REPORT

CAMELLIA PRECINCT

PACKAGE F: HAZARD RISK

IMPLEMENTATION REPORT

NSW GOVERNMENT DEPARTMENT OF PLANNING AND ENVIRONMENT

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ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
CRPS	Camellia-Rosehill Place Strategy
DA	Development Application
DPE	NSW Department of Planning and Environment
EbD	Enquiry by Design
EIS	Environmental Impact Statement
GPOP	Greater Parramatta and the Olympic Peninsula
GSC	Greater Sydney Commission
HIPAP	Hazardous Industry Planning Advisory Paper
LUIS	Land Use and Infrastructure Strategy
LUSS	Land Use Safety Study
NSW	New South Wales
PIC	Place-based Infrastructure Compact
PLR	Parramatta Light Rail
QRA	Quantitative Risk Assessment
SEPP	State Environmental Planning Policy
SSD	State Significant Developments
WSA	Western Sydney Airport

TERMINOLOGY

Term	Definition
Combustible liquid	Any liquid, other than a flammable liquid, that has a flash point, and has a fire point that is less than its boiling point (AS 1940–2004).
Consequence	Outcome or impact of a hazardous incident, including the potential for escalation.
Flammable liquid	Liquids that give off a flammable vapour at temperatures of not more than 60.5°C, closed cup test, or not more than 65.6°C, open cup test, normally referred to as the flash point (AS 1940:2017).
Flash fire	The combustion of a flammable vapour and air mixture in which flame passes through that mixture at less than sonic velocity, such that negligible damaging overpressure is generated.
Flash point	The lowest temperature, corrected to a barometric pressure of 101.3 kPa, at which application of a test flame causes the vapour of the test portion to ignite under the specified conditions of test (AS 1940:2017).
Gasoline	Synonymous with petrol, the common used term in the refining industry.
Individual risk	The frequency at which an individual may be expected to sustain a given level of harm from the realization of specified hazards.
Jet/spray fire	The combustion of material emerging with significant momentum from an orifice.
Lower flammability limit (LFL)	That concentration in air of a flammable material below which combustion will not propagate.
Pool fire	The combustion of material evaporating from a layer of liquid at the base of the fire.
Risk	The likelihood of a specified undesired event occurring within a specified period or in specified circumstances. It may be either a frequency (the number of specified events occurring in unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances.
Societal risk	The relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realization of specified hazards.

1. EXECUTIVE SUMMARY

1.1. Background

New South Wales Department of Planning & Environment (DPE), in collaboration with City of Parramatta Council (Council), industry, the community and State agencies, is leading the development of the Camellia-Rosehill Place Strategy and Master Plan for the Camellia –Rosehill Precinct (the Precinct). The Precinct is defined by Parramatta River to the north, Duck River to the east, the M4 Motorway to the south and James Ruse Drive to the west, all of which form physical boundaries to the Precinct, as shown in Figure 1.1.

Figure 1.1: Precinct boundaries

The Camellia Rosehill Precinct (the Precinct) is presently dominated by industrial activity, with large amounts of land also allocated to Rosehill Gardens Racecourse and stabling yards for Parramatta Light Rail and Sydney Metro. Its industrial legacy means that soils are heavily contaminated across most of the precinct.

Located in the geographic heart of Sydney, the precinct has an important strategic role in the Greater Parramatta and Olympic Peninsula (GPOP). Previous investigations have

identified that the area should be retained for urban service land with a town centre, but that the costs of infrastructure and remediation should be carefully considered when making future land use decisions.

This Place Strategy and Master Plan is being prepared for the whole Precinct and draws on the substantial body of previous investigations, including ongoing collaboration with industry, the community and state agencies.

The overarching objective of the Place Strategy is to provide an integrated 20-year vision, which recognises the strategic attributes of the Precinct, guides future land use and infrastructure investment decisions and which can be delivered with the support of State and local agencies.

DPE has engaged Sherpa Consulting Pty Ltd (Sherpa) to deliver technical studies for Package F (Hazard Risk), with the following scope of work:

- Identify the hazards present in the Precinct in the context of the requirements of the State Environment Planning Policy No. 33 (SEPP 33)[1], Ref [1].
- Develop a quantitative risk model for the Precinct.
- Assess the risk results against qualitative and quantitative criteria for strategic land use planning as detailed in HIPAP 10, Ref [2].
- Provide 'hazard risk' advice at a strategic level to inform the Camellia-Rosehill Place Strategy.

The high-level purpose of the hazard-risk work is to ensure that the proposed:

- land uses and their distribution are consistent with the hazards and associated risks from existing facilities and pipelines storing, using and transferring flammable hydrocarbons within the Precinct.
- the number and location of people residing or working in the Precinct are consistent with the population thresholds that are defined by the Precinct risk profile.

An Enquiry by Design (EbD) process was undertaken to inform the preparation of the Place Strategy. The EbD was an interactive process which explored a number of master plan options for Camellia-Rosehill which could deliver the vision for the precinct and resulted in a master plan which was the subject of public consultation as part of the Camellia-Rosehill Directions Paper. The master plan was further refined following exhibition of the Directions Paper and consideration of the submission received.

The draft place strategy was publicly exhibited on 17 December 2021 until 4 March 2022. The draft master plan was further refined following exhibition of the draft place strategy

[1] SEPP 33 has been incorporated, unchanged and in full as Section 3 of the SEPP (Resilience and Hazards), 2021. For this report, SEPP33 means the relevant sections of the SEPP (Resilience and Hazards).

and consideration of the submissions received. Refer to the DPE's finalisation report for further information.

1.2. Summary of key findings of the report

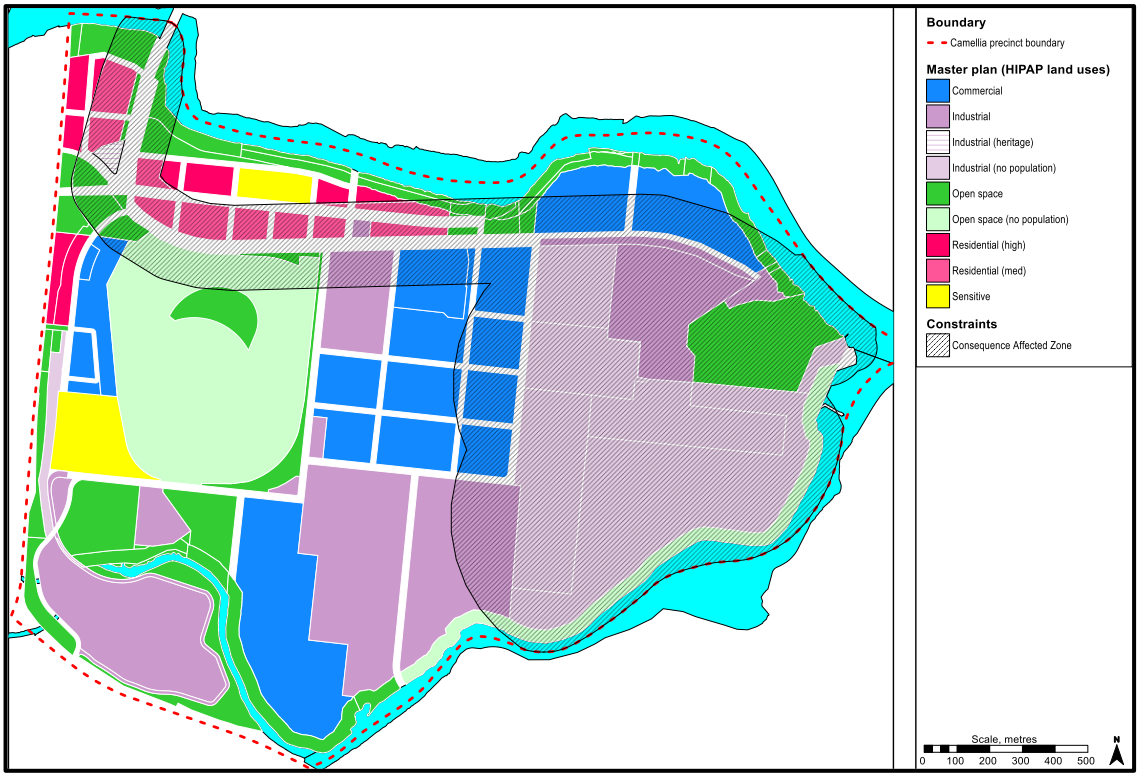
The master plan complies with all qualitative and quantitative risk criteria defined in HIPAP 10, Ref [2], incorporating:

- the separation distance from potentially hazardous industrial facilities
- the separation distance from the pipelines
- population limits specified on development in the Precinct, especially in the pipeline 'consequence affected zone'.

