Appendix XII: GHD BSIA Concept Plan for Quantitative Risk Assessment

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LandCorp

Report for Boodarie Strategic Industrial Area

Concept Plan Quantitative Risk Assessment

July 2012

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Glossary of Terms

Table 1 Abbreviations

Abbreviation	Description
ALARP	As Low as Reasonably Practicable
BSIA	Boodarie Strategic Industrial Estate
DNV	Det Norske Veritas
DoP	New South Wales Department of Planning
DRI	Direct Reduced Iron
EPA	Western Australian Environmental Protection Authority
HAZID	Hazard Identification
HBI	Hot briquetted iron
HIPAP	New South Wales Hazardous Industry Planning Advisory Paper
LSIR	Location Specific Individual Fatality Risk
MRGs	Major Risk Generators
NSW	New South Wales
QRA	Quantitative Risk Assessment
RfP	Request for Proposal
SIA	Structural Industrial Area

Table 2 Glossary of Terms

Term	Definition
Individual Risk	The risk of death to a person at a particular point. Also called Individual Fatality Risk or Location Specific Individual Fatality Risk.
Societal Risk	The risk experienced in a given time period by the whole group of personnel exposed

Executive Summary

GHD performed a Quantitative Risk Assessment (QRA) on the proposed Boodarie Strategic Industrial Area (BSIA) for LandCorp. The primary objective of the assessment was to determine whether the existing BSIA Buffer is adequate to allow the Strategic Industry Area (SIA) to develop to full capacity. A secondary objective was to determine if the land allocated to each of the industries was adequate after considering the risks that each of the industries imposed on their plant boundaries.

The Industrial Ecology Study done by GHD proposed a list of possible industries for the BSIA. These industries were located in various precincts. It should be noted that there was no alignment between the precincts given in the Industrial Ecology Study and those on the concept plan map. The QRA involved screening of the proposed plants based on potential offsite risks posed. From the 31 proposed industries, 7 were selected as being major risk generators (MRGs). These were Chlor-Alkali, Ammonia, Ethane Extraction, Titanium, Sodium Cyanide, Methanol and Ethylene Dichloride (EDC)/Vinyl Chloride monomer plants. These were the ones which were considered to pose sufficient risk to affect the overall site risk contour. These plants were allocated areas within their allocated precincts of the BSIA and they were modelled using Phast Risk 6.7.

The following WA EPA (Western Australian Environmental Protection Authority) criteria were used to assess individual risks:

- For buffer zone boundary, the EPA target is one half in a million per year (0.5×10^{-6} per year). This is the maximum acceptable risk level at the boundary with “sensitive developments”, such as hospitals, schools and childcare facilities.
- For the individual plant boundaries, the EPA target is fifty in a million per year (50×10^{-6} per year). This is the maximum acceptable risk imposed at a plant boundary by the plant.
- For the cumulative risk imposed upon an industry by others, the target which should not be exceeded is one hundred in a million per year (100×10^{-6} per year).

The assessment showed that the proposed buffer zone for the BSIA was adequate. The assessment also showed that the individual plant land allocations were adequate except for the Ethane Extraction and Methanol plants. These plants needed more land to ensure that the target fifty in a million per year contour was within their plant boundaries.

The assessment also showed that iron ore stockpiles could be located in the Downstream Iron Ore Processing precinct as long as they were located within the individual plant site boundaries. The stockpiles were not considered to pose any significant offsite risk.

To further improve the BSIA concept development the following actions are recommended by GHD.

In relation to concept alignment,

1. Landcorp should bring alignment between Industrial Ecology precincts and the current concept plan.

- Industrial Ecology precinct names and those on the concept plan should match.
- Precinct land allocations should be revised to match the finalised concept plan.
- Individual industry land allocations should be revised once the precinct land allocations are finalised.

In relation to the BSIA buffer,

2. Further QRA modelling should be done for the BSIA when the following information is available for the industries identified in this report as major risk generators:

- Processes to be used in the development including chemicals to be used (inputs, intermediates and outputs),
- Inventories of the chemicals to be stored on site,
- Pipelines taking products or by-products from one plant to another;

3. QRA model should be updated whenever an industry (especially a major risk generator) is to be introduced to the BSIA. This needs to be done to ensure that its proposed placement does not lead to the 0.5 x 10^{-6} contour exceeding the BSIA buffer boundary.

In relation to individual plant boundaries,

4. Further QRA modelling should be done for the major risk generators once more information about the specific industries is available and finalised. This will help ensure that if there are any required increases in allocated land-sizes, the allocations are adequate and accurate.
5. The land allocations (at current capacities) for the Ethane Extraction and Methanol Plants should be increased to ensure that the target plant boundary contour is within their compounds. The risk contour diameters should be used as guides for the resizing of these areas. The whole fifty in a million contour should be inside the plant boundary.
6. A QRA should be performed before either the Methanol Plant or EDC/VCM Plant is given approval. This will need to be performed to check if the fifty in a million contours will lie within the respective plant boundaries. This action is recommended since accurate representative QRAs were not available for the two plants.

In relation to industry clustering within the BSIA,

7. GHD recommends that the QRA model be further updated whenever there is a new industry looking to be located in an area where there is a cluster of existing industry. Two things which need to be checked will be the effect of the new industry on the cumulative risk of the area and how far this new industry has to be located from the existing industrial cluster.

In relation to deficiencies,

8. The concept plan should be revised and updated to bring it in line with changes discussed with LandCorp and UrbanPlan. Input from the sketch prepared by GHD should be considered.
9. The QRA model should be updated if the shape of the concept plan changes significantly (for example if a land use type is moved to a completely new area).
10. The QRA model should be updated to include transportation risks once the concept plan has been finalised.
11. A separate QRA model should be developed for the port to cater for the transportation of chemicals through the port. The port was outside the scope of this current study.

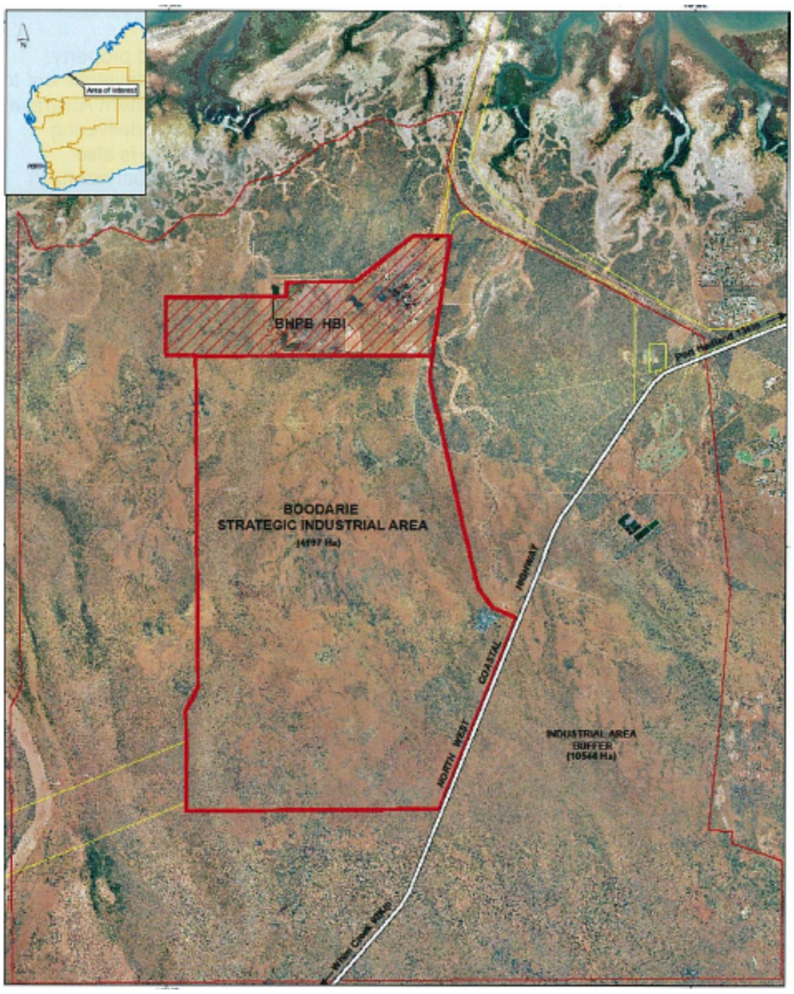
In relation to iron ore stockpiling,

12. LandCorp should ensure that a plant with the potential of having an iron ore stockpile has adequate land allocation so that the stockpile is within the plant's site boundary.

1. Introduction

The Boodarie Strategic Industrial Estate (BSIA) is approximately 5km west of South Hedland [1]. The former BHP Hot Briquetted Iron Plant (HBI) lies to the northern boundary. The potential land to be developed for industrial use is estimated to be 2,230ha. An aerial map of the estate is shown.

Figure 1 Aerial Map of Boodarie Strategic Industrial Area



Currently there are three industries operating within the BSIA [2]. These are EPIC Energy, Mesa Minerals and BJ Young. There are 31 proposed industries for the BSIA. These do not include the three currently there which are going to be relocated.

2. Study Description

2.1 Purpose

The primary objective of the assessment is to determine whether the existing Boodarie Strategic Industrial Estate (BSIA) Buffer is adequate to allow the Strategic Industry Area (SIA) to develop to full capacity by utilising a Quantitative Risk Assessment (QRA) technique.

2.2 Scope

The scope of work includes:

- Review of potential industry activities listed within the Request for Proposal (RfP);
- Generation of likely risk contours for the industrial activities identified within the Strategic Industry Area (SIA);
- Generation of likely risk contours for the industrial activities identified within the Buffer;
- Generation of combined risk contours for the industrial activities identified within the SIA and Buffer;
- Assessment of the adequacy of the Buffer to allow the SIA to reach full capacity;
- Assessment of optimum locations of the range of industries within the SIA;
- Assessment of any restrictions, management options and/or a reduced SIA that may be required to contain industrial risk within the Buffer;
- If required, assess the risk profiles of industrial activities located outside the Buffer boundary which could impact on development of the SIA;
- Assessment of potential locations for an iron ore stockpile.

2.3 Exclusions

- No consideration was given to issues of pollution (or associated chronic health) impact from the operations within the BSIA.
- Radioactive materials were excluded from the assessment, as are military activities.
- Given that the corridors are not yet finalised, information about road, rail and port transport was not included in the models. Pipelines within certain plants were included, but whenever they are not, it is highlighted in the assumptions.

2.4 Limitations

The inputs to the QRA are subject to the following uncertainties and limitations

- Assumptions are included in the "Assumptions Register" in Appendix A.
- Information about many of the current and proposed industries was not available therefore representative estimates were used based on past experience.
- Estimates do not take into account ongoing industry expansions.

3. Boodarie Proposed Description

3.1 Potential Precincts/Zones

The BSIA was divided into various precincts or land use zones. The proposed areas for the various precincts are given in brackets. These were areas estimated from the Industrial Ecology Study [1]. These were:

- Downstream Iron Ore Processing (to contain sintered iron plant, iron ore pelletising plant, DRI iron smelting plant, integrated steel making plant, ferromanganese production plant, ferrosilicon production plant, iron carbide plant) [530ha]
- Downstream Non Ferrous Resource Processing (to contain magnesium production plant, titanium production plant, copper smelter, silicon manganese production plant, silicon metal production plant, Chlor-alkali plant, aluminium smelter, chromite processing plant) [600 ha]
- Downstream petroleum/gas/coal Processing (to contain methanol plant, ammonia/urea plant, ethane extraction, ethane cracker, ethylene dichloride/vinyl chloride plant) [300 ha]
- Port Dependant (to contain two large scale processing plants) [240 ha]
- Utilities and Resource Recovery (to contain two gas fired power stations, coal fired power station, waste-to-energy and material recovery facility, industry feedwater facility, energy facility) [310 ha]
- General Industries [160 ha]
- Noxious Industries [100 ha]

3.2 Potential Industries/Businesses

There is no alignment between the total land allocations in the Industrial Ecology Report and the total land available at the BSIA. There is also no alignment between the naming of the precincts in the Industrial Ecology Report and those on the current concept plan (Figure 2).

3.2.1 Current land allocations

Currently the land allocations are not in alignment with the concept plan. A map of the current concept plan is shown in Figure 3. The total land allocations from the Industrial Ecology Report are 2,230 ha, yet the current concept plan has 1,847 ha available. The 1,847 ha includes the Northern section of the Down Stream Iron Ore Processing area. This was added after discussions with UrbanPlan and LandCorp. A map highlighting that addition is shown in Figure 10 in Appendix C.

Figure 2 Current BSIA Concept Plan

3.2.2 Current naming of precincts

The names in the current concept plan do not correspond to the names in the Industrial Ecology Report. A comparison of the names and areas is given in Table 3.

