

QUANTITATIVE RISK ASSESSMENT

NAPIER BP AND Z TERMINALS CUMULATIVE QRA RESULTS

BP OIL NZ LTD

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CONTENTS

ABBREVIATIONS	4
1. INTRODUCTION.....	5
1.1. Background	5
1.2. Scope and objective.....	5
1.3. Exclusions and limitations	6
2. QRA BASIS.....	7
2.1. Site description.....	7
2.2. QRA Basis.....	7
2.3. Escalation between sites.....	8
3. RESULTS.....	12
3.1. Individual fatality risk	12
3.2. Societal risk.....	12
3.3. Conclusions.....	12
3.4. Potential for future land use conflict.....	13

APPENDIX A. REFERENCES

TABLES

Table 1.1: Scope of updated cumulative QRA changes	6
Table 2.1: Surrounding land uses of the Terminals	7
Table 2.2: Overview of site description at Napier	8
Table 2.3: Major equipment and area in the Terminals.....	10
Table 3.1: Comparison with individual fatality risk criteria.....	14

FIGURES

Figure 2.1: Surrounding land uses around the Terminals	9
Figure 3.1: Cumulative individual fatality risk contour (Current Case).....	16
Figure 3.2: Cumulative individual fatality risk contour (Future Case)	17
Figure 3.3: Cumulative individual fatality risk contour (Future Case) - Sensitivity	18
Figure 3.4: Cumulative societal risk.....	19

ABBREVIATIONS

AGO	Automotive Gas Oil (diesel)
AS	Australian Standard
BP	BP Oil NZ Ltd
DG	Dangerous Good
DPE	Department of Planning and Environment
ESD	Emergency Shutdown
HIPAP	Hazardous Industry Planning Advisory Paper
HSNO	Hazardous Substances and New Organisms
IFR	Internal Floating Roof
IHHLA	Independent High High Level Alarm
LFL	Lower Flammability Limit
LPG	Liquefied Petroleum Gas
MHF	Major Hazard Facility
MLA	Marine Loading Arm
NSW	New South Wales
NZOSL	New Zealand Oil Services Ltd
NZS	New Zealand Standard
P&ID	Piping and Instrumentation Diagram
PFD	Probability of Failure on Demand
PMS	Premium Motor Spirit (gasoline)
QRA	Quantitative Risk Assessment
RMS	Regular Motor Spirit (gasoline)
SFARP	So Far As Reasonably Practicable
Sherpa	Sherpa Consulting Pty Ltd
UK HSE	United Kingdom Health and Safety Executive
VCE	Vapour Cloud Explosion
Z	Z Energy Ltd

1. INTRODUCTION

1.1. Background

The bulk liquids storage and handling facilities operated by New Zealand Oil Services Ltd (NZOSL) and Z Energy Ltd (Z Energy) in the Napier Port, New Zealand are both Major Hazard Facilities (MHFs) under the Health and Safety at Work (Major Hazard Facilities) Regulations 2016.

In 2017, Sherpa Consulting Pty Ltd (Sherpa) was retained to carry out a Quantitative Risk Assessment (QRA) study covering the existing operations, as well as a future growth case for each bulk liquids facility. The detailed methodology, results and QRA findings for each site are documented in site specific QRA reports as follows:

- BP Napier Terminal QRA (operated by NZOSL), Ref (1)
- Z Napier Terminal QRA (operated by Z Energy), Ref (2).

Sherpa also prepared a cumulative QRA for the two Terminals, Ref (3). This was prepared for use if the MHF regulator required the cumulative risk impacts from the adjacent sites to be considered. Some operational changes have occurred since the 2017 studies were carried out as follows:

- BP has made the following changes:
 - Change of service for tanks NA8 and NA9 from RMS (gasoline) to AGO (diesel) in order to achieve greater separation distance and reduce the risk to the residential area to the south of the Terminal.
 - Tank ST4 is now owned by BP (in 2017 was owned by Z and operated by NZOSL). No change to current RMS (gasoline) service.
- Z is also proposing to implement an automatic high level shutdown system on their tanks and has requested that Sherpa update the Z Napier Terminal QRA to assess the potential effect on the existing risk.

Z and BP have jointly requested that Sherpa provide the results of these changes to their Napier sites in the form of an updated cumulative QRA report.

This report contains the cumulative QRA results accounting for the changes to both the BP and Z Napier Terminals.