The following planning considerations are recommended:

- Developments proposed with 'sensitive' uses, such as childcare centres, hospitals and aged care facilities in the consequence affected zone (refer to Figure 1.2) need to be referred to DPE (hazards) for comment to ensure that they comply with the qualitative risk criteria in HIPAP 10.
- The population used to define the master plan has been optimised and therefore further population intensification would **not** meet the risk criteria in HIPAP 10. The consent authority must therefore consult DPE (hazards) if a development is proposed with a population greater than that allowable for any location, particularly those defined as Town Centre (medium) in the master plan (Figure 3.1) prior to submission of a Preliminary Hazard Analysis. A review of land use safety considerations and compliance with HIPAP 10 will be required.
- All development applications must refer to the pipeline operator for comment as per the State Environmental Planning Policy (Transport and Infrastructure) 2021, subdivision 2 'development adjacent to pipeline corridors'.

Figure 1.2: Pipeline consequence affected zone



2. INTRODUCTION

2.1. Background

The Camellia Rosehill Precinct (~321 ha) plays a strategic role in the Greater Parramatta and the Olympic Peninsula (GPOP). Camellia was identified by the NSW Government as a priority growth area in 2014, resulting in precinct wide Land Use and Infrastructure Strategy in 2015 and subsequently development of a Town Centre Master Plan in 2018. Work on the Town Centre was paused pending outcomes of Greater Sydney's 2019 Draft Place-based Infrastructure Compact (PIC) Pilot which aimed to ensure infrastructure delivery was matched with growth across the 26 precincts in the GPOP corridor. The PIC recommended that Camellia be retained for urban service and industrial land, however, should the Government seek to progress a town centre (in the form of the 2018 plan or a modified form), before any rezoning a number of issues had to be resolved. It was determined that a coordinated and strategic approach was required, and a place strategy be prepared for the whole Precinct, drawing on previous work and including ongoing collaboration with industry, the community and state agencies.

DPE has engaged a range of technical services to determine opportunities and challenges at the site. These technical studies have informed the development of the place strategy and master Plan for the precinct. This Implementation Report has been prepared following completion of the technical studies for Package F (Hazard Risk) and considering potential issues associated with the existing industrial sites and pipelines transporting flammable fluids through the Precinct.

2.2. Camellia-Rosehill Vision

The Camellia-Rosehill vision has been set by DPE as is reproduced below:

Camellia-Rosehill has an important strategic role as an industry and employment hub within the Greater Parramatta and Olympic Peninsula (GPOP) Economic Corridor. By 2041, the precinct will be enhanced, with service and circular economy industries, and new recreational and entertainment facilities, all enabled by better transport access via light rail, active transport and road connections.

A well-designed town centre next to the light rail stop will be the focus of community activity.

A new urban services precinct and retention of heavy industrial land will ensure Camellia-Rosehill fulfills its potential to be an employment powerhouse.

New homes and jobs will be close to public transport supported by new quality public spaces including public open spaces, public facilities high quality street infrastructure, and walking and cycling paths.

Key environmental areas such as Parramatta River, Duck River and their wetlands will be protected and enhanced. Camellia's rich heritage will be preserved, celebrated and promoted.

Country and culture will be valued and respected with the renewal guided by Aboriginal people.

The Precinct will be net zero ready and set a new standard for environmental sustainability with embedded renewable energy networks, integrated remediation and water management strategies, and circular economy industries.

Recycled water will be connected to all residences, businesses and public spaces and will support the integrated network of green infrastructure.

Camellia will be a showcase of recovery and restoration – a place of economic prosperity but also a place where people love to live, work and enjoy.

2.3. Objectives and scope

The high-level objective of this report was to provide 'hazard risk' advice at a strategic level to inform the Camellia-Rosehill Place Strategy to guide future growth over the next 20 years.

The more detailed objectives were to:

- Identify the hazards present in the Precinct in the context of the requirements of the State Environment Planning Policy No. 33 (SEPP 33)[2], Ref [1].
  - SEPP 33 requires that detailed analysis must be carried out if dangerous goods[3] greater than a specified threshold are stored or transported.
- Develop a detailed analysis in the form of a quantitative risk model for the Precinct incorporating locations exceeding the SEPP 33 thresholds.
- Assess the risk results against qualitative and quantitative criteria for strategic land use planning in HIPAP 10, Ref [2], and determine the appropriate level of land use safety planning around the locations exceeding the SEPP 33 thresholds related development and infrastructure.
- Provide land use safety advice to inform the Camellia-Rosehill Place Strategy.

[2] SEPP 33 has been incorporated, unchanged and in full as Section 3 of the SEPP (Resilience and Hazards), 2021. For this report, SEPP33 means the relevant sections of the SEPP (Resilience and Hazards).

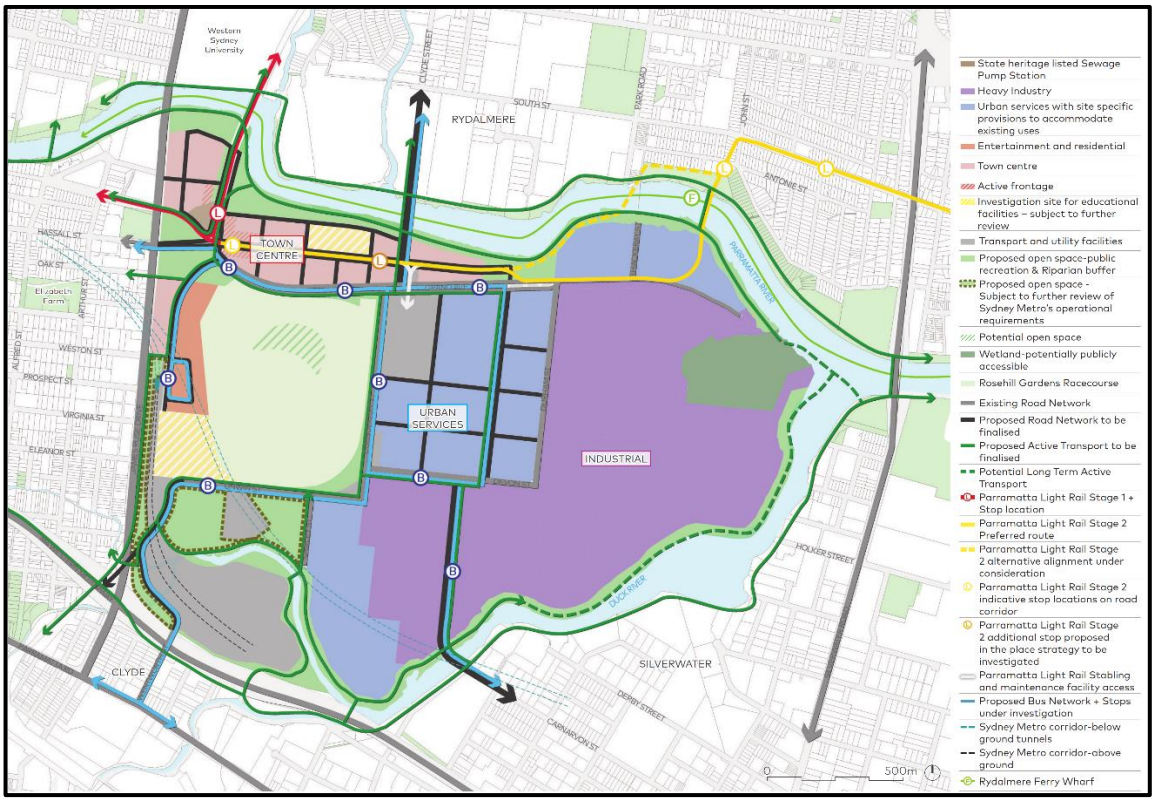
[3] 'Dangerous goods' is a term used in SEPP 33, and has broadly the same meaning a 'hazardous chemical' used in the Work Health and Safety legislation.