Table 3 Misalignment between precinct names and areas

Precincts as per concept plan	Precincts are per Industrial Ecology Report
Downstream Iron Ore Processing [304 ha]	Downstream Iron Ore Processing [520 ha]
Non Ferrous Processing [219 ha]	Downstream Non-ferrous Resource Processing [600 ha]
Downstream Petrol and Gas [60 ha]	Downstream Petroleum/Gas/Coal Processing [300 ha]
Port Dependant [154 ha]	Port Dependant [240 ha]
Utilities [257 ha]	Utilities and Resource Recovery [310 ha]
Noxious [100 ha]	Noxious Industries [100 ha]
General [162 ha]	General Industries [160 ha]
Resource Processing [564 ha]	
Energy [28 ha]	
Total [1847 ha]	**Total [2230 ha]**

Apart from the discrepancy in areas of 383 ha, there is no alignment in the naming of the precincts. GHD recommends that LandCorp brings alignment between Industrial Ecology precinct names and the concept plan.

GHD has included a sketch map (Figure 3) which was used for the modelling. The map incorporates changes to the concept plan which were agreed upon in consultation with LandCorp and UrbanPlan.

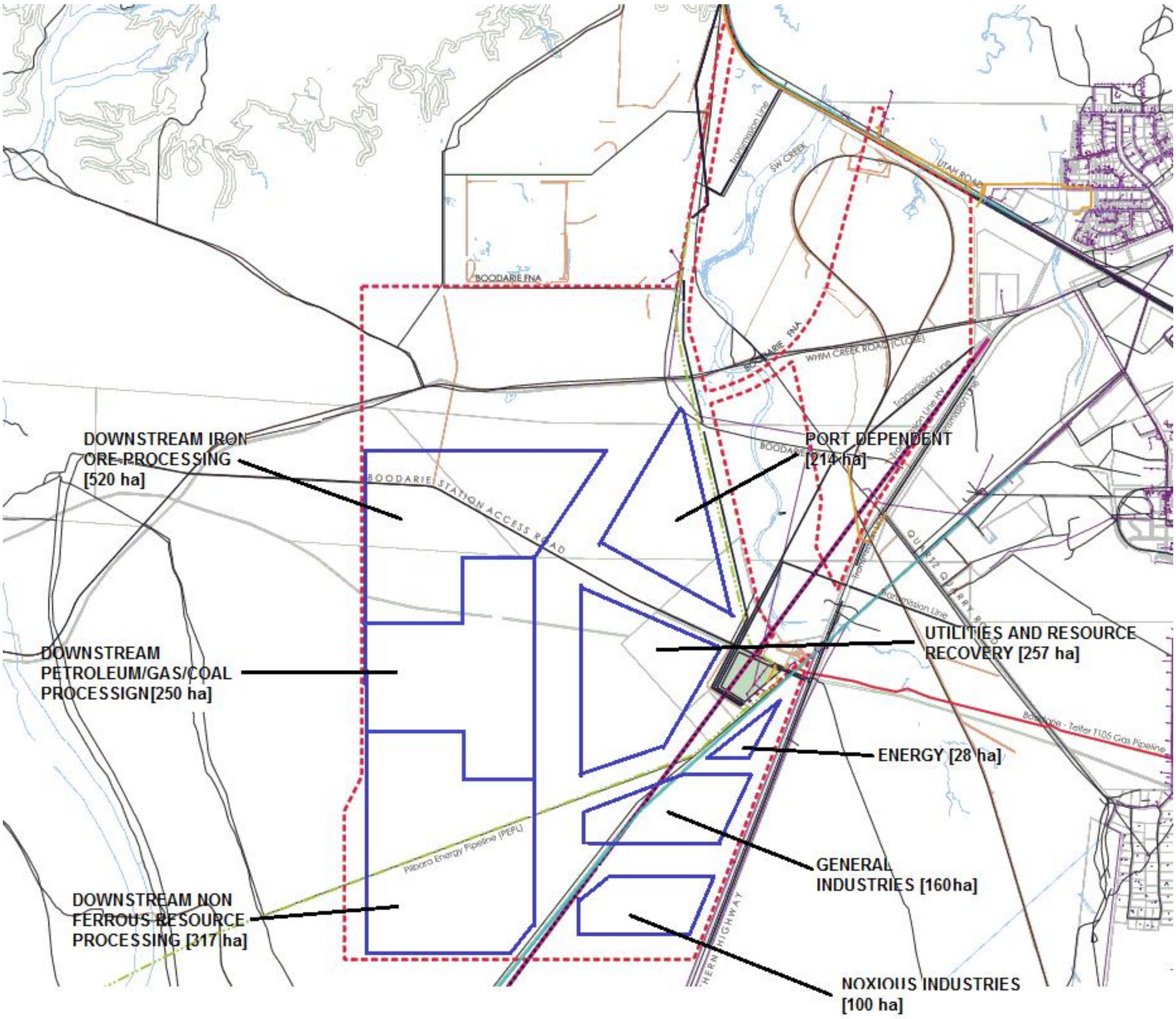
3.2.3 Potential Individual Industries

The potential individual industries within the precincts together with their respective allocated areas are given in Appendix D. These were outputs of the Industrial Ecology Study. Since these allocations are affected by the misalignment issues mentioned above, GHD recommends that these allocations be revised once there is a finalised structural plan. Further discussion on land allocations is in the Deficiencies section of this Report.

3.2.4 Risk Based Land Allocations

Major risk generators (MRGs) are individual industries which have the potential of causing significant offsite risk given their current land allocation. Some of the land allocated for MRGs may need to be increased (or they have to be given individual buffer zones). Findings from this Report (from risk modelling) will determine whether the current allocations for the MRGs are adequate. The land allocations may need to be increased to cater for fire, toxic or overpressure effects. This will ensure that these sites have adequate separation distances from other sites within their vicinity. This will be done by ensuring that the individual risk targets for the site boundaries are met (see Sections 5.1 and 6.1.2 of this Report).

Figure 3 Sketch map of BSIA with revised precincts



3.3 Current Industries

Currently within the precinct there are 3 industries; Epic Energy, BJ Young and Mesa Minerals. BJ Young is a sand extraction business and Mesa Minerals have a manganese ore stockpile. These industries are going to be relocated [2].

4. Methodology

4.1 QRA Methodology

In general, the methodology which was applied for the QRA involved:

- Hazard identification (HAZID);
    - Identification of the likely events to lead to an offsite impact.
- Inventory analysis;
    - Assessment of the likely materials and inventories of materials to be released in the events documented in the HAZID.
- Frequency analysis;
    - Assessment of the frequency of each of the release scenarios identified in the HAZID.
- Risk modelling;
    - Combining each of the release scenarios identified in the HAZID with the inventories of materials to be released and frequency of those events to generate risk contours.
    - Local meteorology data is an input in the model.

GHD used Phast Risk version 6.7, commercial modelling software developed by Det Norske Veritas (DNV) for the assessment of fire, explosion and toxic effects.

In this case, the HAZID, inventory analysis and frequency analysis steps were completed as follows:

4.1.1 Screening

Each of the proposed industries was identified and necessary information was gathered concerning it. From the information gathered a qualitative assessment was undertaken (screening) to determine if the proposed industry had significant offsite impact given its current land allocation. Only those with potential offsite impact were taken forward into the QRA (Table 10 in Appendices G).

4.1.2 Existing industries

None of the existing industries were considered to have offsite impact.

4.1.3 Proposed industries

The following 7 industries were considered to have the potential for significant offsite impact (major risk generators).

- Titanium production plant
- Chlor-alkali plant
- Methanol plant
- Ammonia plant
- Sodium Cyanide Plant

- Ethane Extraction Plant
- Ethylene dichloride (EDC)/Vinyl chloride monomer (VCM) plant.

Since these are proposed industries which have not been taken up by any developer yet, GHD undertook a representative QRA for each type of industry based on past experience for similar facilities. These individual QRAs were then combined to form the current model. For the Methanol Plant and the EDC/VCM plant, no previous QRAs have been found therefore, representative plants and associated QRAs were used to estimate the risk imposed by these sites. Assumptions concerning the screening, the processes, storages and pipelines are in the Assumptions Register in Appendix A and Appendix B.

It is very important to note that BSIA will potentially constitute 31 industrial sites contributing to the overall risk. However, not all pose sufficient risk to affect the overall offsite risk contour. That is why GHD modelled only sites that were classed as 'major risk generators'.

It is also important to note that iron ore stockpiles within the SIA were not considered to be major risk generators. Therefore, iron ore stockpiles could be located in the Downstream Iron Ore Processing precinct as long as they are located within the individual plant site boundaries.

4.2 Location of existing and potential industries

For QRA purposes, only the facilities which were considered as MRGs from the screening process above were allocated specific locations on the map for modelling. All the other industries can be set up around them. The MRGs were located as far away as possible from each other within their allocated land use zones of the concept plan. The following factors were considered when deciding their locations; compatibility between the chemicals present in each industry (to minimise cumulative risk), synergies and proximity to port. In the future when other industries are to be located around the MRGs, the same factors will need to be considered.

4.2.1 Incompatible Chemicals

Industries which have the potential of causing large negative effects (fire, explosive, toxic) have to be allocated areas as far away from each other as practicable. Potential consequences were assessed by checking interactions between chemicals at one industry (inputs, intermediates or outputs) and another. This was done assuming that there was loss of containment in either one of them. Considerations which were taken for each industry are given in Appendix G. For completeness, GHD considered all the potential industries, not only the MRGs.

Prevailing wind across the area has also been considered since it influences the direction and dispersion of emissions from industrial sites [2]. The weather data used is shown in Appendix I.

4.2.2 Synergies

The draft industrial ecology report by GHD [1] identified potential industry groupings based on activity type and potential product exchange. This was used to develop the current concept plan. The risk modelling was done within those constraints. The only deviations were due to the misalignment of the ecology report and the map. This issue is discussed comprehensively in Sections 3.2 and 6.3.1 of this Report.

4.2.3 Proximity to Port

The development of the concept plan included accommodating port dependant activities [1]. Similar to synergies section above, the risk modelling was done within the current constraints and any changes relating to misalignment of ecology report and map which were discussed above apply to this section as well.

4.3 Meteorological Data

The meteorological data which was used for the modelling was taken from the nearest Bureau of Meteorology station in Port Hedland. The annual wind rose and the stability classes for the air mass is shown in Appendix I.

5. Risk Criteria

This study allows for orderly development of BSIA and reduced risk to people by ensuring appropriate developments are in appropriate locations. Important boundaries to be considered are:

- The plant site boundary – for the onsite and offsite risk.
- Buffer zone – for the cumulative risk for all industries.

The risk criteria adopted for this QRA is that developed by the Western Australian Environmental Protection Authority (EPA) [4] in Guidance Note No. 2. The risk criteria given in the Guidance Note measures the risk levels against the following categories:

- Individual Fatality Risk
- Societal Risk

5.1 Location Specific Individual Fatality Risk (LSIR)

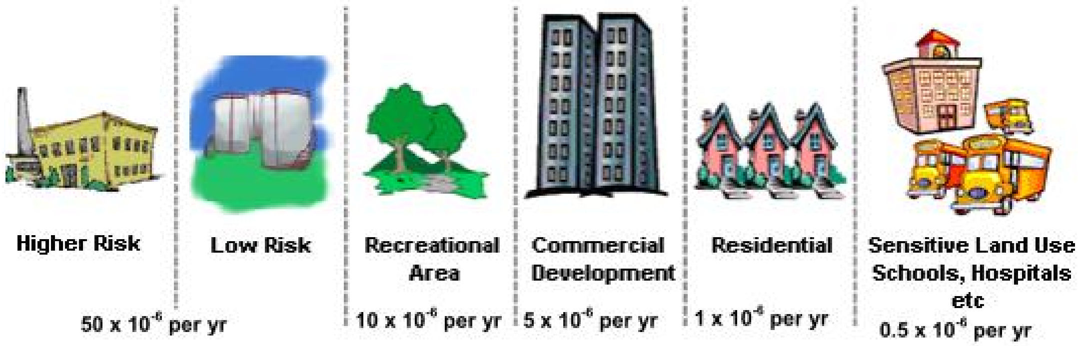
The Location Specific Individual Fatality Risk (LSIR) or Individual Fatality Risk is the risk of death to a person at a particular point. The EPA has set the off-site individual risk criteria for fatalities from hazardous industrial plants at the following levels:

Table 4 EPA LSIR Criteria

Exposure Type	Risk Levels
Residential area	One in a million per year (1 x 10^{-6} per year)
"Sensitive developments", such as hospitals, schools, child care facilities and aged care housing developments,	Half in a million per year (0.5 x 10^{-6} per year)
Industrial Sites	Fifty in a million per year (50 x 10^{-6} per year)
Industrial Site Group (Cumulative)	Hundred in a million per year (100 x 10^{-6} per year)
Non-industrial activity or active open spaces	Ten in a million per year (10 x 10^{-6} per year)
Commercial developments, including offices, retail centres, showrooms, restaurants and entertainment centres	Five in a million per year (5 x 10^{-6} per year)

They are also shown in Figure 4

Figure 4 Risk Levels for Different Usages



The risk level in "sensitive developments", such as hospitals, schools, childcare facilities should not exceed the target of one half in a million per year (0.5 x 10^{-6} per year). In the case of the BSIA, this is the maximum risk imposed by the BSIA offsite that is acceptable at the boundary of the buffer. This is also referred to as the cumulative offsite individual risk (or offsite risk target) in this Report. It was assumed that a 'sensitive development' could occur at the boundary of the buffer zone therefore this criterion was chosen for the buffer boundary. Using this criterion (which is the most conservative) at the site boundary ensures that any development (hospital or recreation or commercial) can be sited safely outside that industrial buffer.

