the cryogenic pipeline (that cannot be buried) to cross roads and possibly other infrastructure. Due to the low temperature of the LNG (-161°C) there are also strict safety exclusion zones around the cryogenic pipelines.

- **Selvan Pillay (TNPA):** A possible location for the onshore location has been indicated to be National Defence Force land. Has there been any contact with them regarding this project? From TNPA's experience the Defence Force is not allowed to sell land, only lease it, which is a slow process to initiate and finalise.
  - **Annick Walsdorff (CSIR):** There has not been any contact with the National Defence Force at Saldanha Bay, but they are known to be difficult to negotiate with.
  - **Carlo Matthysen (PetroSA):** Negotiations with the National Defence Force may prove exceptionally difficult especially in the SAS Provincial Nature Reserve.
  - **Alana Duffell-Canham (CapeNature):** The security of the SA Provincial Nature Reserve is going to be upgraded – the area is going to be completely fenced off.

- **Paul Hardcastle (DEADP):** It seems that any onshore location in the entire Saldanha Bay may be a challenge or a constraint for this project. Saldanha Industrial Development Plans (IDPs) and areas earmarked for industrial development should also be considered and the scope for onshore locations should possibly be widened.
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4. ENVIRONMENTAL SCREENING STUDY APPROACH AND METHODOLOGY (ANNICK WALSDORFF - CSIR)

The ESS process involves a desktop study at a high level in terms of terrestrial ecology, aquatic ecology, marine ecology, heritage resources, planning, as well as safety and risk issues. The sensitivity of the study area is categorised as low, medium, high, very high, and potential fatal flaw. Environments with a very high sensitivity will typically be areas where development activities may significantly alter the ecological form and function of the area. The results are limited to the scale of the spatial data layer, entailing that ground-truthing should be done as the project moves beyond an ESS phase. The risk and safety assessment defines three levels of risk, considers what level of risk is reasonably acceptable within certain concentric zone (exclusion zones), and governs the types of development that are allowed within certain distance from an onshore LNG facility and the gas pipelines.

- **Jessica Courtoreile (PetroSA):** Is a worst case scenario being used for the risk assessment?
    - **Annick Walsdorff (CSIR):** The risk and safety specialist has been very conservative in terms of the risk assessment, because at this time there is limited information on engineering designs and development plans – especially for the land-based facility. The assessment has been done at a screening / high level. A worst case scenario was also adapted for the evaluation of the pipeline in terms of the material used and the pipe wall thickness. Additional management actions may reduce the risks associated with the pipeline, and therefore also minimising the exclusion zone around the pipeline. For instance, the pipe may be placed within a protective sleeve or the wall thickness may be increased.
    - **Jim Petrie (DEDAT):** There are codes of practice that dictate what pipe material and wall thickness should be used at what gas pressures.
    - **Annick Walsdorff (CSIR):** The current study was done with predetermined pipeline standards (English standards). Some of these specifications have are not necessarily adequate when crossing a residential area for instance. In South Africa there is currently not a set of local standards and guidelines for gas pipelines.
    - **Johan Visagie (Energy Business):** There are different gas pipeline requirements depending on whether an urban or a rural area is being traversed. These differences result in varying ground cover over the pipeline, as well as the material and thickness of the pipeline in order to mitigate the associated risks.
    - **Annick Walsdorff (CSIR):** Once the gas pipeline route is refined (after the ESS phase), a detailed risk assessment should be conducted.

Luanita van der Walt (CSIR) provides an example of the terrestrial ecology constraints mapping (preliminary results). Some of the terrestrial ecology features that have been considered are the remaining extent of threatened ecosystems, National Protected Areas, and conservation planning (such as Critical Biodiversity Areas (CBAs), Ecological Support Areas (ESAs)).

- **Alana Duffell-Canham (CapeNature):** In addition to the CBAs being a representation of the biodiversity of an area, it doesn't necessarily represent 100 % of those biological features; the mapping represents at least 50 % of the biological features. Furthermore, the listing of the threatened ecosystems was based on aerial photography which is about 20 years old, and is therefore out of date. The CapeNature conservation planner has undertaken to re-evaluate land cover and the remaining extent of threatened vegetation types. Many of the remaining threatened vegetation patches mapped for this project has already disappeared, resulting the threatened status to be upgraded to a higher status.

- **Rhett Smart (CapeNature):** The CBA layer is also useful to inform on the status of vegetation patches, as it takes many biological features into account (such as the threatened status, irreplaceability of the area, and presence of endangered species).
- **Alana Duffell-Canham (CapeNature):** An updated CBA layer may be available. The next step for the conservation planning in the study are being considered is to engage with land owners and determine what areas are still pristine and what how much of the vegetation has been lost. This will inform on aspects such as what areas can be used as connectivity sites, and what ideal buffer distances should be to effectively protect remaining threatened ecosystems. Since 2008 about 30 % of the CBAs in Saldanha have been lost, therefore there is a need for critical measures to be taken, and the latest available information should be used for ESS such as the current project.