3. THE CAMELLIA-ROSEHILL MASTER PLAN

3.1. Overview

The master plan is shown in Figure 3.1, and forms the basis of the Place Strategy.

Figure 3.1: Master plan



Key features of the master plan include:

- Provision for approximately 10,000 dwellings within a Town Centre serviced by light rail
- Provision for approximately 15,400 jobs
- A new primary school and primary and secondary high school
- District open space facilities
- Introduction of a new entertainment precinct and an urban services area
- Initiatives to Care for Country and continued protection of heritage listed sites
- Retention of the existing state heritage sewerage pumping station (SPS) 067 within the town centre
- Measures to mitigate land use conflicts and risks including regulatory buffers and setbacks from existing fuel pipelines to minimise hazard risks

- Access to the Parramatta River, Duck River and Duck Creek foreshores and potentially the wetland
- New transport infrastructure including a local road network, potential bus services, additional connections into and out of the precinct, and opportunities to integrate with Parramatta Light Rail Stage 2
- An extensive active transport network
- A comprehensive remediation strategy
- A sustainability strategy and integrated water cycle management strategy.

3.2. Hazard-Risk challenges

The master plan has been developed incorporating constraints imposed by:

- Viva Energy's Clyde and Parramatta Terminals.
- Ampol's fuel pipeline that runs under Grand Avenue and then north adjacent to the light rail alignment.
- Secondary main gas pipelines, which although not generally posing constraints run in the same easement as Ampol's pipeline and if they leak, they may lead to a larger, escalated fire.

Viva Energy Clyde and Parramatta Terminals store and handle flammable liquids and hence if loss of containment occurs at these sites, there is potential for offsite impacts due to fires and explosions. Separation of incompatible land use, such as residential, around these terminals is incorporated into the master plan.

The hazard-risk aspects of the liquid fuels and gas pipelines were carefully considered, and constraints imposed based on very low frequency pipe leak scenarios. If these scenarios were to occur, the potential fire would be very large, impacting areas over 100 m from the liquid fuels pipeline. The balance between very low frequency events and their consequence is considered in the published DPE risk criteria, in particular the societal risk. In calculating the impact on the surrounding population, the societal risk considers the population density, the number of people inside and outside as well as protection provided by buildings.

The Ampol pipeline is licensed under the Pipelines Act (1967) and Pipelines Regulation (2013) requiring that Ampol:

- lodges a pipeline management plan with DPE
- monitors performance and procedures by conducting periodic independent third-party audits of their pipeline management system
- uses Australian Standard 2885 (AS 2885) as a mandatory safety standard for the design, construction, operation and maintenance of the pipeline.

It is important to note that this hazard and risk study is not a Safety Management Study (SMS) that is required under AS 2885. The two studies should be seen as working together to ensure the safety of the public in areas adjacent to the pipeline. For this study, information from the Ampol SMS has been reviewed, e.g. pipeline characteristics and existing protection. This study may provide useful information for future updates of the Ampol SMS, e.g. consequence distances and population density.

DPE publishes a performance report on licensed pipelines every year and the latest version covering 2019-2020, Ref [3], highlights concerns related to near misses due to higher activity near licensed pipelines. In the context of the Precinct, this highlights that a high degree of caution must be taken when siting population adjacent to the pipelines.

Consultation with Ampol and the results of the risk assessment have resulted in the separation of population and buildings from the Ampol pipeline in the master plan. Further consultation with Ampol is required during finalisation of the built form to the northwest of the Precinct. This will ensure that activities under AS 2885 can be reviewed and updated against proposed changes.

It should be noted that the hazard-risk issues considered when developing the population constraints, setbacks and buffers are different from those considered by the pipeline operators when determining whether construction activity is permissible adjacent to their pipeline. The constraints imposed via ‘dial before you dig’ relate to avoiding damage to the pipeline during construction. So, although construction may be allowed within a few metres of a pipeline, this does not mean that placing a population a few metres from a pipeline would comply with the NSW hazard-risk criteria.

4. METHODOLOGY

4.1. Overview

The methodology used to develop the QRA for the Precinct followed the NSW State Environmental Planning Policy (SEPP) and Hazardous Industry Planning Advisory Papers (HIPAPs) below:

- SEPP 33 Hazardous and Offensive Development Application Guidelines, Ref [1].
- HIPAP 10 Land Use Safety Planning, Ref [2]
- HIPAP 6 Hazard Analysis, Ref [4].

The high-level method was as follows:

- Context setting which comprised:
  - identification of sites and facilities in the Precinct
  - review of the types and quantities of Dangerous Goods (DG) at each site[4]
  - identification of sites that exceed the screening value for each DG using the SEPP 33 guidelines
  - review of existing hazard assessment information for sites in the Precinct
  - collation of information on the sites that were identified by DPE
  - development of list of sites for risk model analysis
  - conversion of the land use zoning to that required by HIPAP 10.
- Risk model development which comprised:
  - identification of hazards on each site on the list of sites
  - analysis of the consequences of loss of containment events
  - analysis of the frequency of loss of containment events
  - calculation of the Precinct individual risk
  - calculation of the Precinct societal risk using supplied population data.
- Output of risk results and assessment against the criteria for strategic land use planning in HIPAP 10.

Additional details related to the risk model development are provided in the following section.

4.2. Risk model development

The risk model development process for the QRA is described in Figure 4.1, which also describes the inputs and outputs at each stage. The methodology is consistent with that outlined in the HIPAP 6 and HIPAP 10.