1.2. Scope and objective

The objectives of the work are to:

- assess the cumulative risk from both terminals accounting for the changes.
- identify any potential future land use safety planning conflicts.

The scope for the cumulative QRA includes the following areas for each Terminal:

- Transfer pipeline: aboveground sections of the import wharfline from Napier Port within each Terminal site boundary (i.e. from the battery limit valve station)
- Terminal storage and processing: storage tanks, additive storage and handling, pumps, aboveground pipework and manifolds
- Road tanker loading gantry: tanker filling operations and export of fuels.

The previous QRA included two operational cases:

- ‘Current Case’ based on 2017 operating conditions and throughputs.
- ‘Future Case’ including an allowance for future growth in terminal throughputs.

The cases and changes covered in the updated cumulative QRA are summarised in Table 1.1.

Table 1.1: Scope of updated cumulative QRA changes

Updated cumulative QRA case	Base results	Sensitivity Case
‘Current Case’	2017 throughputs for both terminals NA8 and NA9 at BP changed from gasoline to diesel service. ST4 (gasoline) now part of BP terminal (not Z)	As for Current Case – base results plus: Automatic high level shutdown for all Z tanks reduces overfill frequency, probability of failure on demand (PFD) of 0.1
‘Future Case’	As for Current Case but with increased throughputs	As for Future Case – base results plus: Automatic high level shutdown for all Z tanks reduces overfill frequency, probability of failure on demand (PFD) of 0.1

1.3. Exclusions and limitations

This report documents the specific changes to the modelling for affected scenarios only. Details of the overall QRA approach and methodology are not included in this report as they are the same as provided in the individual report for each Terminal.

No changes apart from those noted in Section 2 have been made to the input, modelling assumptions, methodology and software compared to the previous individual site QRAs.

The ship unloading including all operations at the wharf and transfer pipeline outside of the site boundaries are not part of the scope.

The cumulative QRA does not cover onsite risk to personnel/employees, transport risks, injury risk, property damage and accident propagation risk.

2. QRA BASIS

2.1. Site description

The Terminals are located adjacent to each other within the Ahuriri Section of the City of Napier at New Zealand:

- BP Terminal located at 2 Bull Street
- Z Terminal located at 14 Tu Atu Street.

The Terminals are serviced from the Napier Port via a common import wharfline at north-east of the Terminals with offtakes to each site.

A map showing the surrounding land uses to the Terminals is included as Figure 2.1 which is based on the City of Napier District Plan Map, Ref (4).

Table 2.1 summarises the land uses surrounding the Terminals. The surrounding area is primarily characterised by mixed use, commercial and residential environments. Napier Port is located approximately 1.15 km north-east of the Terminals.

The Terminals are located in an industrial area zoned as mixed use and comprise four sites with pipelines operating within and between the sites. The four sites are BP Terminal, ST4 Compound, Z Terminal Contact Compound and Z Terminal Ex-Chevron Compound.

Table 2.1: Surrounding land uses of the Terminals

Direction	Surrounding land use
North	Designation area for freight transportation Residential areas and commercial environments north of railway line
East	Mixed use (storage warehouses) and residential areas
South	Battery Road Character Area (residential areas) Z Energy sub-leased lots, occasionally have empty cylinders, overnight Liquefied Petroleum Gas (LPG) truck parking and non-Dangerous Goods (DGs) storage containers
West	Mixed use (storage warehouses) and residential areas

2.2. QRA Basis

An overview of each site is provided in Table 2.2. This includes the owner and operator of the facilities. The cumulative QRA covers all four areas.

Table 2.3 summarises the scope of equipment covered in the cumulative QRA.

The throughput figures for the individual terminals remain as for the site specific QRAs. In total this is approximately 300,000m³/year for all terminals spilt about 60% AGO and 40% total gasoline grades. The Future Case increase is based on approximately 2% increase in throughput over 10 years with no change in product split resulting in approximately 380,000m³/yr over both terminals.