- **Paul Hardcastle (DEADP):** Does the environmental sensitivity assessment directly relate to the gas pipeline route and was existing servitudes considered as the most ideal location for the pipeline routing?
  - **Johan Visagie (Energy Business):** Existing pipeline and road servitudes were considered as the preferable option for the gas pipeline routing. In some cases the existing servitudes may have to be extended (possibly with up to 20 m wide) to accommodate the gas pipeline.
  - **Annick Walsdorff (CSIR):** Just outside of Langebaan the pipeline follows and existing oil pipeline servitude that traverses the West Coast National Park. Although an existing servitude is being followed, the fact that it in within a National Park should be considered and will most probably entail negotiations with the National Parks authorities.

5. GENERAL DISCUSSION

- **Jim Petrie (DEDAT):** Was the land currently zoned within the Saldanha Spatial Development Framework (SDF) for industrial development, been planned with some preliminary environmental screening that considers the existence of critical biodiversity features within those areas?
  - **Paul Hardcastle (DEADP):** Challenge with SDFs is that environmental aspects are not necessarily considered. Therefore, it cannot be confirmed that areas within Saldanha Bay earmarked for industrial development have been screened for potential environmental sensitivities. The information of past environmental screening may have been used, but is outdated. Another challenge is the scale of the available data.

- **Jim Petrie (DEDAT):** Does private land that is currently situated within the SDF need to be considered independently?
  - **Paul Hardcastle (DEADP):** The SDF allocates a land-use, but does not withdraw any rights or get excluded from any regulatory requirements, therefore private land owners still need to undergo the EIA process and assess the environmental conditions.

- **Alana Duffell-Canham (CapeNature):** The development in the Saldanha Bay Infrastructure Development Zone (IDZ) is very haphazard and has not been strategically planned. As an environmental authority (CapeNature) it is important to engage with the land owners to identify, in a strategic manner, where CBA corridors must be established and preserved to maintain ecological function and connectivity.
  - **Paul Hardcastle (DEADP):** A strategic level of assessment has not been conducted for the Saldanha Bay area, but should be prioritised in order to inform and provide certainty for developers and conservation authorities.

- **Jim Petrie (DEDAT):** Will the need for a strategic assessment of Saldanha Bay natural environment have any implications (especially in terms of time-fames) for the importation of LNG into the Western Cape, that may have the need to develop a piece of land within the SDF.
- **Paul Hardcastle (DEADP):** Once all the options have been assessed and considered, and high sensitivity areas and fatal flaws are known, the project will be able to move forward and unlock the challenges regarding environmental constraints.

- **Alana Duffell-Canham (CapeNature):** Approximately 80 % of the land portions in the area from Saldanha Bay IDZ to St. Helena bay have at least one active development on them (EIA applications in progress or approved). The developments are not aligned and this is leading to fragmentation of the landscape.

- **Morné Theron (CCT ERM):** Atlantis is an area where the City of Cape Town (CCT) wants to unlock job opportunities; however the land owners cannot get any developments started on their land because they cannot obtain Environmental Authorisation due to the presence of threatened vegetation. Thus the regulatory and legislative processes are halting development. If environmentally sensitive areas cannot be avoided biodiversity offsets should be considered, however it is important to state in the terms of reference of a project who the party responsible for those offsets in the future is.

- **Morné Theron (CCT ERM):** Will a 20 m servitude be necessary for the construction and maintenance of the gas pipeline?
  - **Johan Visagie (Energy Business):** A maximum of 20 m is adequate for construction vehicles to lay the pipeline, and longer term maintenance.

- **Paul Hardcastle (DEADP):** In the process of going forward with this project it should be determined what sensitive environments can be avoided, if unavoidable how to mitigate the effects of development or to determine biodiversity offsets. However, the biodiversity offset option is the last resort, because not only is biodiversity going to be lost, it's going to take a substantial amount of money to obtain the offset.

- **Jessica Courtoreile (PetroSA):** It seems that there is an assumption that after construction the area cannot be effectively rehabilitated?
  - **Paul Hardcastle (DEADP):** The best approach would be avoidance first and then mitigation.
  - **Alana Duffell-Canham (CapeNature):** The rehabilitation success depends on the species. Ultimately, even after rehabilitation approximately 40 % of species will be lost, resulting in a net loss of biodiversity, especially in the Strandveld vegetation types.

- **Morné Theron (CCT ERM):** Biodiversity conservation is important but a project such as the importation of LNG into the Western Cape will contribute greatly on a socio-economic level. What if the servitude is not widened but the infrastructure is rather constructed in an area which has already been disturbed?
  - **Jim Petrie (DEDAT):** Possibilities such as utilising the old Cape gas network may be considered.
  - **Annick Walsdorff (CSIR):** Constraints for "sharing" servitudes in terms of risk and safety is that the main incidents (i.e. gas leaks) occur during the maintenance of other pipeline infrastructure that also occurs in the servitude. Therefore it is not recommended to lay pipelines on top of each other, but rather a few metres apart.