For an individual industry, the risk it imposes at its plant boundary should not exceed fifty in a million per year (50 x 10^{-6} per year). If this risk contour goes beyond its plant boundary, there are at least two options. Either the inventories of the major risk drivers within the plant could be reduced or the plant boundary could be increased so as to accommodate this contour. Since this is a proposed estate, GHD recommends that more land be allocated to individual industries in instances where required by the risk profile.

The cumulative risk imposed upon an industry by others should not exceed a target of one hundred in a million per year (100 x 10^{-6} per year). This criterion is used to check the effect of a new industry on other industries nearby. Landcorp can assess the suitability of locating any new industry next to existing industry using this criterion.

Individual Risk for offsite population assumes that a person is always present and stationary. It does not take into account any actions that people might take in the area to escape from an event, or the actual time that people are present. It is independent of the actual exposed population [4].

5.2 Societal Risk

Societal risk is the risk experienced in a given time period by the whole group of personnel exposed. Societal risk criteria are used to manage the risks to local communities or to the society as a whole from the hazardous activity. In particular, they are used to limit the risk of catastrophes affecting many people at once. Society is particularly intolerant of accidents, which though infrequent, have a potential to create multiple fatalities.

Societal risks include the risk to every exposed person, even if they are only exposed on one brief occasion. They are particularly important for the activities whose special features are not best managed by individual risk criteria such as:

- Transport activities, which spread their risks over a constantly changing population along the routes,
- Toxic gases, whose release may affect very large numbers of people – albeit at very low probability,
- Hazardous activities near busy roads or recreational areas, where many people in vehicles may be exposed to the risk for brief periods.

The societal risk in this study is presented in the form of an FN curve, showing the relationship between the cumulative frequency (F) and number of fatalities (N). It reflects the severity of the hazard and the number of people in proximity to it.

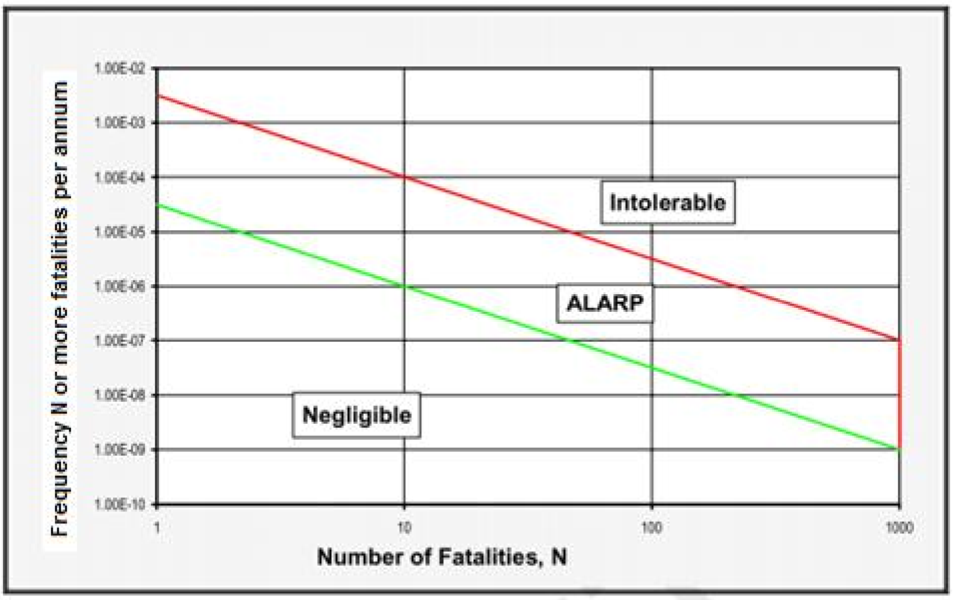
Guidance has not yet been established by the WA EPA for the assessment of risk to many people (societal risk). Therefore the NSW Department of Planning (DoP) FN indicative criteria are used. It appears in Hazardous Industry Planning Advisory Paper Number 4 (HIPAP No 4) [5]. It should be noted that these are only indicative criteria and therefore are not regulated/legislated as in the case of Individual Risk. The values are given in Table 5:

Table 5 NSW DoP Indicative Societal Risk Criteria

(Frequency of N or more Fatalities per year)			
Number of Fatalities	**Intolerable Societal Risk Criteria**	**ALARP Societal Risk Criteria**	**Negligible Societal Risk Criteria**
10	$>1 \times 10^{-4}$	Region between intolerable and negligible	$< 1 \times 10^{-6}$
1000	$>1 \times 10^{-7}$	Region between intolerable and negligible	$< 1 \times 10^{-9}$

The indicative criteria is also shown in Figure 5

Figure 5 NSW DoP Indicative Risk Criteria



Above the intolerable line, an activity is considered undesirable, even if individual risk criteria are met. Within the ALARP region, the risk is considered to have been minimised to the lowest practical level.

6. Results and Discussion

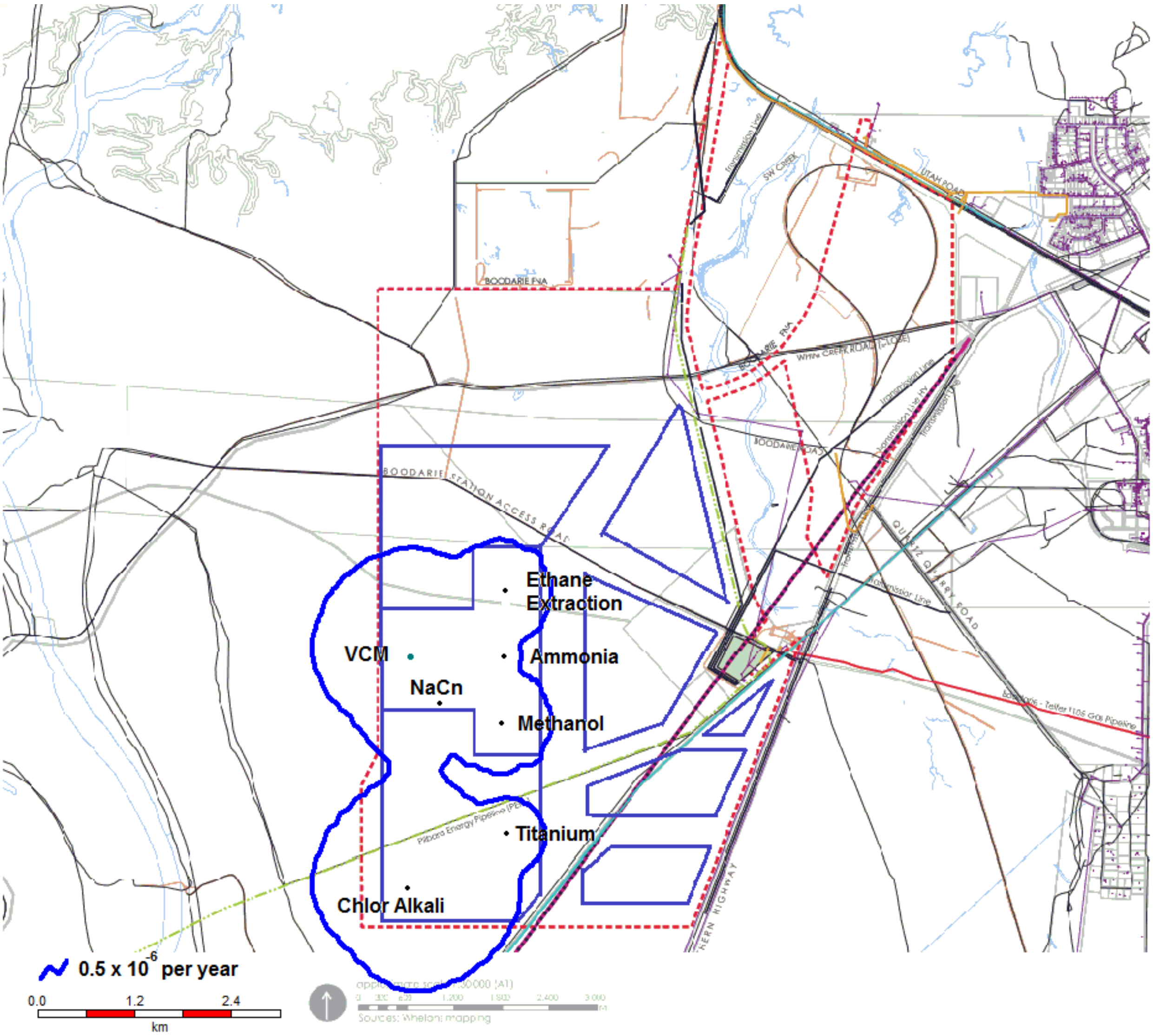
6.1 Individual Risk

The risk assessment results are presented as individual risk contours and as societal risks or FN curves. An overview of the plants included in the assessment is contained in the Appendix A.

6.1.1 BSIA Buffer Zone Allocation

The cumulative offsite individual risk results for the fixed facilities identified as major risk generators within the BSIA are shown in Figure 6 (also Appendix C). The 0.5 x 10^{-6} contour is within the proposed buffer zone.

Figure 6 Cumulative Offsite Individual Risk



The results show that with the current list of proposed industries, the proposed buffer zone is adequate. The proposed buffer zone is 3km wide from the edge of the BSIA boundary. These findings can be used for planning purposes. These results are based on the following major assumptions:

- The proposed plants (MRGs) will use the same processes as those used in the representative QRAs used in the modelling.
- The proposed plants (MRGs) will have comparable inventories of high risk materials (flammable, toxic or overpressure causing) as those used in the representative QRAs used in the modelling.
- The locations of the major risk contributors are as per the sketch provided by GHD in this Report.
- The locations of the corridors are as per the sketch provided by GHD in this Report. Other assumptions which apply to the modelling in general are in the Appendix.
- Although the BSIA will potentially constitute 31 industrial sites contributing to the overall risk, not all pose sufficient risk to affect the overall offsite risk contour. That was the logic behind modelling only the MRGs.

These assumptions will need to be modified as more information becomes available about the actual sites. As more information is made available, the model will need to be updated to reflect an up to date status of the BSIA.

GHD recommends that further QRA modelling be done for the BSIA when the following information is available for the industries identified in this report as major risk generators:

- Process to be used in the development including chemicals to be used (inputs, intermediates and outputs);
- Inventories of the chemicals to be stored on site (from Dangerous Goods Licences);
- Pipelines taking products or by-products from one plant to another;

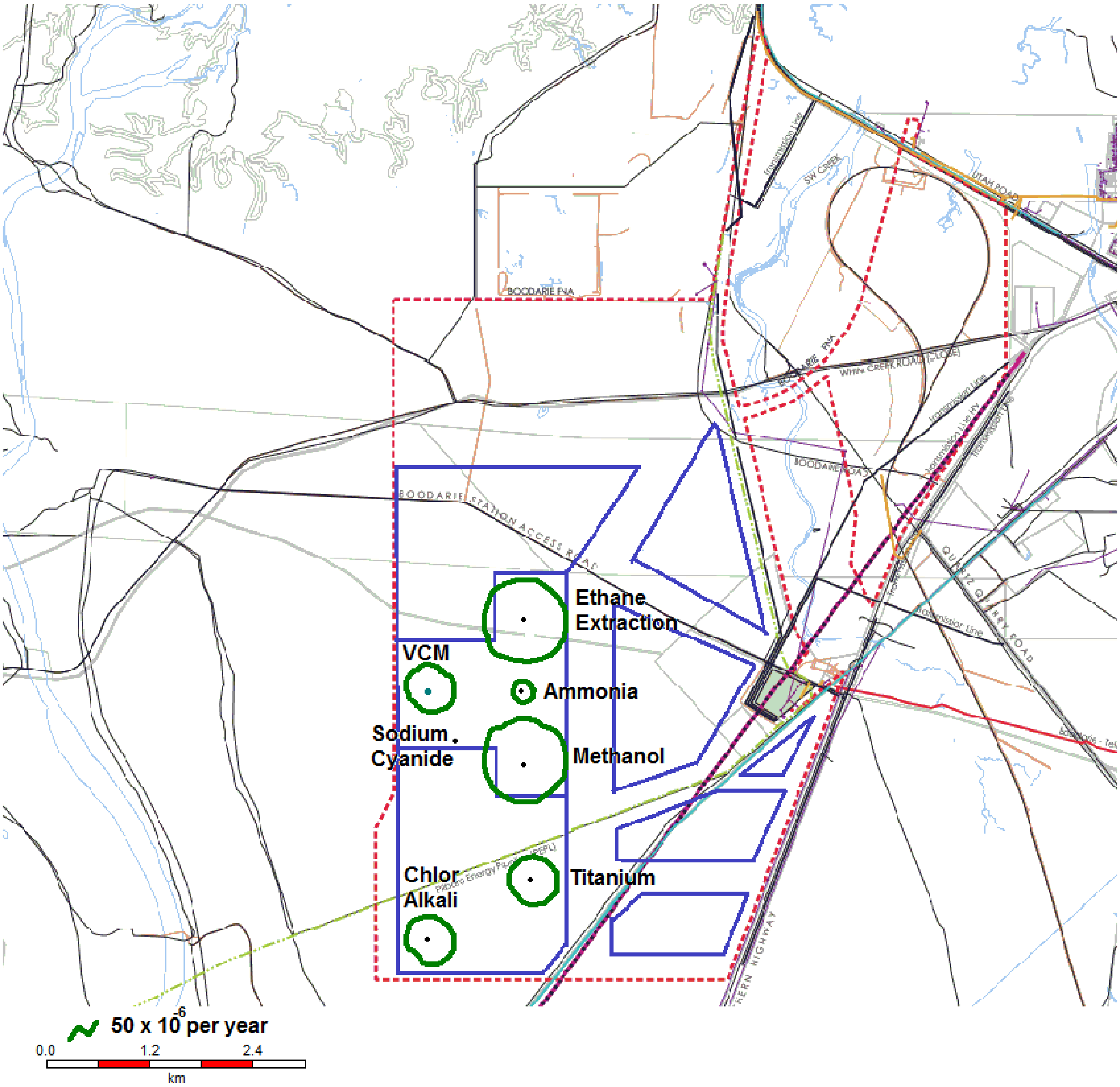
GHD recommends that the model be updated whenever an industry (especially a major risk contributor) is to be introduced to the BSIA. This needs to be done to ensure that its proposed placement does not lead to the 0.5 x 10^{-6} contour exceeding the BSIA buffer boundary.