Table 2.2: Overview of site description at Napier

Site	Description	Owner	Operator	Covered in Cumulative QRA
BP Terminal	For receipt of bulk hydrocarbon fuels by ship, storage and load out of fuel through road tanker exports	BP	NZOSL	Yes
ST4 Compound	For receipt and storage of all RMS and receipt of slops (periodically pumped for blending) from the BP Terminal Note: RMS tank ST4 is now a BP asset; BP owned the product and is operated by NZOSL.	BP	NZOSL	Yes
Z Terminal Contact Compound	For receipt of bulk hydrocarbon fuels by ship and storage Note: Tanks C1 and C2 are currently decommissioned.	Z Energy	Z Energy	Yes
Z Terminal Ex-Chevron Compound (a)	For receipt of bulk hydrocarbon fuels by ship, storage and load out of fuel through road tanker exports	Z Energy	Z Energy	Yes
<p>Notes:</p> <p>(a) The cumulative QRA covered modelling of C1 storing RMS and C2 storing AGO in the ex-Chevron compound (acquired by Z in 2016) Future Case modelling to allow for future recommissioning.</p> <p>PMS = Premium Motor Spirit, RMS = Regular Motor Spirit, AGO = Automotive Gas Oil</p>				

2.3. Escalation between sites

As per the individual site QRAs there were no escalation risks between the Z and BP sites identified, ie separation distances between tanks on the two sites was sufficient to prevent escalation effects. Therefore there are no escalation scenarios included in the cumulative QRA.

Figure 2.1: Surrounding land uses around the Terminals



Table 2.3: Major equipment and area in the Terminals

Site	Equipment/area	Description	Covered in the QRA	
			Current Case (2017 basis)	Future Case (nominal)
BP Terminal	Bulk storage tanks	NA1, NA2 (remains diesel) NA8, NA9 (changed from gasoline to diesel)	Yes	Yes
	Slops tank	NA10	Yes	Yes
	Firewater tank	NA6	No – non-hydrocarbon fuel	No – non-hydrocarbon fuel
	Additive compound	Contains three additive (diesel and gasoline) tanks in compounds 1 and 2	Yes	Yes
	Additive rack bund	Contains additive delivered to site stored in intermediate bulk containers (IBCs) only	Yes	Yes
	Pump compound	Contains three pumps: P004 (RMS), P005 (PMS) and P020 (AGO)	Yes	Yes
	Slops pump	P803	Yes	Yes
	Valve exchange/cage station	Connects Napier Port wharf line to BP wharf line (into BP Terminal) and Z Contact wharf line (through BP Terminal into Z Terminal)	Yes	Yes
	Wharf line manifold	Contains slops pump P803 and connects the BP wharf line to pump compound	Yes	Yes
	Road tanker loading gantry	Two loading bays	Yes	Yes
	Interceptor/separator compound	-	No – small inventory only	No – small inventory only
ST4 Compound (part of BP terminal)	Bulk storage tank	ST4 (RMS)	Yes – operated by NZOSL	Yes – operated by BP
	Pump	P009 (RMS)	Yes	Yes
	Drainage pump	F505 (mostly water with a small amount of hydrocarbons to interceptor)	No	No
	Manifold compound	Transfers RMS and slops from BP Terminal into ST4 and connects Z Contact wharf line with Z Ex-Chevron wharf line	Yes	Yes
Z Terminal Contact Compound	Bulk storage tanks	C1 and C2, A3 (AGO)	Yes (tank A3 only)	Yes (all three tanks) C1 with RMS C2 with AGO
	Slops tank	C4 (to be decommissioned)	No	No

Site	Equipment/area	Description	Covered in the QRA	
			Current Case (2017 basis)	Future Case (nominal)
	Pump compound	Assume contains three pumps in the compound as identified from hazardous area layout NASH1034G Rev D.	Yes	Yes
	Interceptor	-	No – small inventory only	No – small inventory only
Z Terminal Ex-Chevron Compound	Bulk storage tanks	T424, T526	Yes	Yes
	Slops tank	T528	Yes	Yes
	Additive compound	Contains additive stored in 205L drums or IBCs until they are pumped into the additive tanks. There are currently two additive tanks – 1 x 10kl, 1 x 5kl. An additional 5kl tank will be added in May 2017 and is included in QRA.	Yes	Yes
	Manifold	-	Yes	Yes
	Pump compound	Contains four pumps: P1 (RMS), P2 (AGO), P3 (PMS), P4 (returns pump)	Yes	Yes
	Tanker Truck Loading Rack (TTLR)	One loading bay (current operation) and an addition of one extra loading bay in future	Yes	Yes (addition of an extra loading bay BP site)
	Separator compound	-	No – small inventory only	No – small inventory only
Legend:				
	Changes in future growth case			

3. RESULTS

As there are no New Zealand specific risk criteria guidelines, the QRA results continue to be assessed against the criteria outlined in Australian New South Wales (NSW) Department of Planning and Environment (DPE) Hazardous Industry Planning Advisory Paper (HIPAP) No 4 *Risk Criteria for Land Use Safety Planning (HIPAP 4)*, Ref (5).