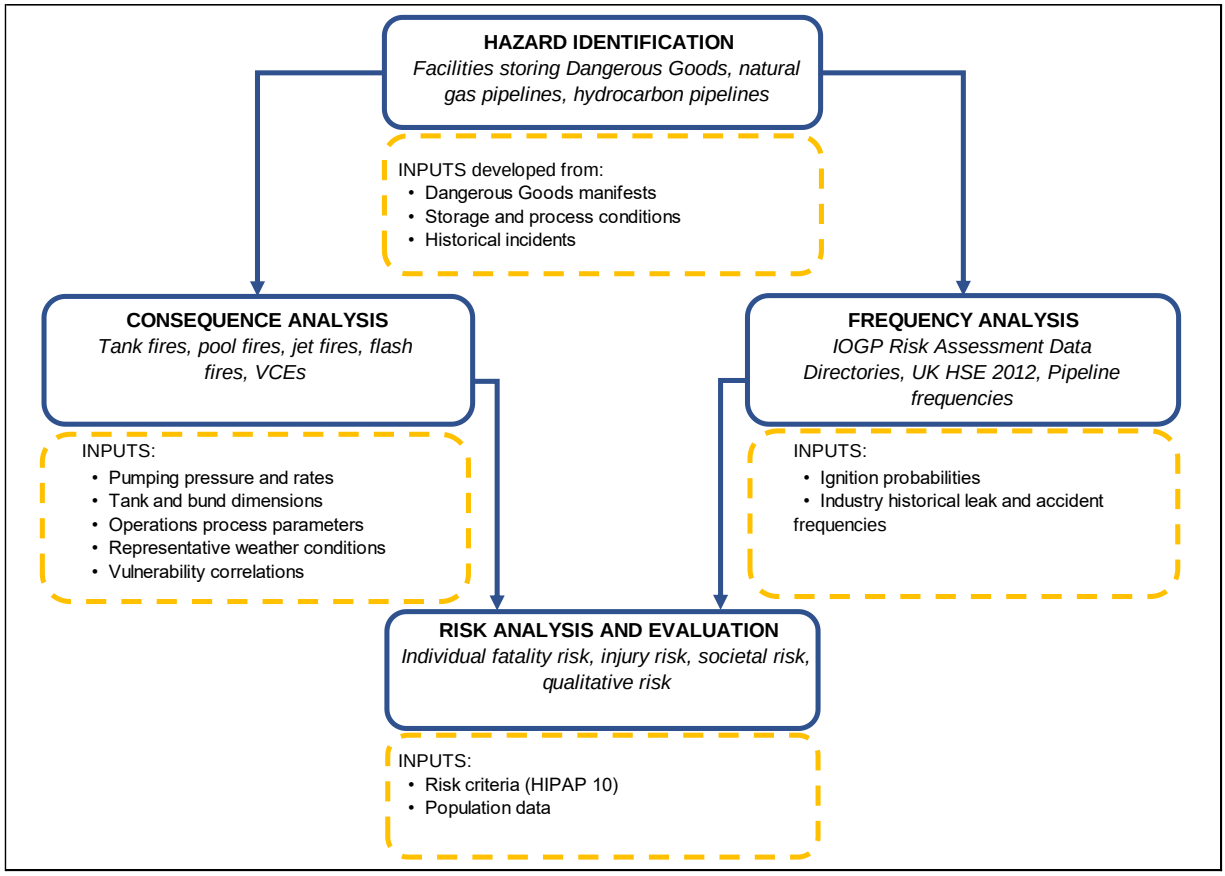
[4] Examples of DG are: petrol, natural gas (methane), jet fuel, Liquefied Petroleum Gas (LPG).

The risk model development comprises:

- **hazard identification**, which is the process of establishing the scenarios that could result in an adverse impact, together with their causes, consequences and existing safeguards. Hazards were identified for each site on the site list and a hazard identification word diagram was developed for each site.
- **consequence analysis** of identified scenarios was undertaken to determine the impact area and the resulting extent of adverse effects.
- **frequency analysis**, which determines the likelihood of the identified consequences.
- **risk analysis**, which combines the consequences and frequencies to produce contours of equal risk values.

Escalation is when an initial consequence impacts on adjacent equipment and causes a larger consequence. This type of event was considered for pipelines in the same corridor, and for adjacent equipment on a case-by-case basis. Escalation between operating sites was considered with reference to the consequence analysis, e.g. between Parramatta and Clyde Terminals.

Figure 4.1: Overview of risk model development



4.3. Risk criteria

HIPAP 10, Ref [2], describes risk criteria in terms of quantitative and qualitative aspects. These two aspects are described in the following sections.

4.3.1. Quantitative criteria

Quantitative criteria are described in HIPAP 10 for:

- individual fatality risk
- individual injury risk
- societal risk.

Individual fatality risk is the likelihood of a fatality based on the frequency of specified consequences (such as fire) impacting a location. The fatality probability at the location is based on a 'dose' of thermal radiation, which accounts for its duration and intensity. No factors are included for protection by buildings.

Injury risk is calculated in the same way as individual fatality risk, but uses a lower thermal radiation threshold, i.e. one that may injure a person after 30 seconds exposure. This value is taken from HIPAP 6, Ref [4].

Societal risk provides a mechanism by which the number of people exposed, as well as protection factors can be considered. It is used to ensure that the risk impact on the community is not excessive.

The individual risk criteria are specified in Table 4.1 (fatality) and Table 4.2 (injury) for five land use categories.

The societal risk criteria are shown in Figure 6.1, and for this project the risk is not allowed to enter the 'intolerable region'. The criteria were developed for single facilities or a 1 km section of pipeline, however, for this study a single graph was presented which includes all risk sources in the Precinct.

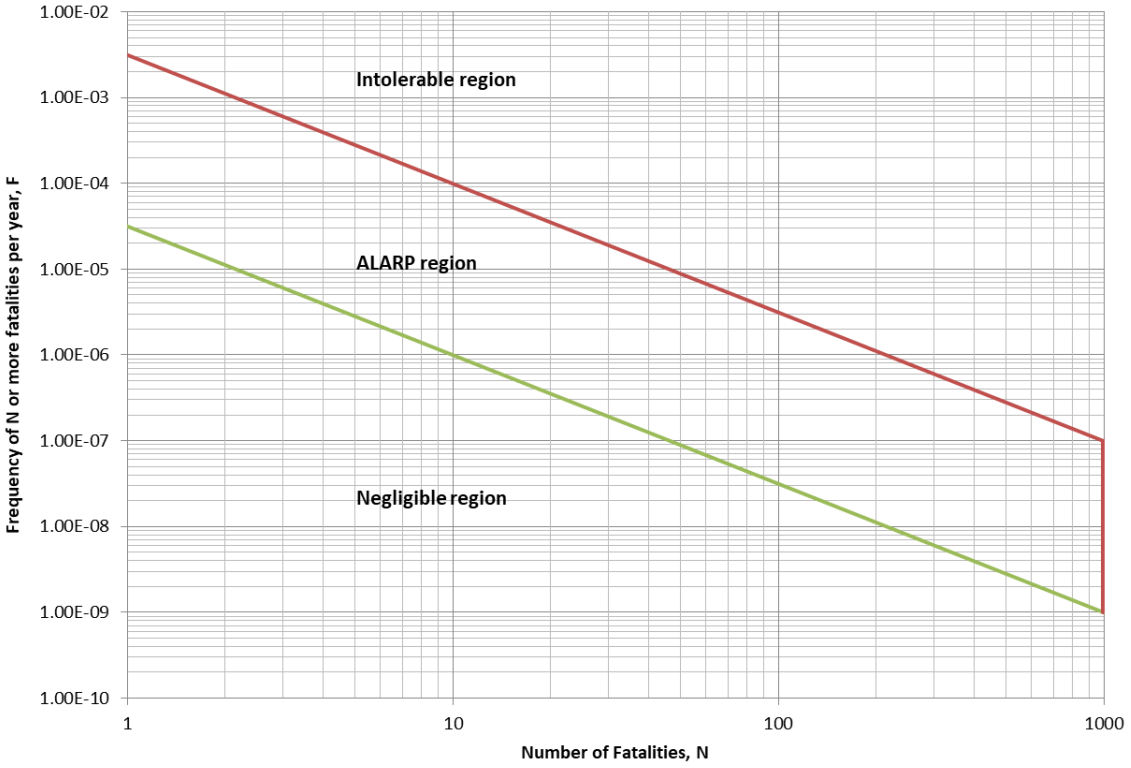
Table 4.1: Individual fatality risk criteria

Risk levels (individual fatality risk per year)	HIPAP 10 Land Use	Limit of exposure at the following locations
0.5×10^{-6}	Sensitive	Hospitals, child-care facilities, old age housing.
1×10^{-6}	Residential	Residential developments and places of continuous occupancy such as hotels and tourist resorts.
5×10^{-6}	Commercial	Commercial developments, including offices, retail centres and entertainment centres.
10×10^{-6}	Recreational	Sporting complexes and active open space areas.
50×10^{-6}	Industrial	Target for site boundary.