6.1.2 Major Risk Generators Land Size Allocation

The target for maximum risk at the plant boundary is 50 x 10^{-6} per year (fifty in a million per year). This target caters for all the possible loss of control events within a plant (fire, toxic, overpressure effects). This contour indicates the separation distances required from a certain plant. This contour has to fall within the plant allocated area otherwise the plant will be in breach of WA EPA regulations.

For the major risk contributors, the size of the target contour is shown in Figure 7.

Figure 7 Site boundary target contours (50 in a million per year



A comparison of the target contour diameter and the plant length is shown in Table 6.

Table 6 Comparison of plant boundaries against the fifty in a million contour

MRG	Allocated Area [ha]	Length/Width [m]	$50x10^{-6}$ Contour Diameter [m]	Area of contour [ha]	Exceeds Site Boundary
Chlor-Alkali	50	707	582	26.6	No
Ethane Extraction	60	775	960	72.4	Yes
Titanium	60	775	600	28.3	No
Ammonia	65	806	145	1.7	No
Sodium Cyanide	25	500	70	0.4	No
Methanol	50	707	960	72.4	Yes
VCM/EDC	50	707	660	34.2	No

From the study, the following plants require more land allocation to ensure that the individual plant boundary risk target is met. These are the Ethane Extraction Plant, the Titanium Plant and the Methanol Plant. The target contour for the sodium cyanide plant is very small, therefore it appears as a small point on the map [70 m].

It was assumed that:

- If the fifty in a million contour was outside the plant boundary, the plant would have to be allocated more land in order that the contour falls within the plant boundary. It is also possible to reduce the size of this contour by reducing the capacity and/or inventory of the chemicals on the plant. The decision to either increase land allocation or reduce capacity/and or inventory will depend on discussions between LandCorp and the proposed industrial owner.
- Proposed plants will have product outputs which are given in the industrial ecology report [1].
- Plots which were allocated to these industries were square in shape. This meant that the target boundary contour had to fit within that square. The other assumptions in Section 6.1.1 also apply here.

GHD recommends that further QRA modelling be done for the major risk generators once more information about the specific industries is available and finalised. This will help ensure that if there are any required increases in allocated land-sizes, the allocations are adequate and accurate.

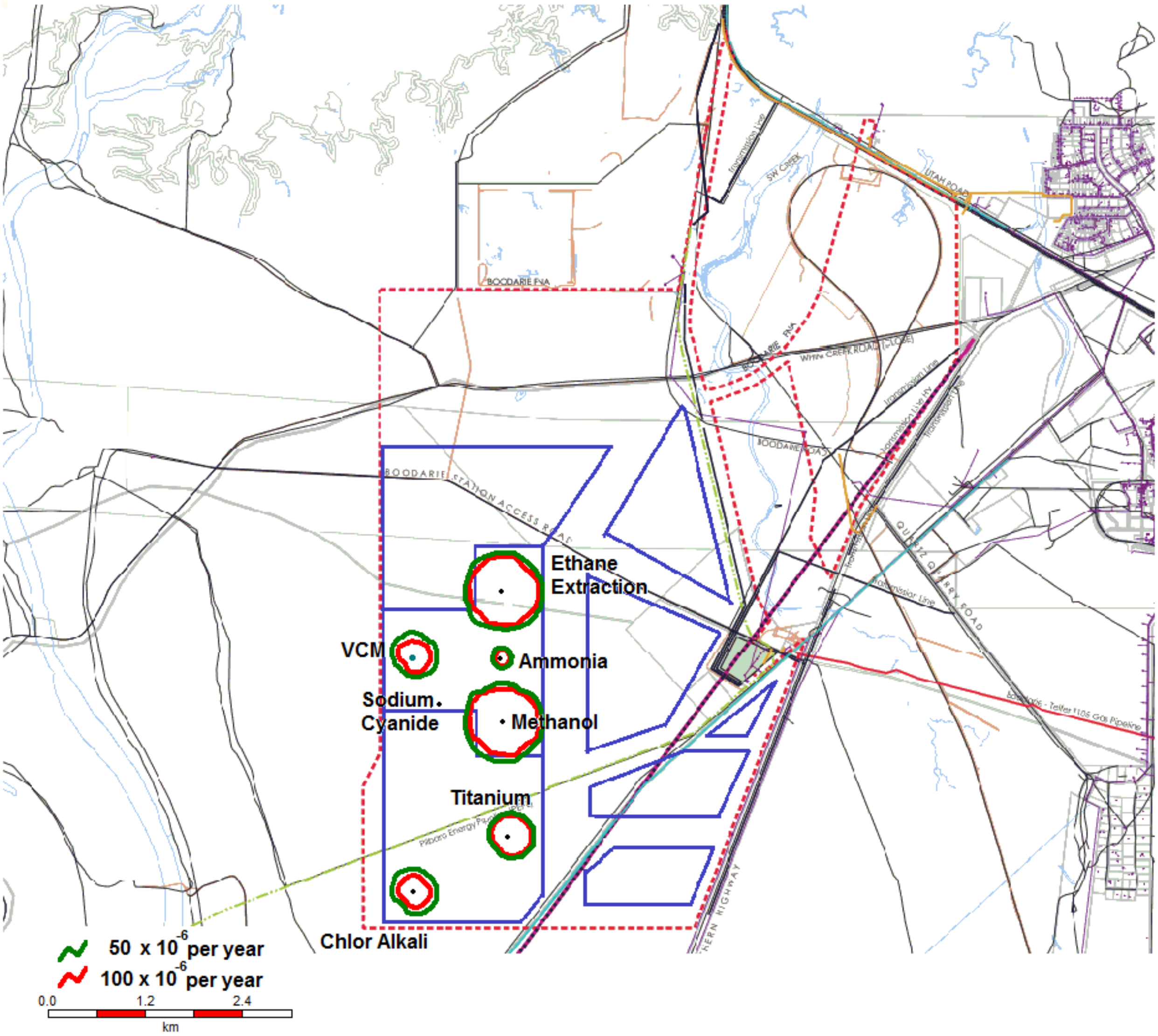
GHD recommends that the land allocations (at current capacities) for the Ethane Extraction and Methanol plants be increased to ensure that the target plant boundary contour is within their compounds. The risk contour diameters should be used as guides for the resizing of these areas. The whole fifty in a million contour should be inside the plant boundary.

For two of the major risk generators, the Methanol Plant and EDC/VCM, accurate representative QRAs were not available. Therefore, preliminary fifty in a million curves were generated using comparable sites with similar toxic chemicals. Rationale for using these as representative curves is given in Appendix B. Due to this, GHD recommends that before either the Methanol Plant or EDC/VCM Plant is given approval, a QRA needs to be performed. This will need to be performed to check if the fifty in a million contour will lie within the plant boundary.

6.1.3 Cumulative risk upon other industries within BSIA

The cumulative risk imposed by existing industries on other industries can only be assessed once proximity of the land occupants to each other in the BSIA is known. For completeness the 100×10^{-6} contours for the MRGs are shown in Figure 8.

Figure 8 Risk Imposed on other industries by cluster



This contour is within the boundary of each of the sites. As mentioned earlier, this factor only becomes significant when there is a cluster of industries. Landcorp can use this criterion for a variety of things:

- To decide whether or not a new industry can go next to a group of industries, i.e. if the offsite risk posed by this new industry will lead to a cumulative risk of greater than 100×10^{-6} in nearby lots, permission should be denied.

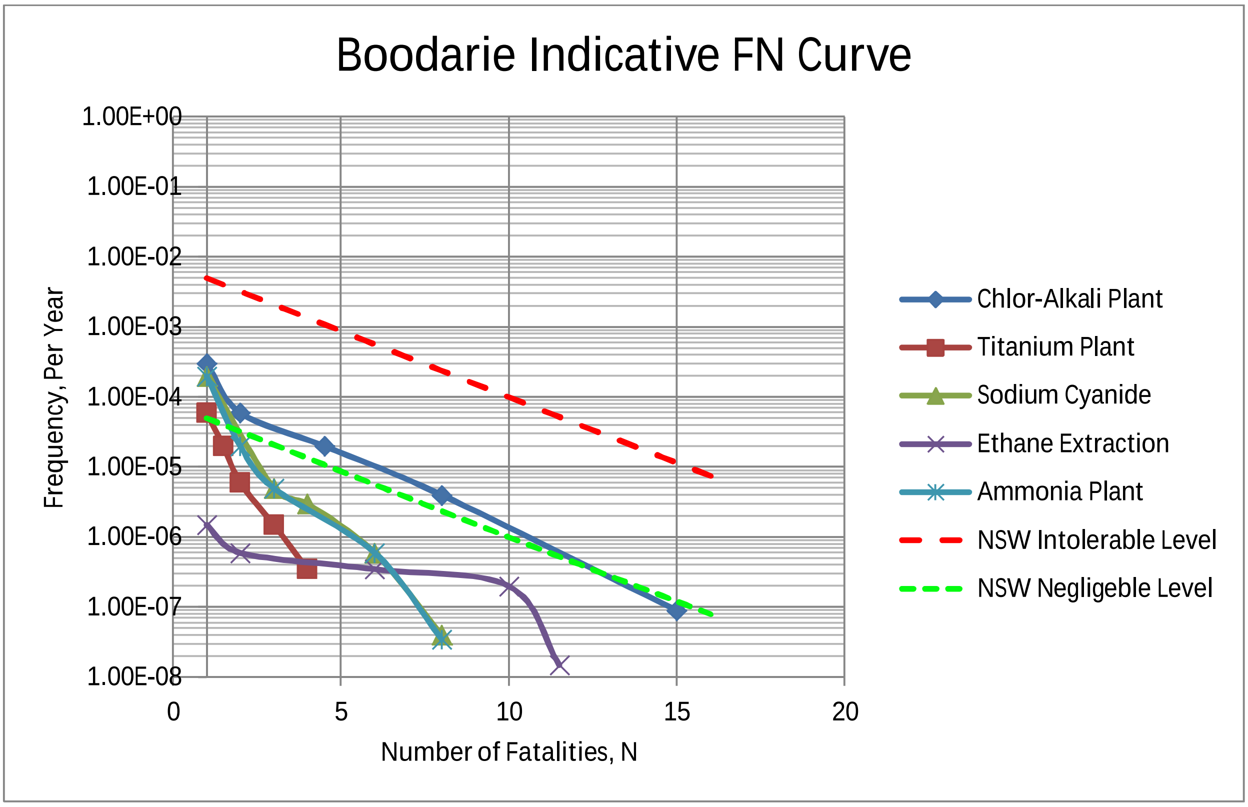
* To decide the boundary of a new lot which is going to be located in an area where there are existing industries that are cumulatively providing an offsite risk of 100 x 10^{-6} in their surroundings.

GHD recommends that the model be further updated whenever there is a new industry looking to be located in an area where there is a cluster of existing industry. Two things which need to be checked will be the effect of the new industry on the cumulative risk of the area and how far this new industry has to be located from the existing industrial cluster.

6.2 Societal Risk

A series of FN curves were produced for the current model. The individual curves in Figure 9 represent societal risk posed by each of the MRGs on the neighbouring industrial populations. This considers all facilities around an MRG being assessed. For example for the Chlor-Alkali plant, this is the societal risk on all surrounding populations (with the exception of Chor-Alkali plant onsite population).