The cumulative risk results are presented as individual fatality risk contours and societal risk curves.

3.1. Individual fatality risk

3.1.1. Base Case

Figure 3.1 shows the cumulative individual fatality risk contours for the Current Case.

Figure 3.2 shows the cumulative individual fatality risk contours for the Future Case.

Comparison of the risk against the risk criteria is presented in Table 3.1.

3.1.2. Sensitivity Case

Figure 3.3 shows the cumulative individual fatality risk contours for the Future Case - Sensitivity case with the effect of automatic high level shutdown at Z included.

The main effect is to reduce the extent of the 1×10^{-6} per year and 0.5×10^{-6} per year risk contour (sensitive land uses). There is minimal effect on the near field risk contours as these are dominated by fire events not the overfill scenario.

3.2. Societal risk

The cumulative societal risks for all cases are presented in the form of an F-N curve in Figure 3.4.

In all cases the major societal risk contributor is from the tank overfill flash fire consequence from major tank failure/rupture of gasoline tanks (ST4, T526, T424 and T528) at the Terminals. This is because the flash fires from spills from gasoline tanks have the highest consequence effect areas, whereas most other consequence effect areas remain close to the Terminal boundaries.

3.3. Conclusions

As for the individual studies, compliance with the HIPAP 4 individual fatality risk criteria is not fully achieved as follows:

- The 50×10^{-6} individual fatality per year contour (site boundary target) extends marginally offsite at the northern and western site boundary of the Terminals. However, this does not reach any occupied areas or other hazardous facilities or inventories.
- The criteria for all other land uses are met as per Table 3.1 for existing land uses.

- The main difference compared to the 2017 QRA results is that the change of use of NA8 and NA9 from gasoline to diesel has reduced the risk in the residential area to the south of the BP terminal so that it now complies with the residential risk criterion.

As for the individual studies, societal risk is in the ALARP for number of fatalities (N) up to approximately 200 and the negligible region for N greater than approximately 200 for all cases.

The major risk contributors to societal risk remain the gasoline tank overfill scenarios which can generate flammable clouds extending more than 300 m into the nearest residential areas.

3.4. Potential for future land use conflict

There is some potential for future reverse sensitivity effects as follows if land uses around the Terminals change:

- The societal risk results mean that changes of land use near the terminal that result in increased populations would further increase the societal risk, extending the F-N curve towards the intolerable level. Even if the individual fatality risk criteria were met for a proposed land use or changed land use, a societal risk assessment would still be required to confirm the risk does not approach the intolerable level.
- As per Figure 2.1 the land to the south and west of Z is zoned 'Mixed Use'. These areas are partly within the commercial individual fatality risk contour. While the current land use is industrial, changes towards more sensitive land uses that could be permitted with consent under the zoning (e.g. commercial, residential or sensitive uses) may result in non-compliance with the individual fatality risk criteria.

Table 3.1: Comparison with individual fatality risk criteria

Description	Risk criteria (per year)	Compliance with criteria?		Comments
		Current operations	Future operations	
Hospitals, child-care facilities and old age housing (sensitive land uses).	0.5 x 10 ⁻⁶	Yes	Yes	<p>The risk contour extends offsite in all directions, up to:</p> <ul style="list-style-type: none"> - approximately 55 m (Current Case) and 85 m (Future Case) from the northern boundary - approximately 145 m (Current Case) and 190 m (Future Case) from the southern boundary - approximately 36 m (Current Case) and 51 m (Future Case) from the eastern boundary - approximately 35 m (Current case) and 42 m (Future case) from the western boundary. <p>However, there are no sensitive land uses in this area. The nearest sensitive area (childcare centre) is located approximately 127 m from the western boundary of the Terminals.</p>
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1 x 10 ⁻⁶	Yes	Yes	<p>The residential land use target is met for both the current and future cases.</p> <p>The nearest residential areas consist of three areas located approximately 5 m from the southern boundary, approximately 17 m from the eastern boundary and approximately 47 m from the northern boundary of the Terminals respectively.</p> <p>NOTE: this is the main change from the 2017 results where the residential risk contour extended into the residential areas to the south of the site and is due to change of storage from gasoline to diesel in BP tanks NA8 and NA9.</p>