Table 4.2: Individual injury risk criteria

Risk levels (individual injury risk per year)[(a)]	Type
50 x 10^{-6}	Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m^2.
(a) Toxic and overpressure criteria excluded as it is not applicable to this study.	

Figure 4.2: Societal risk criteria



4.3.2. Qualitative criteria

General qualitative risk principles are described in HIPAP 10. To measure compliance against the principles, an interpretation and a measurement was provided by DPE. The principles, interpretation and measurement applicable to this study are shown in Table 4.3. Following this activity, items (b) and (d) were not found to be applicable to this study, and so items (a) and (c) were tested.

Table 4.3: Qualitative risk criteria

HIPAP 10 qualitative principle	Interpretation	Measurement
(a) All 'avoidable' risks should be avoided.	Relevant for both development in the vicinity of hazard sources and for the sources of hazard. Particularly relevant for high density development and sensitive development. Ensure incompatible land uses are not introduced.	Review whether evacuation for the proposed development is feasible within the consequence affected zone. Evacuation is less feasible with high density populations and sensitive land uses, such as schools, hospitals, and correctional facilities.
(b) The risk from a major hazard should be reduced wherever practicable.	Relevant for hazard sources. Ensure Hazard sources explore all options to reduce risks to as low as reasonably practicable, and therefore minimise its risk impact to neighbouring land uses.	N/A as the existing risk sources have implemented risk reduction where practicable. The pipelines are designed and managed per AS 2885 and the risk is demonstrated to be reduced ALARP. Similarly, risk from the Viva Energy site is reduced so far as is reasonably practicable as described in their Safety Case.
(c) The consequences (effects) of the more likely hazardous events (i.e. those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	Relevant for hazard sources. Ensure the high risk activities are appropriated located within the facility.	There is no boundary for the pipelines and so this criterion is not applicable. For Viva Energy sources, 'more likely' hazardous events will be reviewed to determine whether they extend offsite.
(d) Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.	Relevant for high risk industrial development. Ensure the risk level in the area are appropriately managed.	N/A as high risk industrial development is not proposed. High Risk industrial development is interpreted as development where it may be deemed as a major hazard facility.

4.4. Key assumptions

The QRA model contains many technical assumptions, subject to uncertainty and as required by HIPAP 6, Ref [4]:

> *Assumptions should usually be made on a 'conservative best estimate' basis. That is, wherever possible the assumptions should closely reflect reality. However, where there is a substantial degree of uncertainty, assumptions should be made which err on the side of conservatism.*

Key assumptions are described below with an explanation of how they impact the model particularly for the risks posed by the Ampol pipeline to the town centre, and additional details are provided in APPENDIX A.

4.4.1. Hydrocarbon pools

When there is a leak from a pipeline transporting flammable liquid, the consequence will depend on many factors including the size of the release, the exact release location, the depth of cover, the type of material covering the pipeline and the substance released. For this model, all leaks from the Ampol pipeline were modelled as gasoline (petrol) and result in a pool fire, with the pool size limited by either the hole size or the pumping rate through the pipeline. The maximum pool diameter is approximately the width of Grand Avenue, which is appropriate given that the road has drains which would limit the pool size alone the road.

Modelling the pools as diesel or jet fuel would reduce the probability of ignition and hence the risk posed, however, given the uncertainty in the product mix over the next 20 years, modelling the pools as petrol was appropriately conservative.

For aboveground equipment, it would be usual to model jet fires for small releases, pool fires for larger releases and flammable gas dispersion and ignition to account for the vapour generated on release. There is a large degree of uncertainty in the consequences, due to the location of the release (a buried pipeline) and it is likely that any release would impact either the overburden or the side of the crater formed by the release, resulting in momentum being lost and the liquid pooling. If impacted by external interference, the resulting liquid release may be fountain vertically up, but then form a pool centred approximately at the release point.

For completeness, comparisons were made between jet fires and pool fires for small hole sizes and the impact distance was found to be similar. For flammable gas dispersion, the idealised plume (i.e., excluding impacts with the crater, or buildings) was found to be longer and narrower than the pool fire consequence. However, it was considered that the plume shape was not realistic given the location of the pipeline and it is unlikely that the cloud would remain unignited given the proposed activity around the pipeline. Therefore, a pool fire was used as the conservative best estimate consequence.

4.4.2. Escalation between pipelines

The Jemena and Ampol pipelines are in the same easement at certain locations in the Precinct and so escalation between the pipelines was included in the model. It was determined that the consequences from the Ampol pipeline were worse than those from the Jemena pipelines and so on loss of containment from the Jemena pipeline (excluding small holes), the fire was assumed to engulf the Ampol pipeline resulting in a consequence equivalent to a rupture of the Ampol pipeline.

4.4.3. Pipeline pressure

The Ampol pipeline releases were taken at the Maximum Operating Pressure (MOP), and the flowrate taken at the maximum capacity. Although the pipeline would not be operating at these pressures and throughputs 100% of the year, they are conservative best estimates for modelling purposes.

4.4.4. Dangerous goods transportation

Road traffic accidents involving trucks transporting dangerous goods is not included in the risk model. Dangerous goods transport is regulated in NSW under the Dangerous Goods (Road and Rail Transport) Act 2008 and Dangerous Goods (Road and Rail Transport) Regulation 2014. With the associated Australian Code for the Transport of Dangerous Goods by Road & Rail (ADG) Code, requirements for vehicles, drivers and loading/unloading are specified.

The main source of dangerous goods transported through the Precinct is Viva Energy's Parramatta Terminal, which exports petrol, diesel and jet fuel by road tanker. Although, due to compliance with the ADG Code, the likelihood of a vehicle accident resulting in loss of containment of fuel is low, the resulting fire may be large.

The transport of dangerous goods into and out of the Precinct has been considered in Package D – Infrastructure – Traffic and Transport Study. With the addition of exit points away from the Grand Avenue James Rouse Drive junction, there is an opportunity to reduce the number of Dangerous Goods vehicle movements at this junction and hence reduce the risk to the residential population proposed in the northwest of the Precinct.

5. CONTEXT AND MODEL DEVELOPMENT

5.1. SEPP 33 and site identification

A list of sites with submitted DG manifests was provided by WorkCover and DPE, and the DG manifest for each site on the list which is within the Precinct was assessed using the SEPP 33 screening process. A list of types and quantities of DG stored or handled at each site was developed and all sites storing DG above the SEPP 33 screening threshold were carried forward for analysis.

The following were identified as sites having greater than the SEPP 33 screening threshold or pipelines that traversed the Precinct:

- Clyde terminal
- Parramatta terminal
- EarthPower facility
- Ampol Hunter pipeline
- Gore Bay pipeline
- Jemena secondary mains.