Figure 9 FN Curves for Industrial Populations



According to the criteria, all the activities meet the indicative societal risk criteria. Since the BSIA is still in the planning stage, all the population estimates were taken from the Kwinana Study [6]. They are estimates based on layouts in Kwinana therefore they should only be taken as indicative for the industry mix at BSIA [6].

GHD recommends that, these estimates be updated once a credible industry base is available at BSIA and also once the concept plan is finalised.

6.3 Deficiencies

At this stage of the proposed BSIA, there are various elements which are yet to be finalised. Those which directly affect the risk modelling are; the general land allocations (concept plan), the proposed transportation routes (pipelines included here) and industrial processes (includes process types and inventories). Some work has been done in development of corridors [2] but these are going to be updated to accommodate the up to date land use allocations.

6.3.1 General Land Allocations

The proposed industry land allocations overestimate the available BSIA area by 383 ha. The proposed list requires at least 2230 ha of land yet what's available currently on the BSIA map (concept plan) is 1847 ha. Table 7 indicates the deficiencies.

Table 7 Land allocation discrepancies

Land Use	Allocated Area [ha] (ecology study)	Available Area [ha] (see GHD sketch)	Discrepancy [ha]
Downstream Iron Ore Processing [520 ha]	520	520	0
Downstream Non-ferrous Resource Processing [600 ha]	600	317	283
Downstream Petroleum/Gas/Coal Processing [300 ha]	300	250	50
Port Dependant [240 ha]	240	214	26
Utilities and Resource Recovery [310 ha]	310	257	53
Noxious Industries [100 ha]	100	100	0
General Industries [160 ha]	160	161	negligible

Depending on how these land allocations are done to bring alignment, the risk model might need to be updated.

GHD recommends the following in relation to the concept plan:

- The concept plan should be revised and updated to bring it in line with changes discussed with LandCorp and UrbanPlan. Input from the sketch prepared by GHD should be used.
- The proposed land allocations for individual industries should be revised in the Industrial Ecology Report to align them to the updated concept plan.
- The QRA model should be updated if the shape of the concept plan changes significantly (for example if a land use type is moved to a completely new area).

6.3.2 Transportation Routes and Corridors

Since transportation routes are dependent on the concept plan, they will only be finalised when the land allocations for the structural plan are complete. The risks associated with transportation (trucks, trains, pipelines etc.) can only be modelled meaningfully when the concept plan has been updated. The accuracy of that modelling will also depend on the information available on about the new industries and how they are going to be moving their products.

GHD recommends the following in relation to transportation routes:

- The risk model should be updated to include transportation risks once the concept plan has been updated.
- A separate risk model should be developed for the port to cater for the transportation of chemicals through the port. The port was outside the scope of this current study.

6.3.3 Industrial processes

Since the BSIA is still in the planning stages, there was no information on how different materials were going to be processed and also how much of the chemicals would be part of the inventory at any given time. GHD therefore used representative plants which used the most likely processes. The results therefore assume that the final industry owners at the BSIA will use the processes GHD has selected. They also assume that they have the inventories which GHD has chosen.

Since this is the case, GHD recommends that the risk model be updated as more information becomes available about potential landowners and their processes.

7. Conclusions and Recommendations

When compared to the sensitive area criteria, 0.5 x 10^{-6} per annum (half in a million per year), the proposed buffer zone for the BSIA is adequate.

When compared to the plant boundary target, 50 x 10^{-6} per annum (fifty in a million per year), the individual plant allocations are adequate except for the Ethane Extraction and Methanol plants. These plants need increased allocations to ensure that their site risk contours of 50 x 10^{-6} per annum are within their site boundaries.

To improve the BSIA concept development the following actions are recommended by GHD.

In relation to alignment,

1. Landcorp should bring alignment between Industrial Ecology precincts and the current concept plan.

- Industrial Ecology precinct names and those on the concept plan should match.
- Precinct land allocations should be revised to match the finalised concept plan.
- Individual industry land allocations should be revised once the precinct land allocations are finalised.

In relation to the BSIA buffer,

2. Further QRA modelling should be done for the BSIA when the following information is available for the industries identified in this report as major risk generators:

- Process to be used in the development including chemicals to be used (inputs, intermediates and outputs);
- Inventories of the chemicals to be stored on site (from Dangerous Goods Licences);
- Pipelines taking products or by-products from one plant to another;

3. QRA model should be updated whenever an industry (especially a major risk contributor) is to be introduced to the BSIA. This needs to be done to ensure that its proposed placement does not lead to the 0.5 x 10^{-6} contour exceeding the BSIA buffer boundary.

In relation to individual plant boundaries,

4. Further QRA modelling should be done for the major risk generators once more information about the specific industries is available and finalised. This will help ensure that if there are any required increases in allocated land-sizes, the allocations are adequate and accurate.
5. The land allocations (at current capacities) for the Ethane Extraction and Methanol Plants should be increased to ensure that the target plant boundary contour is within their compounds. The risk contour diameters should be used as guides for the resizing of these areas. The whole fifty in a million contour should be inside the plant boundary.
6. A QRA should be performed before either the Methanol Plant or EDC/VCM Plant is given approval. This will need to be performed to check if the fifty in a million contours will lie within the respective plant boundaries. This action is recommended since accurate representative QRAs were not available for the two plants.

In relation to industry clustering within the BSIA,

7. GHD recommends that the QRA model be further updated whenever there is a new industry looking to be located in an area where there is a cluster of existing industry. Two things which need to be checked will be the effect of the new industry on the cumulative risk of the area and how far this new industry has to be located from the existing industrial cluster.

In relation to deficiencies,

8. The concept plan should be revised and updated to bring it in line with changes discussed with LandCorp and UrbanPlan. Input from the sketch prepared by GHD should be considered.
9. The proposed land allocations for individual industries should be revised in the Industrial Ecology Report to align them to the updated concept plan.
10. The QRA model should be updated if the shape of the concept plan changes significantly (for example if a land use type is moved to a completely new area).
11. The QRA model should be updated to include transportation risks once the concept plan has been finalised.
12. A separate QRA model should be developed for the port to cater for the transportation of chemicals through the port. The port was outside the scope of this current study.

In relation to iron ore stockpiling,

13. LandCorp should ensure that an industry with the potential of having an iron ore stockpile has adequate land allocation to ensure that the stockpile is within the industry's site boundary.

8. References

[1] GHD, “Report for Boodarie Strategic Industrial Area Industrial Ecology Strategy,” 2011, 29 August.

[2] urbanplan Worley Parsons, “Boodarie Strategic Industrial Area Phase One Concept Plan,” 2011, p. 58.

[3] WA EPA, “Guidance for Risk Assessment and Management: Off-site individual Risk from Hazardous Industrial Plant,” Western Australia, 2000, July.

[4] UK HSE, “Reducing Risks, protecting people. HSE's decision making process,” 2001. [Online]. Available: http://www.hse.gov.uk/risk/theory/r2p2.pdf. [Accessed 10 June 2012].

[5] NSW Department of Planning, “Hazardous Industry Planning Advisory Paper No 4: Risk Criteria for Land Use Safety Planning,” 2011, January.

[6] GHD, “Report for Kwinana Cumulative Risk Assessment and Land Use Plannning Stage 2 - Technical Report,” Perth, 2008.

[7] Woodward-Clyde, “Consultative Environmental Review Proposed Boodarie Resource Processing Estate,” 1995, December.

[8] GHD, “Australian Nitrogen Gladestone Ammonia Plant QRA,” 2006, August.

[9] WA EPA, “Locating and Estimating Air Emmissions from Sources of Ethylene Dichloride,” March 1984. [Online]. Available: http://www.epa.gov/ttnchie1/le/ethyldi.pdf. [Accessed 1 June 2012].

[10] Western Australian Planning Commission, “Port Hedland Area Planning Study Final,” 2003, September.

Appendix A

Assumptions Register

A. General Assumptions

A1. EPA Criteria

1. The EPA criterion used at the boundary of buffer was 0.5 x 10^{6} per year (half in a million per annum). This criterion is for sensitive developments. It is assumed that sensitive developments can be located outside the buffer zone. This is the most conservative of the EPA criteria therefore if a sensitive development can be next to the buffer zone then any other development is eligible.

2. The EPA criteria used at the boundary of each individual industry is 50 x 10^{6} (fifty in a million). This means that the risk imposed by an industry at its site boundary should not exceed this value. If this target is exceeded either the inventory of the major risk contributor has to be reduced or the size of the allocated plot should be increased so that this target is within the site boundary.

3. The EPA target for cumulative risk imposed upon an industry by others should not exceed a target of one hundred in a million per year (100 x 10^{-6} per year). This means that for a group of industries the risk they impose on a nearby empty block should not exceed this target. This was highlighted to help LandCorp when they are allocating blocks next to industrial clusters.

4. The NSW HIPAP, FN indicative criteria were used since WA EPA has not published any societal risk criteria yet.

A2. Screening

1. Sites which were screened out were assumed to have no significant effect on overall offsite risk contour.

2. A summary of screening plan is shown in Table 10 Appendix G.

3. Only 7 of the 31 industrial sites were considered to have significant offsite risk. The 7 were classed as Major Risk Generators.

A3. Modelling Methodology

1. All industries which were modelled were based on similar representative plants, since currently there are no industries at the BSIA.

2. Representative QRA’s were used for all the plants which were modelled.

3. All failure cases were as per original QRAs. This allowed for meaningful validation of the Boodarie models.

4. Leak durations were also as per original QRAs.

5. For the methanol plant and the Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant, representative risk curves were used. They were based on the potential inventories of toxic chemicals. This was done because no representative QRAs could be found for these two plants.

6. Only 7 of the 31 industrial sites were modelled. The 7 were classed through screening as Major Risk Generators. Only 7 were modelled because they were the ones which pose sufficient off-site risk to affect the overall offsite contour.

7. Each industry was modelled as a point source in the centre of its allocated area. This was because no layouts of the new plants were available. Generated risk contours were compared to the original QRAs for validation.
8. The weather conditions for a standard day used in the model are based on statistical data from the Bureau of Meteorology. They are taken from the meteorological station at Port Hedland Airport. This data was used because it is the most reliable data closest to the BSIA.

A4. Map

1. The Buffer zone is 3km from the edge of the BSIA [7].
2. A sketch map prepared by GHD was used (Appendix C). This was used because it reflected the outputs of the discussions GHD had with LandCorp and UrbanPlan. The sketch map was also used for clarity purposes since contours can be viewed easily against a white background.

Appendix B

Model Information and Assumptions

Phast Risk 6.7 Modelling

The following steps were taken to complete the modelling

- An individual industrial plant in BSIA was selected.
- Previous QRA results from a similar industrial plant were reviewed. Only QRAs done by GHD were used.
- A representative QRA was performed for individual plant using the previous QRA.
- The representative QRA was validated against the previous QRA. This was done by comparing the diameters of the risk contours.
- Once validation was completed, inventory adjustments were made to the representative QRA to match BSIA capacities.
- Risk contours were generated for the individual representative QRAs with BSIA capacities.
- This process was repeated for 5 of the MRGs. In the case of the Methanol Plant and the VCM/EDC plants, representative contours from 2 of the MRGs already modelled were used.
- Finally, the 7 risk contours for MRGs were combined to give the cumulative risk contours for the BSIA.

B1 Chlor-Alkali Plant

B1.1 Boodarie Information

- Area 50 hectares
- Sodium chloride coming in: 400 ktpa
- Approximately 240 ktpa of chlorine being produced.

B1.2 Coogee Chlor Alkali Plant

- Representative plant taken from Kwinana QRA.
- Plant capacity is 2251 kg/hr. which is approximately equal to 20 ktpa.

B1.3 Remodelling of representative QRA for Validation

- Completed.
- Results were comparable.
  - Boodarie 1×10^{-6} line has diameter of 700m yet the Coogee one has diameter of 515m.
  - Boodarie Model will therefore represent the worst case scenario for a Chlor-Alkali plant with capacity of 20 ktpa.

B1.4 Inventory Adjustments Assumptions

- Boodarie is 12 times bigger than Coogee.
- Therefore all inventories have been multiplied by 12.
- The validated model was therefore adjusted using 12 times the original inventory.

B2 LPG Extraction

B2.1 Boodarie Information

- Area 60 Hectares
- LPG Production Capacity: 2 450 ktpa

B2.2 Wesfarmers LPG

- Representative plant taken from Kwinana QRA.
- Plant capacity is 350, 000 tonnes per annum which is equal to 350 ktpa

B2.3 Remodelling of representative QRA for Validation

- Completed.
- Results were comparable.
    - 1×10^5 contour has diameter of 1146m for Boodarie and diameter of 1147m for Wesfarmers. Boodarie is comparable.

B2.4 Inventory Adjustments Assumptions

- Boodarie is 7 times bigger than Wesfarmers.
- Therefore all inventories have been multiplied by 7.
- The validated model was therefore adjusted using 7 times the original inventory.