Description	Risk criteria (per year)	Compliance with criteria?		Comments
		Current operations	Future operations	
Commercial developments, including offices, retail centres and entertainment centres (commercial land use).	5 x 10 ⁻⁶	Yes	Yes	<p>The risk contour extends offsite up to:</p> <ul style="list-style-type: none"> - approximately 30 m (Current and Future Cases) from the southern boundary - approximately 15 m (Current Case) and 20 m (Future Case) from the western boundary <p>There are no existing commercial land uses within the relevant risk contour. The nearest existing commercial area is located approximately 100 m from the northern boundary of the Terminals.</p> <p>NOTE: the land to the south of Z is zoned Mixed Use hence there is potential for a commercial type land use to establish that may not comply with the criteria.</p>
Sporting complexes and active open space areas (recreational land use).	10 x 10 ⁻⁶	Yes	Yes	There are no sporting complexes and active open space areas in this area.
Target for site boundary (boundary limit).	50 x 10 ⁻⁶	No	No	<p>The site boundary target is not met for both the current and future cases.</p> <p>The risk contour extends offsite up to:</p> <ul style="list-style-type: none"> - approximately 10 m (Current and Future Cases) from the northern boundary of the BP site - approximately 5 m (Current case) and 20 m (Future case) from the western boundary of the Z site

Figure 3.1: Cumulative individual fatality risk contour (Current Case)