5.2. Land use zoning and population

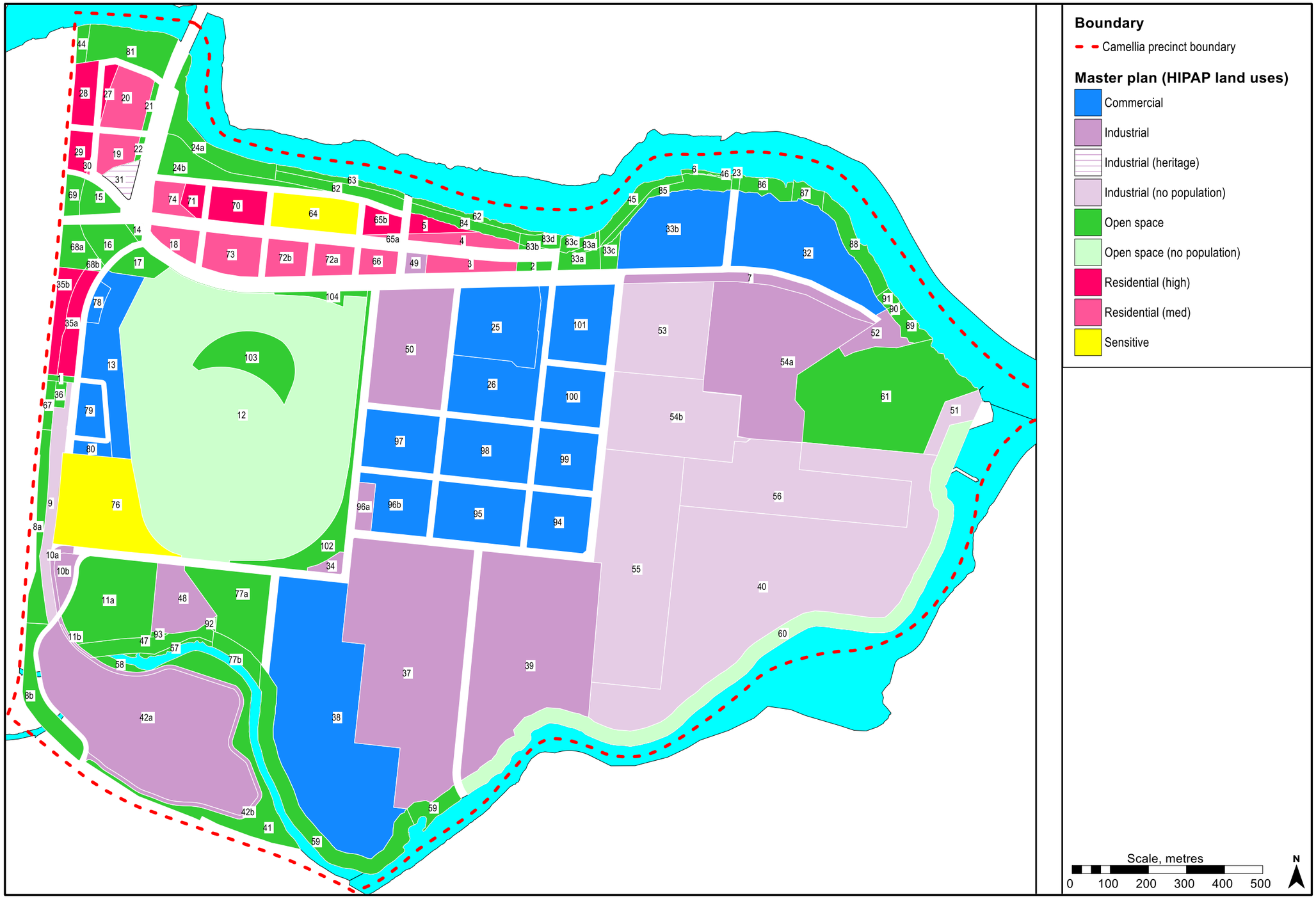
The land uses described in Figure 3.1 were converted to those used in HIPAP 10 and described in Table 5.1. The final populations and land use assumptions are shown in Figure 5.1.

In response to the possibility of night-time population existing in locations zoned as ‘urban services’, a sensitivity run was carried out for locations close to the Viva Energy Clyde Terminal (populations: 32, 33, 94, 99, 100 and 101), where the night-time population was assumed to be 20% of the daytime population. This is the same assumption used for the industrial land use.

Table 5.1: HIPAP 10 land use conversion

HIPAP 10 Land use	Description
Sensitive	Includes developments that may house people that are more sensitive than the general population and/or may be difficult to evacuate. Examples are hospitals, schools, aged or childcare facilities.
Residential	Includes all densities of residential development.
Commercial	Commercial developments including retail centres, offices and entertainment centres.
Open space	Sporting complexes and active open space.
Industrial	Target for the boundary of the industrial site.

Figure 5.1: Master plan - HIPAP land uses map and populations



ID	Use	HIPAP use	Population[c]	Jobs[b]	Other	Total Day[a]	Total Night
1	Open space-public recreation & Riparian buffer	Open Space	0	0		4	0
2	Open space-public recreation & Riparian buffer	Open Space	0	0		8	0
3	Mixed use-medium	Residential (med)	587	33		137	600
4	Mixed use-medium	Residential (med)	1239	70		291	1267
5	Mixed use-high	Residential (high)	669	38		164	676
6	Open space-public recreation & Riparian buffer	Open Space	0	0		4	0
7	Heavy Industry	Industrial	0	41		41	8
8a	Open space-public recreation & Riparian buffer	Open Space	0	0		49	0
8b	Open space-public recreation & Riparian buffer	Open Space	0	0		58	0
9	Transport facilities and utility[e]	Industrial	0	0		0	0
10a	Transport facilities and utility	Industrial	0	7		7	1
10b	Transport facilities and utility	Industrial	0	14		14	3
11a	Open space-public recreation & Riparian buffer	Open Space	0	0		166	0
11b	Transport facilities and utility	Industrial	0	2		2	0
12	Rosehill Gardens Racecourse	Open Space	0	0		0	0
13	Entertainment mixed use	Commercial	2862	335		740	3030
14	Open space-public recreation & Riparian buffer	Open Space	0	0		5	0
15	Open space-public recreation & Riparian buffer	Open Space	0	0		24	0
16	Open space-public recreation & Riparian buffer	Open Space	0	0		34	0
17	Open space-public recreation & Riparian buffer	Open Space	0	0		28	0
18	Mixed use-medium	Residential (med)	834	47		195	853
19	Mixed use-medium	Residential (med)	962	54		225	984
20	Mixed use-medium	Residential (med)	1792	101		419	1832
21	Open space-public recreation & Riparian buffer	Open Space	0	0		7	0
22	Open space-public recreation & Riparian buffer	Open Space	0	0		3	0
23	Open space-public recreation & Riparian buffer	Open Space	0	0		3	0
24a	Open space-public recreation & Riparian buffer	Open Space	0	0		67	0
24b	Open space-public recreation & Riparian buffer	Open Space	0	0		57	0
25	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	777		777	0
26	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	700		700	0
27	Mixed use-high	Residential (high)	343	19		84	347
28	Mixed use-high	Residential (high)	1311	74		321	1326
29	Mixed use-high	Residential (high)	809	46		198	818
30	Mixed use-medium	Residential (med)	25	1		6	25
31	State heritage listed Sewage Pump Station	Industrial	0	13		13	0
32[f]	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	1200		1200	0
33a	Open space-public recreation & Riparian buffer	Open Space	0	0		19	0
33b[f]	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	964		964	0
33c	Open space-public recreation & Riparian buffer	Open Space	0	0		13	0
34	Transport facilities and utility	Industrial	0	8		8	2
35a	Mixed use-high	Residential (high)	1540	87		378	1558
35b	Mixed use-high	Residential (high)	1325	75		325	1340
36	Open space-public recreation & Riparian buffer	Open Space	0	0		7	0
37	Heavy Industry	Industrial	0	441		441	88
38	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	3037		3037	0
39	Heavy Industry	Industrial	0	367		367	73
40	Heavy Industry	Industrial	0	656		656	131
41	Open space-public recreation & Riparian buffer	Open Space	0	0		135	0
42a	Transport facilities and utility	Industrial	0	373		373	75
42b	Transport facilities and utility	Industrial	0	33		33	7
44	Open space-public recreation & Riparian buffer	Open Space	0	0		10	0
45	Open space-public recreation & Riparian buffer	Open Space	0	0		26	0
46	Open space-public recreation & Riparian buffer	Open Space	0	0		2	0
47	Open space-public recreation & Riparian buffer	Open Space	0	0		44	0
48	Transport facilities and utility	Industrial	0	54		54	11
49	Transport facilities and utility	Industrial	0	7		7	1
50	Transport facilities and utility	Industrial	0	151		151	30
51	Heavy Industry	Industrial	0	25		25	5
52	Heavy Industry	Industrial	0	24		24	5
53	Heavy Industry	Industrial	0	144		144	29
54a	Heavy Industry	Industrial	0	270		270	54
54b	Heavy Industry	Industrial	0	167		167	33
55	Heavy Industry	Industrial	0	301		301	60
56	Heavy Industry	Industrial	0	215		215	43
57	Open space-public recreation & Riparian buffer	Open Space	0	0		7	0
58	Open space-public recreation & Riparian buffer	Open Space	0	0		1	0
59	Open space-public recreation & Riparian buffer	Open Space	0	0		23	0
59	Open space-public recreation & Riparian buffer	Open Space	0	0		23	0
60	Open space-public recreation & Riparian buffer	Open Space	0	0		282	0