B3. Ammonia

B3.1 Boodarie Information

- Area 65 Hectares
- Ammonia Production Capacity: 250 ktpa

B3.2 Australian Nitrogen

- Representative plant taken from Australian Nitrogen QRA at Gladstone in Queensland [8].
- Plant capacity is 750 tonnes per day which is equal to 274 ktpa.

B3.3 Remodelling of representative QRA for Validation

- Completed
- Results comparable
  - $1x10^5$ contours has D 300m for Boodarie and D 340m for Australian Nitrogen.
  - Results are reasonable since Boodarie's capacity is slightly lower than that of Australian Nitrogen.

B3.4 Inventory Adjustments Assumptions

- None required.
- Sites are comparable.

B4. Titanium Dioxide

B4.1 Boodarie Information

- Area 60 Hectares
- Production Capacity: 50 ktpa

B4.2 Tiwest

- Representative plant taken from Tiwest QRA at Kwinana
- Plant capacity is 70 ktpa

B4.3 Remodelling of representative QRA for Validation

- Completed
- Results not comparable
  - $1x10^5$ contour has D 676 m for Boodarie and D 400 m for Tiwest.
  - Boodarie model will therefore represent the worst case scenario for Titanium Plant with a capacity of 70 ktpa.

B4.4 Inventory Adjustments Assumptions

- None required.
- Sites are comparable.

B5. Sodium Cyanide

B5.1 Boodarie Information

- Area 25 hectares
- Production capacity: 15 ktpa

B5.2 CSBP Limited in Kwinana

- Representative plant taken from Tiwest QRA at Kwinana
- Plant capacity is 63 ktpa

B5.3 Remodelling of representative QRA for Validation

- Completed
- Results for combined plant comparable.
  - $1x10^5$ contour has D 1302 for Boodarie and D 1200m for CSBP. This means the Boodarie case represents the worst case scenario for such an incident.
  - The validation was done on a cumulative model that included production of Sodium Cyanide, Ammonia, Chlorine and Ammonium Nitrate at CSBP.
  - The Boodarie contour for sodium cyanide on its own is D 70m. Since it was taken from a validated model, it was assumed to be reasonable.
  - More research on independent sodium cyanide plant QRA's should be done in the future.

B5.4 Inventory Adjustments Assumptions

- Boodarie capacity is a quarter of Tiwest
- The inventories were divided by 4
- The model was therefore adjusted using a quarter of the original inventory.

B6. Methanol

B6.1 Boodarie Information

- Area 50 hectares
- Production capacity: 800 ktpa

B6.2 Representative QRA

- No reliable representative QRA could be found; therefore representative risk contours from this study were used.

B6.3 Process and Inventories

Steam-methane reforming, water-gas shift reaction, catalytic reaction

50% of methanol is exported through port

Methanol Process Description

The process consists of four main process steps: feed gas preparation, synthesis gas generation, methanol synthesis and distillation supported by utilities and offsite units. This is the process description for a methanol plant at Kwinana.

Feedgas Preparation

Natural gas is compressed and sulphur removed by hydrodesulphurisation. The desulphurised gas is cooled and then contacted with hot water over a bed of packing to saturate the gas. Additional steam generated in the boiler is used to achieve the required steam to carbon ratio for steam reforming. The total feedstream is then pre-heated prior to reforming.

Synthesis Gas Generation

Preheated gas flows from the pre-heater to the tube side of the gas heated reformer (GHR) where it is partly reformed over a catalyst. The partly reformed gas flows from the GHR to the secondary reformer where the bulk of the reforming takes place. The heat required for the endothermic reforming in both the GHR and secondary reformer is provided by partially burning the GHR effluent with pure oxygen.

The three main chemical reactions which occur are:

Steam reforming - $CH_4 + H_2O = CO + 3H_2$

Shift reaction - $CO + H_2O = CO_2 + H_2$

Combustion - $2H_2 + O_2 = 2H_2O$

The net effect of these reactions is the production of a synthesis gas stream which is composed of carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen (H_2).

Methanol Synthesis

The synthesis gas joins the synthesis loop recycle gas and is fed to the methanol converter. The converter is a tubular cooled converter design where the gas is preheated to reaction temperatures inside the tubes as it flows up through the hot catalyst bed. The hot reacted gas leaves the converter and provides heat to the saturator water circuit before finally being cooled. Crude methanol is sent to distillation whilst the uncondensed gases are recirculated back to the converter.

The two main chemical reactions which occur are:

$CO + 2H_2 = CH_3OH$
$CO_2 + 3H_2 = CH_3OH + H_2O$

Distillation

Crude methanol is let down in pressure and fed to the product purification section. This section consists of a topping column and a refining column. The product methanol specification is for a water content of less than 0.10 wt %. The water bottoms from the refining column have a specification of less than 100 ppm of methanol and are recycled back to the saturator.

Estimated Inventories

From the industrial ecology study 595ktpa natural gas is required to produce 800 ktpa methanol.

B6.4 Estimated Risk Contours

From the current models, the ethane extraction curves would most likely represent a methanol plant.

This is because, the risk in driven by flammable gas effects in both cases. The ethane extraction contours will most likely be very conservative since the inventories of flammable gas are much higher in that process.

As more information about the methanol plant becomes available, a QRA on that specific plant can be done.

B7. VCM/EDC

B7.1 Boodarie Information

- Area 50 hectares
- Production capacity: 100 ktpa EDC and 240 ktpa VCM

B7.2 Representative QRA

- No reliable representative QRA could be found; therefore representative risk contours were used.

B7.3 Process and Inventories

EDC – Iron (III) chloride-catalysed reaction of ethene and chlorine [9].

VCM – EDC is used in the production of VCM

In this case the risk is mainly driven by toxic effects.

B7.4 Estimated Risk Contours

Judging from the inventories, the Chlor-Alkali contours will most likely represent this plant. The Chlor Alkali contours are most likely to be bigger in size because of the greater inventories of toxics on a Chlor Alkali Plant. Therefore these contours are worst case estimates for a VCM/EDC plant.

As more information about the VCM/EDC plant becomes available, a QRA on that specific plant can be done.