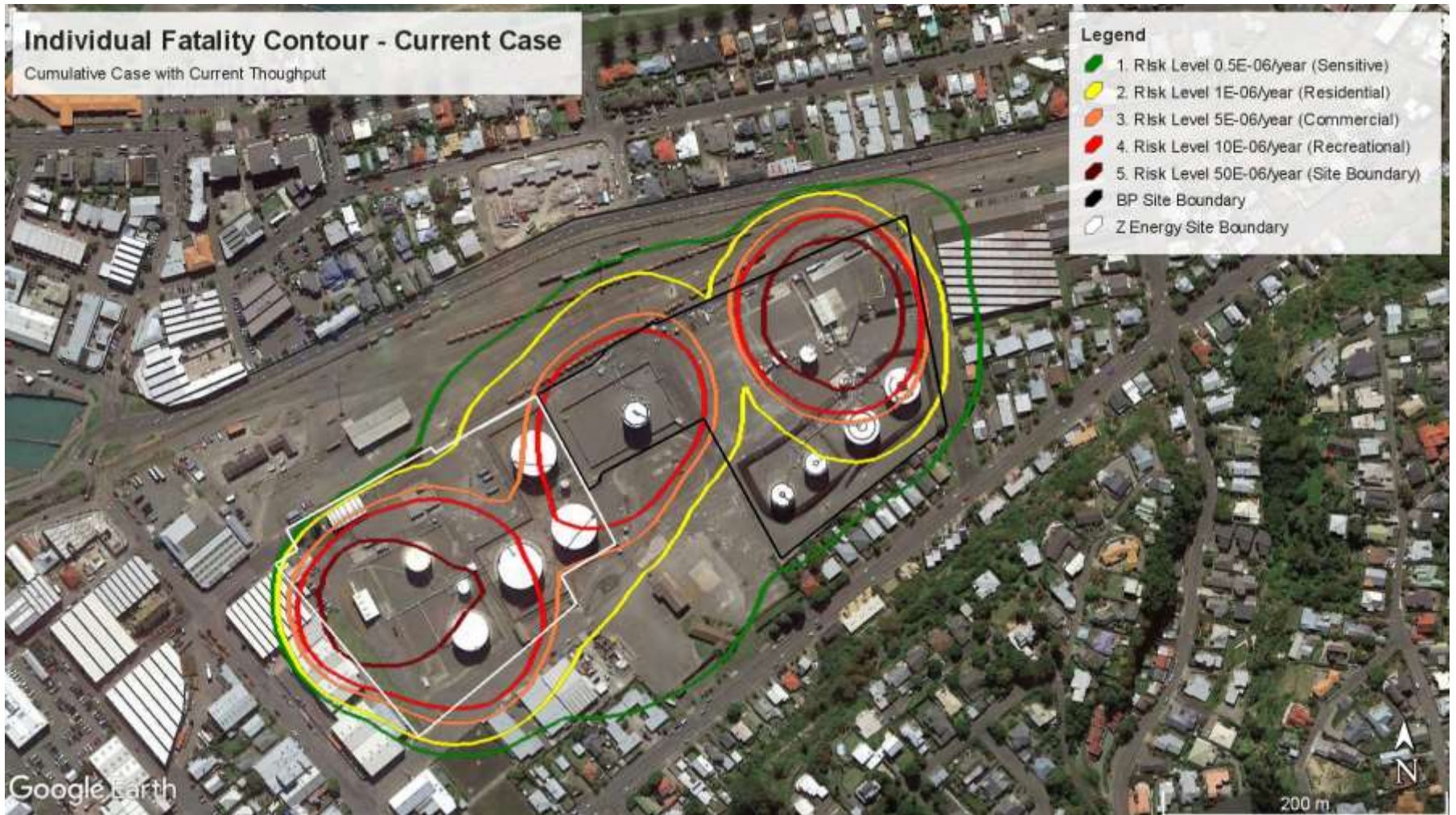


Figure 3.2: Cumulative individual fatality risk contour (Future Case)