- **Jim Petrie (DEDAT):** What are the other opportunities / constraints in terms of the back of port area which has been mentioned to be a possible option for a land-based terminal?
  - **Abigail Links (TNPA):** TNPA is currently restricted in terms of identifying the best areas for various developments. The aspects that are considered include commercial, technical, environmental, social and economic, as well as the water space and metocean conditions regarding certain activities.

- **Jim Petrie (DEDAT):** The position of the LNG vessel berth in the Port of Saldanha will be determined by the metocean conditions. This will inform on where the best opportunity of for a land-based facility.
  - **Annick Walsdorff (CSIR):** There are areas within port land that is not an option for an onshore facility, for instance the area west of the iron ore jetty has been earmarked for vessel maintenance and service activities and not for bulk liquid fuel activities.

- **Paul Hardcastle (DEADP):** It may be a useful exercise to do constraints mapping in terms of the availability of land for an onshore facility. Indicate which areas of land in Saldanha Bay are not available due to what reasons. Therefore land availability may also be a very informative layer for the constraints mapping done for this project.
  - **Annick Walsdorff (CSIR):** That is essentially what this ESS has aimed to do. However, only port property has been considered due to the cryogenic line.
  - **Morné Theron (CCT ERM):** Is the focus on Saldanha Bay for the entry site for the importation of LNG into the Western Cape as a result of creating economic and job opportunities?
  - **Paul Hardcastle (DEADP):** The floating options are also considered, so the focus is not entirely on Saldanha Bay. The reason other ports such as the Port of Cape Town is not being considered is because that Cape Town Port is a container port most probably not open for LNG activities and infrastructure.

- **Carlo Matthysen (PetroSA):** The importation of LNG is a government initiative for diversifying the energy options and reducing carbon emissions in South Africa. This project focuses on the opportunity of the conversion of gas to electricity as most of the Western Cape's electricity is generated in the North of South Africa.
  - **Johan Visagie (Energy Business):** The additional vessel traffic from LNG importation may sterilise a part of the Port of Cape Town, which is not desirable.

- **Morné Theron (CCT ERM):** What will the visual impact of a cryogenic pipeline be?
  - **Paul Hardcastle (DEADP):** In an area zone for industrial activities where visual impacts are not necessarily such as substantial priority.

- **Deon Jeannes (ESKOM):** Regarding the exclusion zones around Koega Nuclear Power Station (KNPS). The 5 km zone stipulates no increase in population density is allowed and no new development unless it supports KNPS, is allowed. The gas pipeline is not foreseen to be constrained by the 5 km exclusion zone. The 16 km zone entails evacuation strategies and to a lesser extent the prohibition of the increase of human population. The KNPS may pose regulatory challenges to the gas pipeline (especially in terms of seismic events that damage the pipelines and calls for evacuation procedures from KNPS). However, this may not necessarily be a major constraint for the gas pipeline.

- **Morné Theron (CCT ERM):** What is the procedure to go to shore from a FSRU?
  - **Johan Visagie (Energy Business):** The pipeline will be directionally drilled through the beach, no open trench or land-based facility is necessary.

- **Ryan Lewis (Transnet Group Planning):** Are marine features being taken into account for the activities in the port?
    - **Annick Walsdorff (CSIR):** Yes, however for the FSRU option no water will be discharged into the bay, it is a closed system.
    - **Pat Morant (CSIR):** The greatest impact development may have on marine ecology is usually during construction and not during operation.

- **Jessica Courtoreile (PetroSA):** What are the marine impacts for the Yzerfontein area – especially the whales?
    - **Pat Morant (CSIR):** There have not been any incidents of whale entanglements with FSRU infrastructure.
    - **Johan Visagie (Energy Business):** The FSRU has similar design to oil rigs (5 anchored) moor system, and no significant problems have been found with whales.

CONCLUDING REMARKS AND THANKS BY ANNICK WALSDORFF

6. KEY OUTCOMES AND ACTIONS

- The latest spatial biodiversity layers for the Western Cape should be obtained from CapeNature.
- Considering Saldanha Bay development strategies, land-use zoning, and land ownership may inform on further possible locations for land-based facilities (land availability constraints and opportunities mapping).
- The old Cape Gas Network infrastructure may be a possible opportunity as a servitude for the gas pipeline.
- There needs to be a greater alignment between the studies conducted by PetroSA and the current WC LNG study, also to standardise the criteria used for the sensitivity analysis.
- The usefulness of this study lies in how it informs the objective selection/screening of alternatives of locations and technologies.

Environmental Screening Study for the importation of LNG into the Western Cape
Workshop with key stakeholders
9 June 2014
Attendance Register

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