Appendix C

Sketch Map

GHD Sketch Map Incorporating Output from Discussions with LandCorp

Figure 10 Boodarie Concept Plan with Increased Iron Ore Allocation

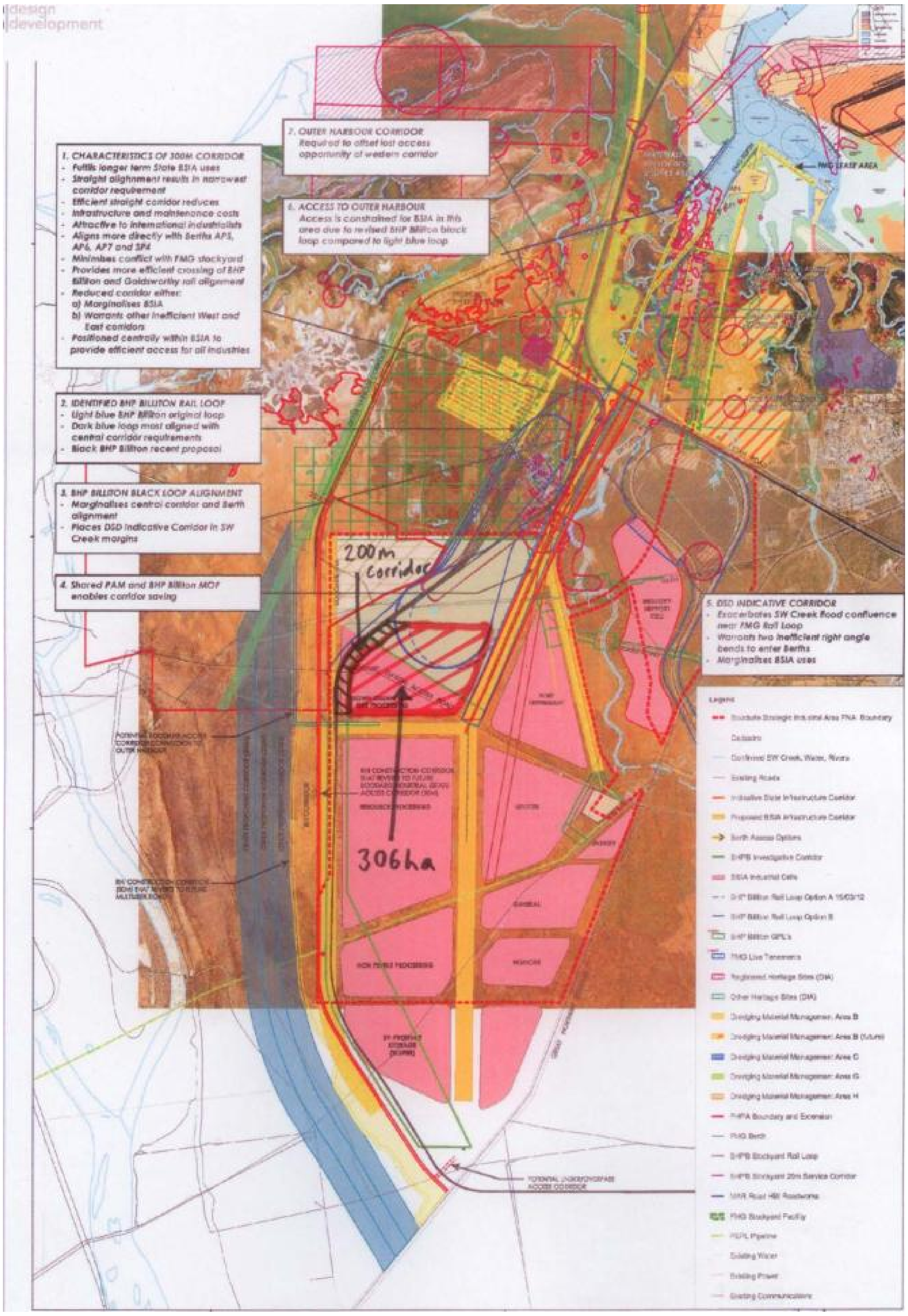


Figure 11   Sketch map of BSIA with revised precinct sizes

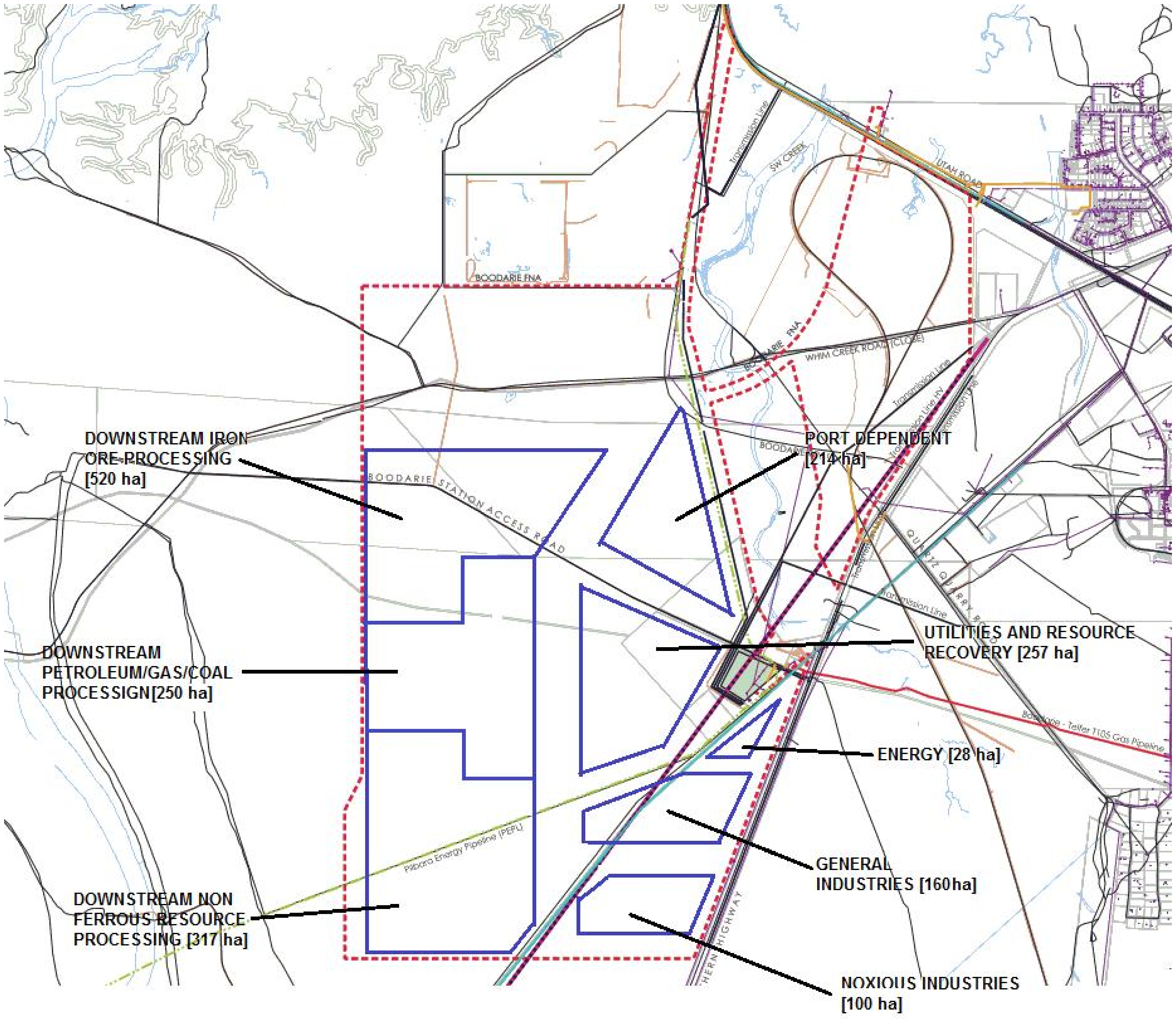


Figure 12 Cumulative Offsite Individual Risk Contours for BSIA

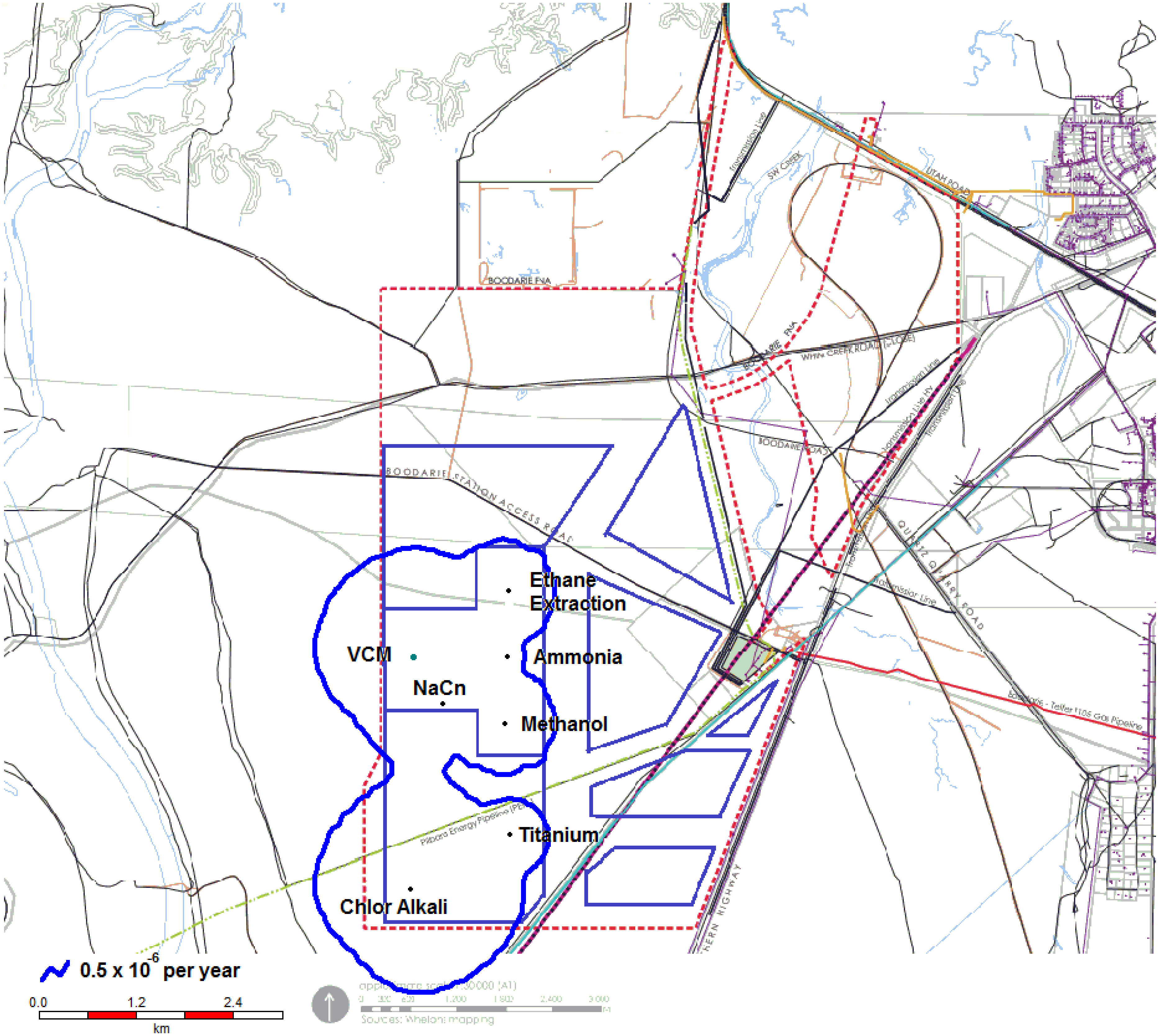


Figure 13 Site Boundary Target Contours (50 in million per annum)

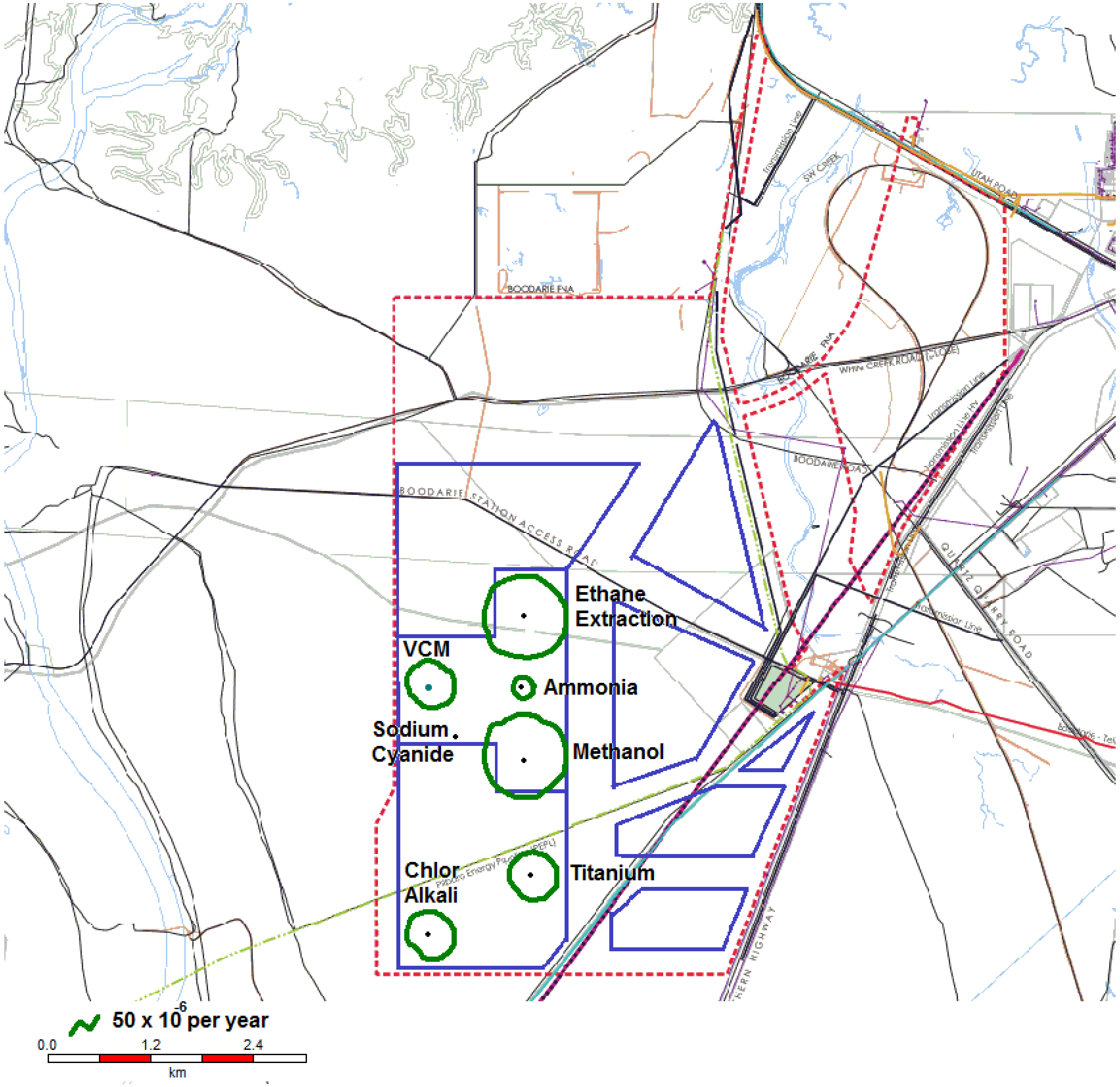
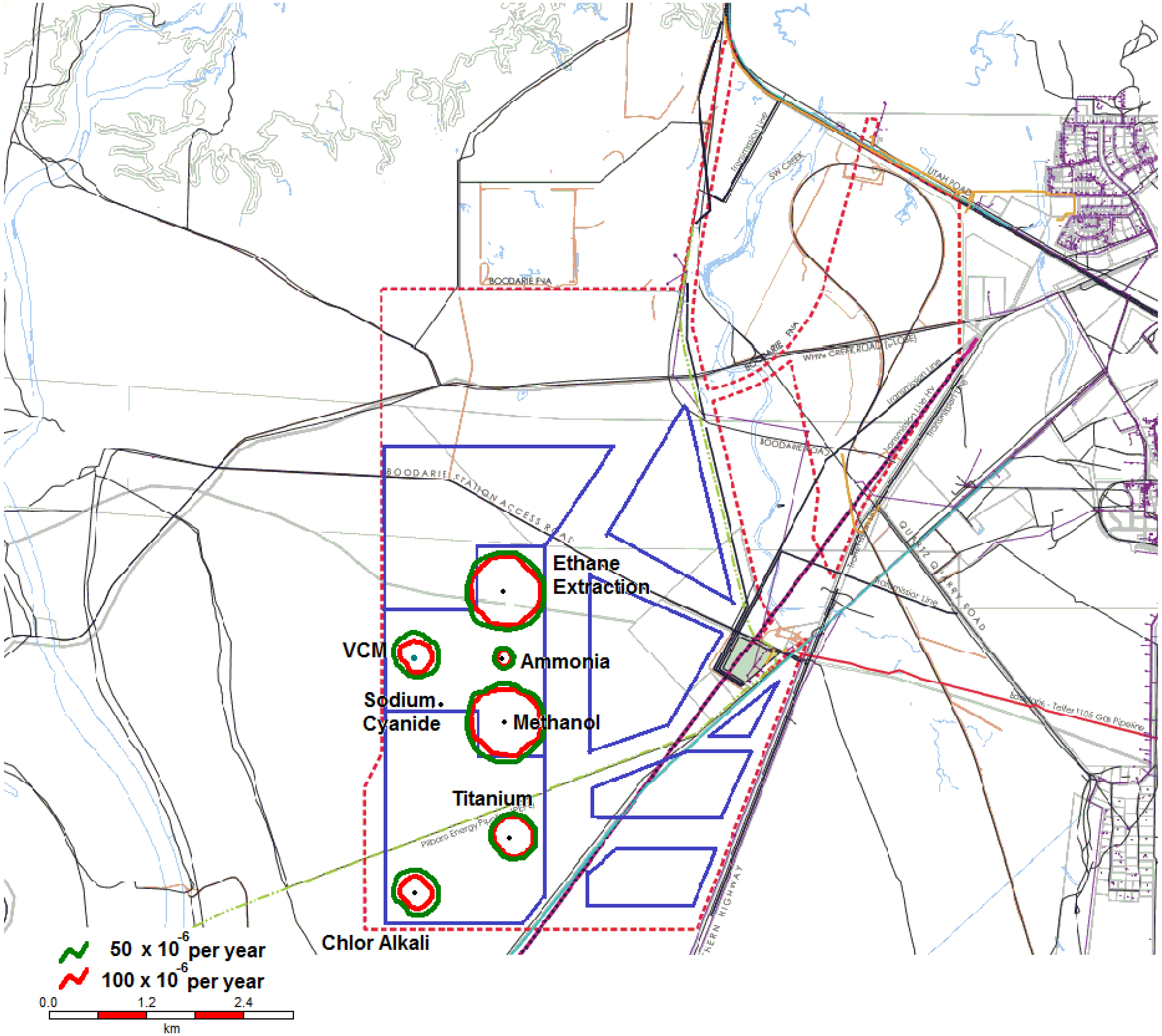


Figure 14 Risk Imposed on other industries by cluster



Appendix D

Allocated Industry (Industrial Ecology Study)

Table 8 Allocated Land Use

Land Uses	Potential Industry Types	Area [ha]
Downstream Iron Ore Processing	Sintered iron plant	80
	Iron ore pelletising plant	80
	DRI / alternative smelting iron plant	140
	Integrated steel making plant	120
	Ferromanganese production plant	40
	Ferrosilicon production plant	40
	Iron carbide plant	20
Downstream Non-Ferrous Resource Processing	Magnesium production plant	50
	Titanium production plant	60
	Copper smelter	120
	Silicon manganese production plant	50
	Silicon metal production plant	50
	Chlor-alkali plant	50
	Aluminium smelter	120
	Chromite processing plant (ferro-chromium production)	100
Downstream petroleum/gas/coal processing	Methanol plant	50
	Ammonia / urea plant	65
	Ethane extraction	60
	Ethane cracker	50
	Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant	50
	Sodium cyanide plant	25
Port Dependant	Large scale processing plant (liquids - not defined)	120
	Large scale processing plant (conveyors - not defined)	120
Utilities and Resource Recovery	Gas fired power station (250 MW)	50
	Gas fired power station (120MW)	25
	Coal fired power station (800 MW)	100
	Waste-to-energy and material recovery facility	10
	Industry feedwater facility	65