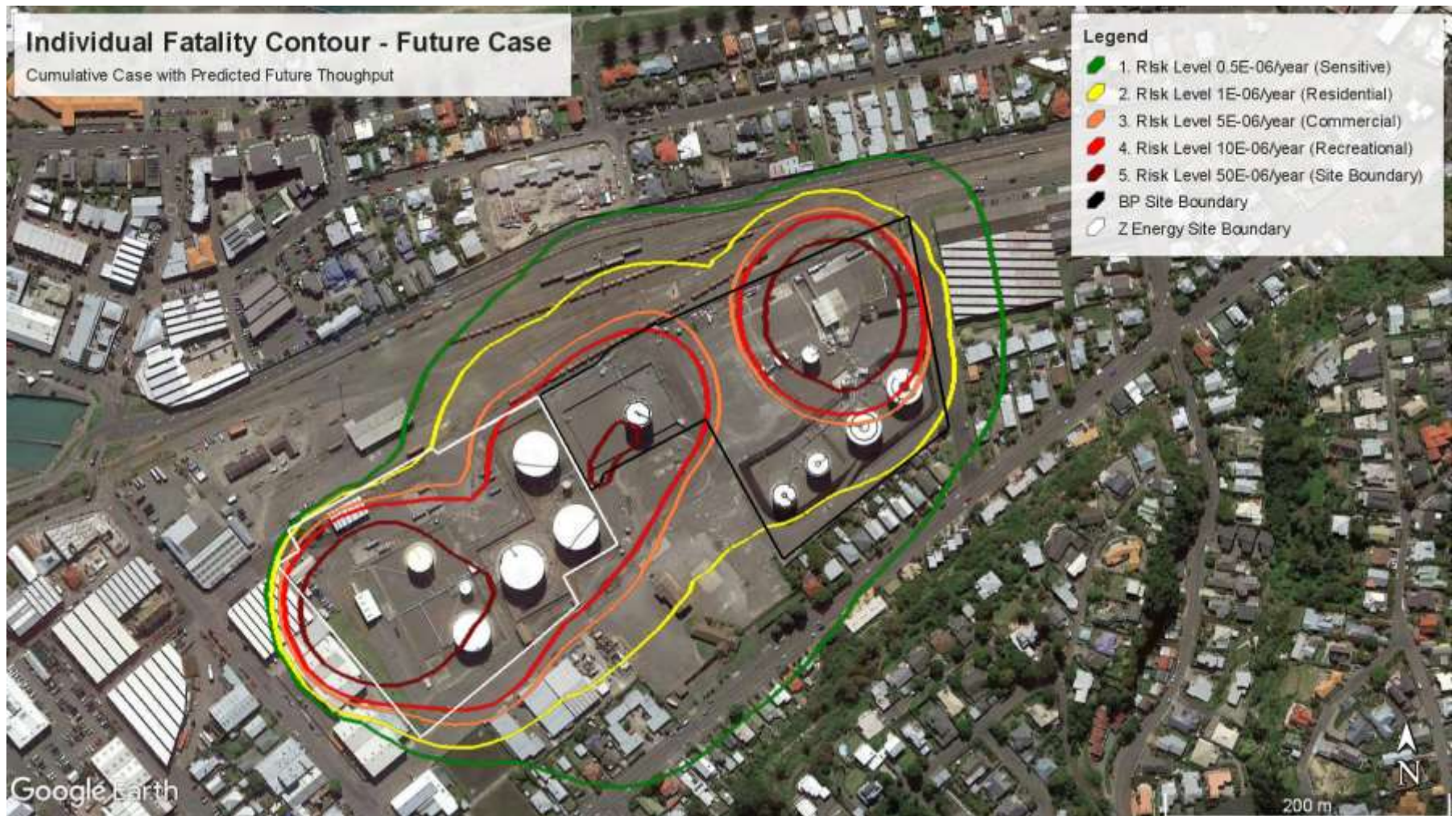


Figure 3.3: Cumulative individual fatality risk contour (Future Case) - Sensitivity