ID	Use	HIPAP use	Population[c]	Jobs[b]	Other	Total Day[a]	Total Night
61	Wetland potentially publicly accessible	Open Space	0	0		355	0
62	Open space-public recreation & Riparian buffer	Open Space	0	0		19	0
63	Open space-public recreation & Riparian buffer	Open Space	0	0		20	0
64	Investigation site for educational facilities - subject to further review - Primary School	Sensitive	0	100	1000	1100	0
65a	Mixed use-medium	Residential (med)	81	5		19	83
65b	Mixed use-high	Residential (high)	812	46		199	821
66	Mixed use-medium	Residential (med)	700	39		164	716
67	Open space-public recreation & Riparian buffer	Open Space	0	0		11	0
68a	Open space-public recreation & Riparian buffer	Open Space	0	0		30	0
68b	Open space-public recreation & Riparian buffer	Open Space	0	0		4	0
69	Open space-public recreation & Riparian buffer	Open Space	0	0		16	0
70	Mixed use-high	Residential (high)	1753	99		430	1773
71	Mixed use-high	Residential (high)	580	33		142	586
72a	Mixed use-medium	Residential (med)	1106	62		259	1130
72b	Mixed use-medium	Residential (med)	918	52		215	939
73	Mixed use-medium	Residential (med)	1678	95		392	1716
74	Mixed use-medium	Residential (med)	776	44		181	793
76	Investigation site for educational facilities - subject to further review - K-12 school	Sensitive	0	200	2000	2200	0
77a	Open space-public recreation & Riparian buffer	Open Space	0	0		114	0
77b	Open space-public recreation & Riparian buffer	Open Space	0	0		23	0
78	Entertainment mixed use	Commercial	286	34		74	303
79	Entertainment mixed use	Commercial	786	92		203	832
80	Entertainment mixed use	Commercial	343	40		89	363
81	Open space-public recreation & Riparian buffer	Open Space	0	0		77	0
82	Open space-public recreation & Riparian buffer	Open Space	0	0		34	0
83a	Open space-public recreation & Riparian buffer	Open Space	0	0		11	0
83b	Open space-public recreation & Riparian buffer	Open Space	0	0		13	0
83c	Open space-public recreation & Riparian buffer	Open Space	0	0		5	0
83d	Open space-public recreation & Riparian buffer	Open Space	0	0		2	0
84	Open space-public recreation & Riparian buffer	Open Space	0	0		27	0
85	Open space-public recreation & Riparian buffer	Open Space	0	0		32	0
86	Open space-public recreation & Riparian buffer	Open Space	0	0		23	0
87	Open space-public recreation & Riparian buffer	Open Space	0	0		14	0
88	Open space-public recreation & Riparian buffer	Open Space	0	0		43	0
89	Open space-public recreation & Riparian buffer	Open Space	0	0		17	0
90	Open space-public recreation & Riparian buffer	Open Space	0	0		3	0
91	Open space-public recreation & Riparian buffer	Open Space	0	0		7	0
92	Open space-public recreation & Riparian buffer	Open Space	0	0		2	0
93	Open space-public recreation & Riparian buffer	Open Space	0	0		2	0
94[f]	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	442		442	0
95	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	653		653	0
96a	Transport facilities and utility	Industrial	0	14		14	3
96b	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	439		439	0
97	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	545		545	0
98	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	654		654	0
99[f]	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	443		443	0
100[f]	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	435		435	0
101[f]	Urban Services with site specific provisions to accommodate existing uses	Commercial	0	596		596	0
102	Open space-public recreation & Riparian buffer	Open Space	0	0		73	0
103	Potential open space	Open Space	0	0		95	0
104	Open space-public recreation & Riparian buffer	Open Space	0	0		18	0

Notes:

(a) Day population includes people in open space land use.

(b) This is the total number of jobs available in that land use. These are spilt over the day and night percentages.

(c) This is the maximum total population in the land use. For residential it is the night time population, while for other land uses it is day time population.

(d) Zero population assumed for Rosehill Racecourse area.

(e) Zero population assumed for Parramatta Light Rail track and Sydney Metro rail corridor.

(f) Night-time population for sensitivity (20% of day population): 32: 240, 33b: 193, 94: 88, 99: 89, 100: 87, 101: 119.

5.3. Risk Model Development

Hazard identification tables for each study site within the Precinct were developed, containing the hazard, loss of control event, cause, potential consequences and control measures.

The consequences of loss of containment events were then calculated and it was found that consequences from the EarthPower site did not extend beyond the site boundary and therefore this site was not subject to further analysis. From the consequence analysis, a ‘consequence affected zone’ was defined around the pipeline of 130 m, limiting the population density in this area. Outside this zone, population density will not impact the risk model.

The likelihood of occurrence of each of the consequences identified was calculated by estimating the initiating event frequency, and then populating an 'Event Tree' to characterise the accident pathways.

The consequence and likelihood data were then entered into the risk model, which output the quantitative risk for comparison against the quantitative risk criteria.

6. RISK ASSESSMENT

6.1. Overview

Risk assessment was conducted against the criteria described in Section 4.3.