Land Uses	Potential Industry Types	Area [ha]
	Energy facility (electricity, steam, heat, chill)	60
General Industry	General industries	160
Noxious Industry	Noxious industries	100
	Total	2,230

Notes

14. List taken from the Industrial ecology study [1]

15. Allocated land uses were used by GHD to prepare the sketch map

Appendix E

Land Allocation Calculations

Figure 15 Area Calculation

Zone	Required Area (ha) [from ecology report]	Allocations on map [sketch map]		Current Amended Area [sketch map]	Additional Required
Downstream iron ore processing	520	1. Original Allocated Area (164)	164	520	0
		2. Triangle at the top (140)	140		
		3. Top half of the resource processing area (520-304)	216		
Downstream non-ferrous resource processing	600	1. Original Allocated Area (219)	219	317	283
		2. Bottom part of Resource Processing Area Less some DPGC (98)	98		
Downstream petroleum / gas / coal processing (DPCG)	300	1. Ethane Extraction (60)	60	250	50
		2. Ammonia (65)	65		
		3. Sodium Cyanide (25)	25		
		4. VCM/EDC (50)	50		
		5. Methanol (50)	50		
Port dependant	240	Original allocated area (214)	214	214	26
Utilities and resource recovery	310	Original allocated area (257)	257	257	53
General Industry	160	Ok	161	161	-1
Noxious Industry	100	Ok	100	100	0
Energy			28	28	-28
	2230		1847	1847	383

Notes:

1. Proposed land uses go over the available land by 383 ha.
2. LandCorp accepted GHD suggestions for amendment of map on 15 June, 2012.
3. Land uses marked in yellow are those that require additional area.
4. Correspondence from UrbanPlan on 19 June, 2012, confirmed what GHD had already sketched out for the Downstream iron ore processing area.

Appendix F

Potential Industrial Processes

Table 9 Potential Industrial Processes

Industry	Possible Processing Method
Sintered iron plant	Thermal treatments, sintering furnace
Iron ore pelletising plant	Grinding, concentration and slurry transport, pelletising furnace
DRI / alternative smelting iron plant	HYL or Midrex process
Integrated steel making plant	Basic Oxygen Furnace or Electric Arc
Ferromanganese production plant	Production of ferromanganese from iron-containing manganese ores (blast furnace)
Ferrosilicon production plant	Carbothermic reaction of silica (quartz) in an electric arc furnace
Iron carbide plant	Haematite and magnetic reduction of iron carbide
Magnesium production plant	Electrowinning of magnesium or chemical reduction of magnesium compounds at high temperatures with carbon, calcium carbide or ferrosilicon
Titanium production plant	Purification, sponge production
Copper smelter	Smelting to produce blister copper
Silicon manganese production plant	Electric furnace
Silicon metal production plant	Carbothermic reaction of silica (quartz) in an electric arc furnace
Chlor-alkali plant	Electrolysis of sodium chloride with chlorine and sodium hydroxide as products
Aluminium smelter	Hall-Heroult process (electrolytic process)
Chromite processing plant (ferro-chromium production)	Submerged electric arc furnace
Methanol plant	Steam-methane reforming, water-gas shift reaction, catalytic reaction
Ammonia / urea plant	Haber Process
Ethane extraction	Isolation from natural gas
Ethane cracker	Production of ethylene from ethane in steam cracking
Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant	Direct chlorination and oxy-chlorination of ethylene
Sodium cyanide plant	Treating hydrogen cyanide with sodium hydroxide
Large scale processing plant (liquids - not defined)	Subject to specific industry type

Industry	Possible Processing Method
Large scale processing plant (conveyors - not defined)	Subject to specific industry type
Gas fired power station (250 MW)	Gas fired power generation
Gas fired power station (120MW)	Gas fired power generation
Coal fired power station (800 MW)	Coal fired power station
Waste-to-energy and material recovery facility	Waste to gas thermal conversion technology, including material recovery facility (MRF)
Industry feedwater facility	Production of industry feedwater at different qualities, feeding from range of potential water sources.
Energy facility (electricity, steam, heat, chill)	Potential joint-industry cogeneration or tri generation plant, potential to feed from industry waste heat
General industries	Subject to specific type of industry
Noxious industries	Subject to specific type of industry

Appendix G

Industry Screening

Table 10 Screening to identify major risk generators

All Potential Industry Types	Hazards (fire, toxic or explosion)	Possible offsite effects	Modelled in QRA (MRGs)
Sintered iron plant	Dust explosion from coke breeze	No	
Iron ore pelletising plant	No notable issues	No	
DRI / alternative smelting iron plant	Fire and explosion from coal gas Dust explosion from coal dust	No	
Integrated steel making plant	Oxygen may cause localised burning Dust explosion from coal dust	No	
Ferromanganese production plant	Dust explosion from coal dust	No	
Ferrosilicon production plant	Dust explosion from coal dust	No	
Iron carbide plant	Natural gas may cause fire and/or explosion.	No	
Magnesium production plant	Petroleum may act as fuel if there is a fire	No	
Titanium production plant	Toxic effects from Chlorine release Toxic effects Liquid Chlorine pools Toxic effects of liquid Toluene Fire from methane release	Yes	Yes
Copper smelter	Sulphur dioxide off gas could be vented to atmosphere	No	
Silicon manganese production plant	Coke and coal dust may cause dust explosion	No	
Silicon metal production plant	Carbon monoxide is a waste which may be released	No	
Chlor-alkali plant	Toxic effects from Chlorine release Toxic effects of liquid Chlorine pools.	Yes	Yes
Aluminium smelter	HF is an exhaust gas with toxic effects.	No	
Chromite processing plant (ferro-chromium production)	Toxic effects of Carbon monoxide is a waste product which could be released	No	
Methanol plant	Fire or explosion on natural gas Fire or explosion due to methanol	Yes	Yes

All Potential Industry Types	Hazards (fire, toxic or explosion)	Possible offsite effects	Modelled in QRA (MRGs)
Ammonia / urea plant	Fire from methane release Fire from hydrogen release Toxic release of ammonia vapour Liquid Ammonia pools	Yes	Yes
Ethane extraction	Fire or BLEVE from the release of methane or ethane or propane or butane.	Yes	Yes
Ethane cracker	Fire effects of ethane	No	
Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant	Toxic effects of EDC Toxic effects of VCM Toxic effects of Chlorine Fire and explosive effects of VCM	Yes	Yes
Sodium cyanide plant	Toxic effects of HCN which is an intermediate Toxic effects of ammonia Fire or explosion effects of natural gas	Yes	Yes
Large scale processing plant (liquids - not defined)	Not defined	No	
Large scale processing plant (conveyors - not defined)	Not defined	No	
Gas fired power station (250 MW)	As above for natural gas	No	
Gas fired power station (120MW)	As above for natural gas	No	
Coal fired power station (800 MW)	As above for natural gas	No	
Waste-to-energy and material recovery facility	Not defined	No	
Industry feedwater facility	No notable issues	No	

Notes:

1. Screening process was a qualitative process carried out by GHD based on past experience.
2. All those which were not taken to the QRA stage were left out because they were considered to have no significant offsite effects. This does not mean that they do not have onsite effects.

Appendix H

Weather Data

Figure 16 Port Hedland Airport Annual Wind Rose

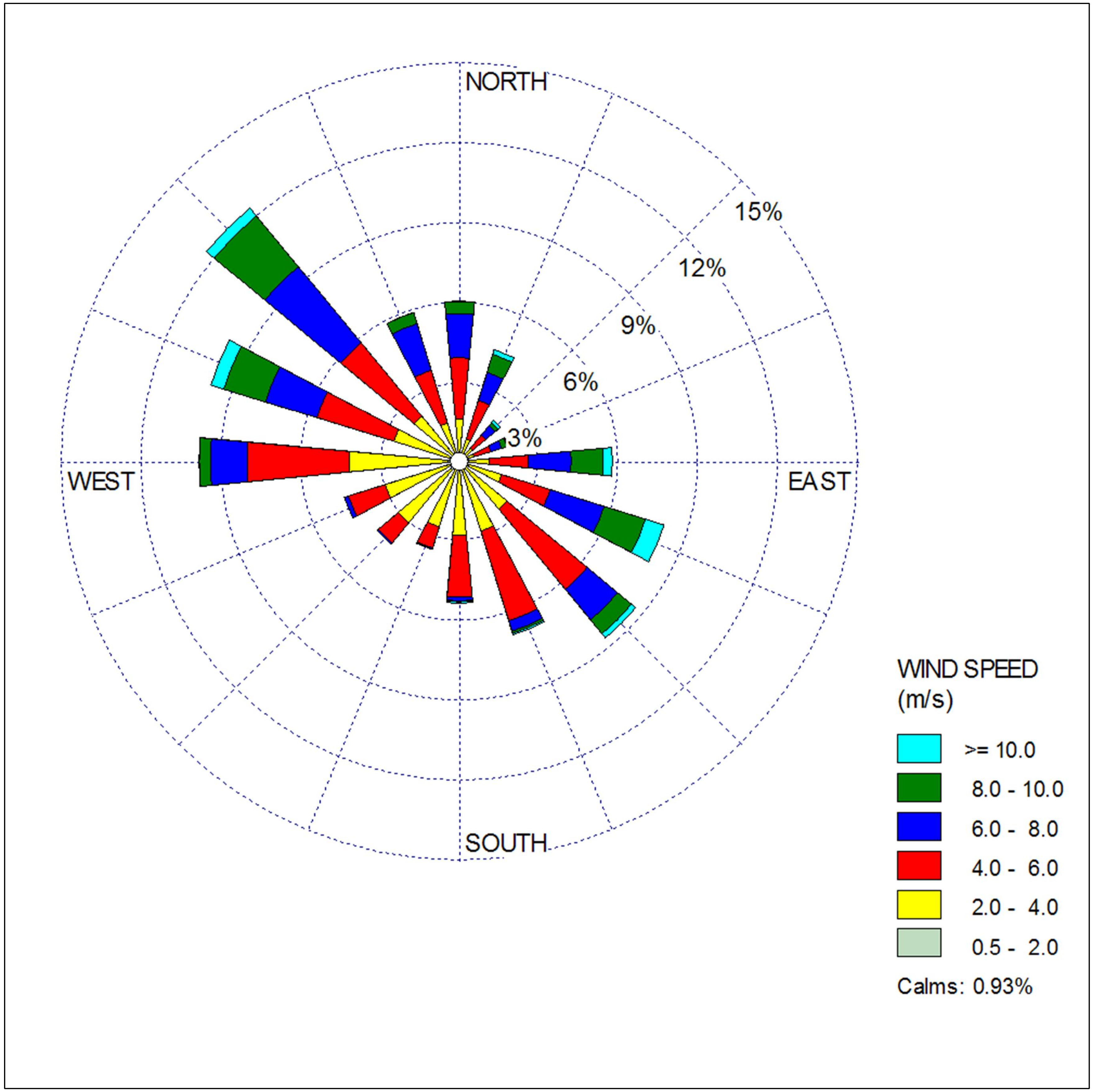


Table 11 Wind Direction Dependent Risk Factors

Directions/Wind Classes (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	SUB-TOTAL
A,B&C	0.017836189	0.02159118	0.00985684	0.0065712	0.0144332	0.0124384	0.008801	0.007158	0.004811	0.005046	0.007158	0.00528	0.005163	0.009505	0.034382	0.023586	0.193616522
D (1-5 m/s)	0.011969021	0.00305093	0.00176015	0.0031683	0.0059845	0.0090354	0.015255	0.012556	0.008566	0.006219	0.00575	0.007627	0.007745	0.006219	0.007979	0.006571	0.119455527
D(>5 m/s)	0.020769772	0.01701479	0.00668857	0.0066886	0.031448	0.0455292	0.029453	0.007862	0.004459	0.001056	0.001525	0.003286	0.024759	0.04682	0.054447	0.017484	0.319291246
E&F	0.010326215	0.00316827	0.00234687	0.0032856	0.0065712	0.0144332	0.03356	0.041422	0.036259	0.023117	0.026637	0.029805	0.061253	0.035907	0.02781	0.011734	0.367636705
Total	0.060901197	0.04482516	0.02065243	0.0197137	0.058437	0.0814363	0.087069	0.068998	0.054095	0.035438	0.04107	0.045999	0.09892	0.098451	0.124619	0.059376	1

Directions/Wind Classes (m/s)	Average Wind Speed (m/s)
A,B&C	3.15
D (1-5 m/s)	3.27
D(>5 m/s)	7.17
E&F	2.57
total average	4.87

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Document Status

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