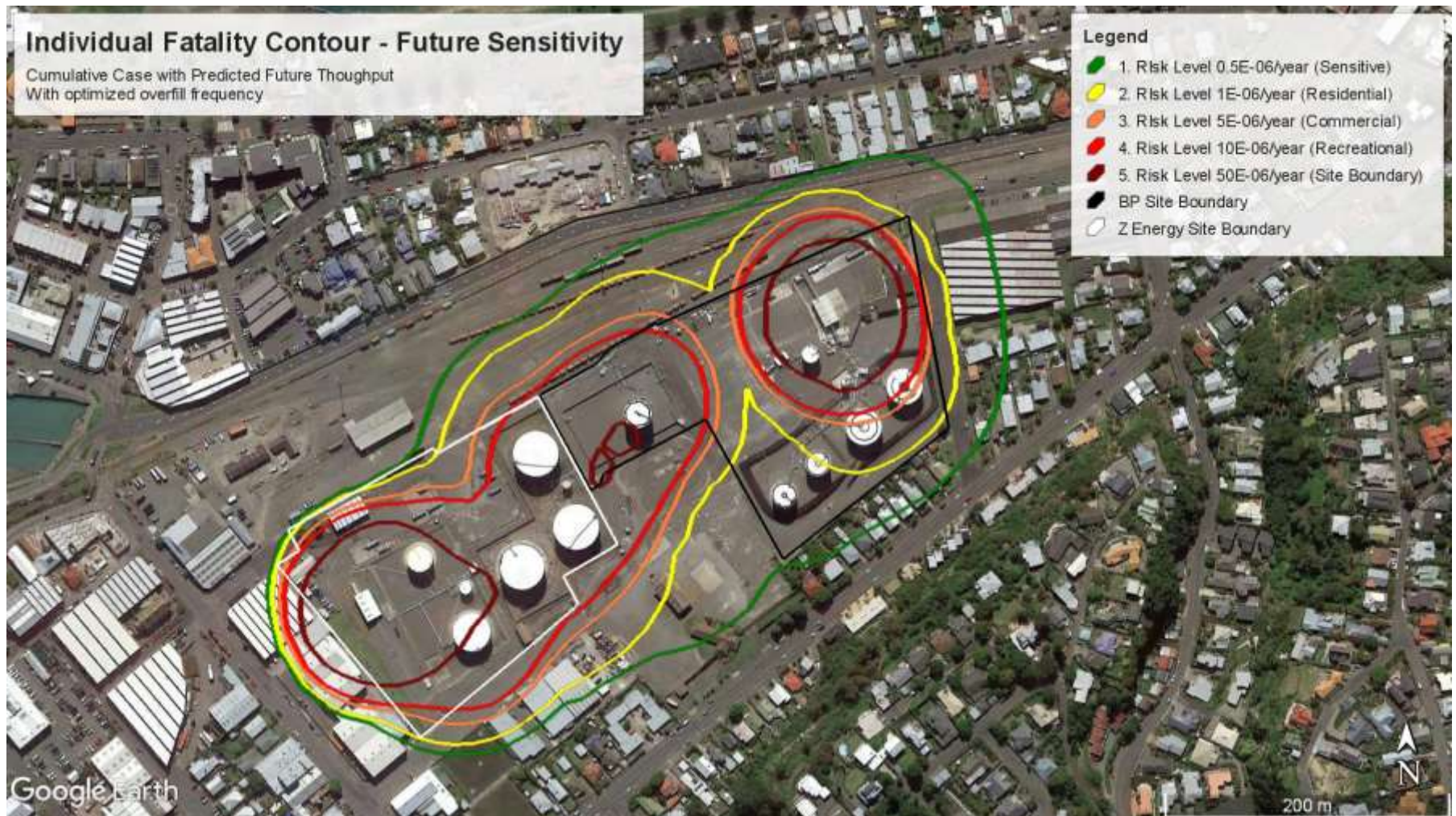
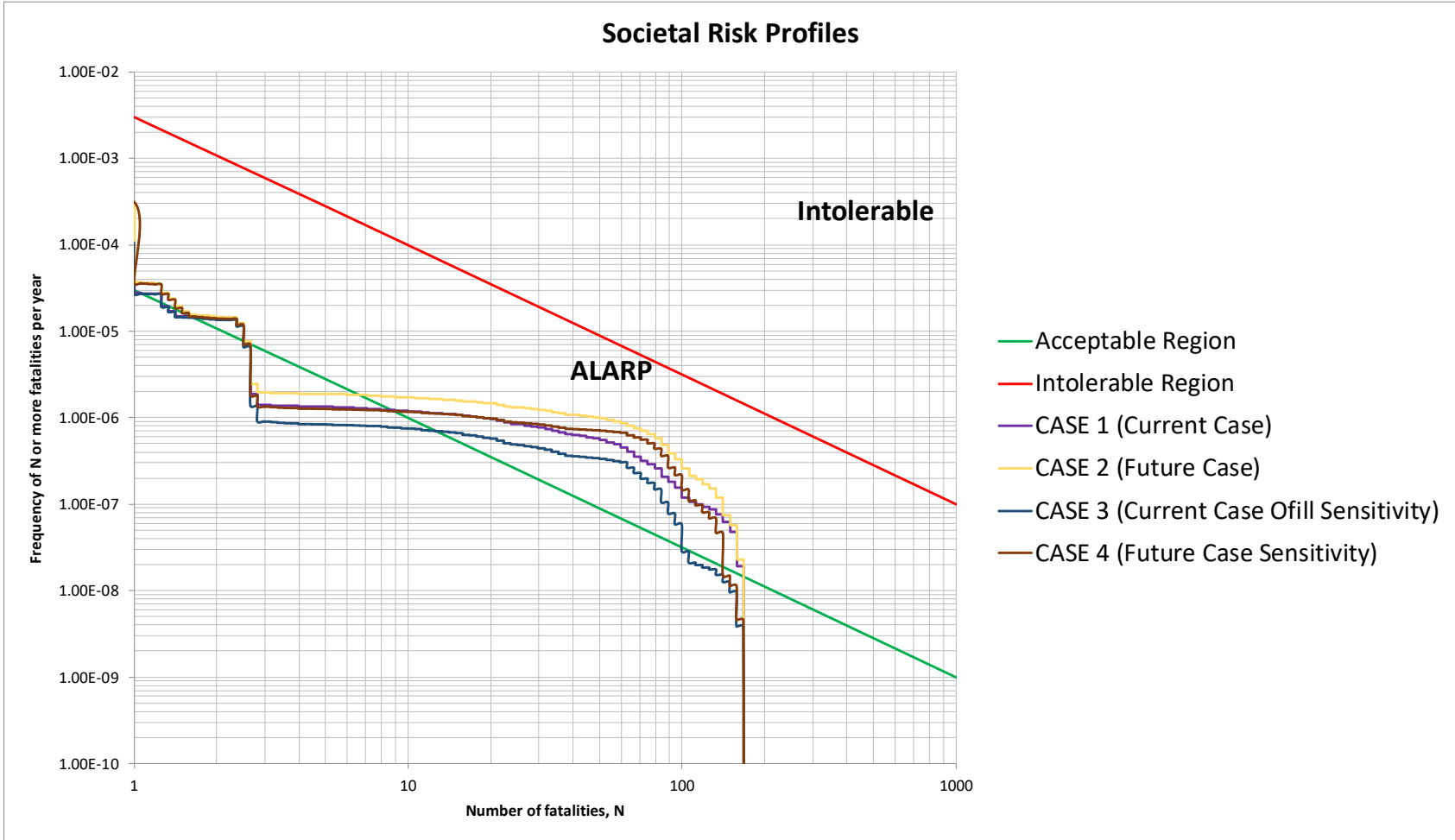


Figure 3.4: Cumulative societal risk



APPENDIX A. REFERENCES

1. **Sherpa Consulting Pty Ltd.** *Quantitative Risk Assessment (QRA) - BP Napier Terminal.* 2017. 21134-RP-001.
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