6.2. Individual fatality risk

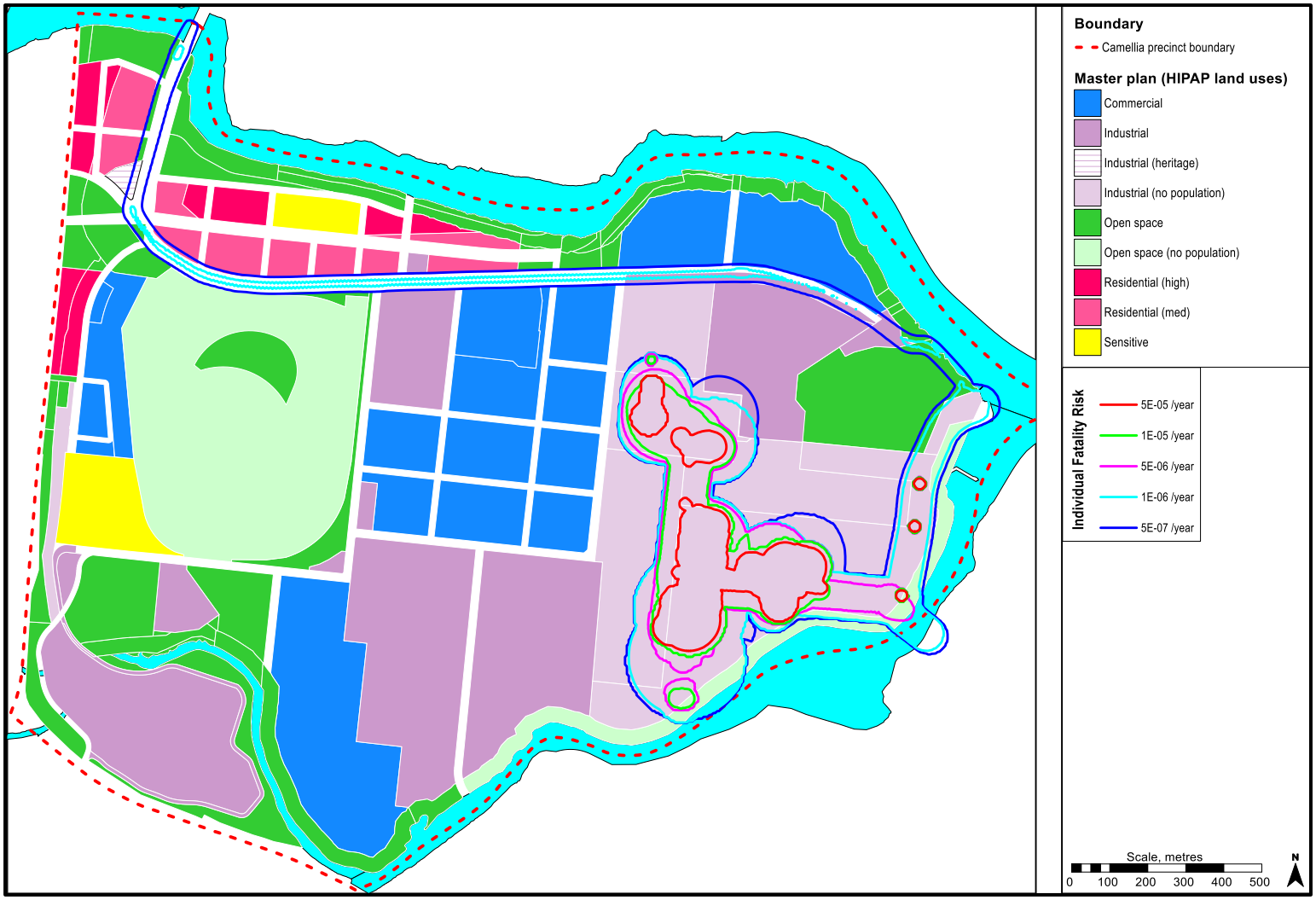
The individual fatality risk contours are shown in Figure 6.1, and an assessment against the individual fatality risk criteria is shown in Table 6.1.

The fatality risk criteria are met, noting that the set-back of residential population in the master plan follows the 0.5 x 10^{-6}/year contour.

Table 6.1: Individual fatality risk assessment

Risk levels (per year)[(a)]	HIPAP 10 Land use	Criteria met?	Description
0.5 x 10^{-6}	Sensitive	Yes	Contour does not impact sensitive land uses.
1 x 10^{-6}	Residential	Yes	Contour does not extend to residential land uses.
5 x 10^{-6}	Commercial	Yes	Contour does not impact Commercial land uses.
10 x 10^{-6}	Open space	Yes	Contour does not impact open space.
50 x 10^{-6}	Industrial (target for site boundary)	Yes	Contour does not extend outside of the Viva Energy property boundary.
(a) Based on 24 hour-per-day exposure with no allowance for the protection buildings may offer or for the potential to move away and escape from a developing incident.			

Figure 6.1: Individual fatality risk contours



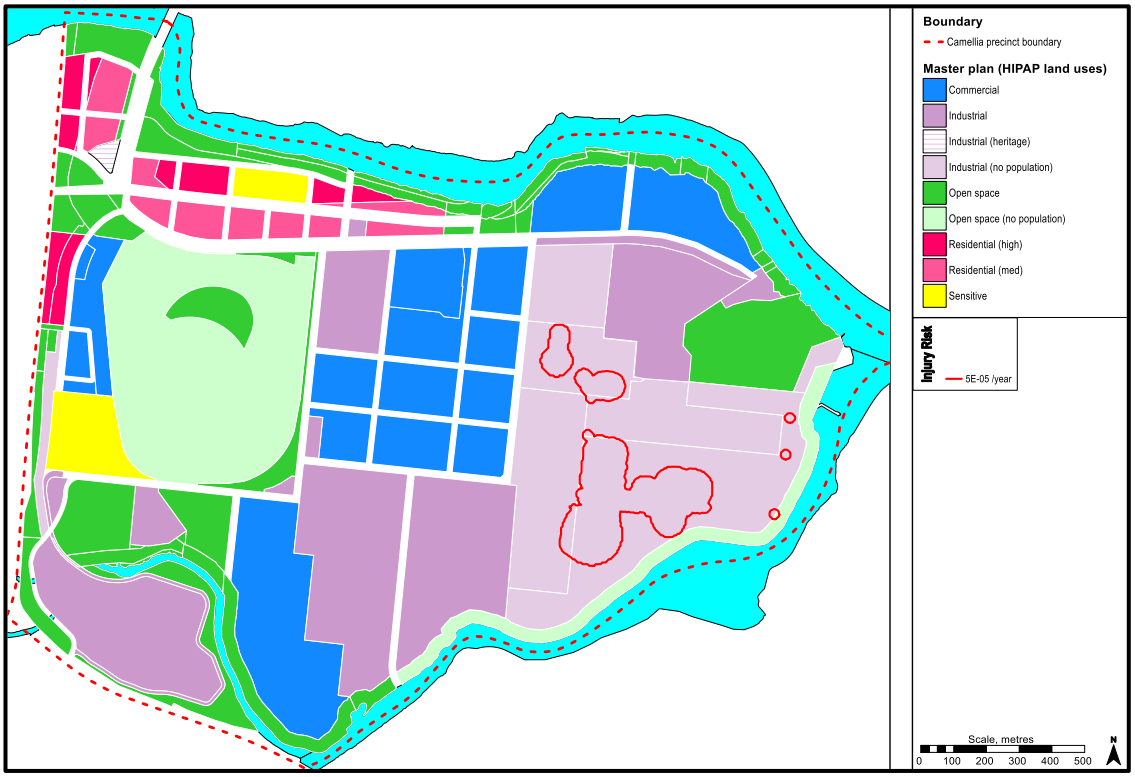
6.3. Injury risk

The injury risk contours for the master plan are shown in Figure 6.2, and an assessment against the injury risk criteria is shown in Table 6.2. The injury risk criterion is met.

Table 6.2: Injury risk assessment

Risk levels (per year)	Land use	Criteria met?	Description
50 x 10^{-6}	Sensitive and Residential	Yes	Contour does not extend into sensitive or residential areas.

Figure 6.2: Injury risk contours



6.4. Societal risk

The F-N curve for the master plan is shown in Figure 6.3, where the societal risk does not extend into the Intolerable Region (above the red line), and hence meets the criterion defined in Section 4.3.1.

An important aspect of compliance is that the town centre population within the 'consequence affected zone' is defined as medium density and is limited to the population values described in Figure 5.1.

The sensitivity to the model with respect to the night-time population in the 'urban services' area to the north and west of the Viva Energy site is shown in Figure 6.4. With 20% of the daytime population assumed to be in 32, 33b, 94, 99, 100 and 101 (refer to

Figure 5.1), the societal risk does not move into the intolerable region but increases slightly at the left of the curve (N=1 to 10).

Figure 6.3: Societal risk F-N curve

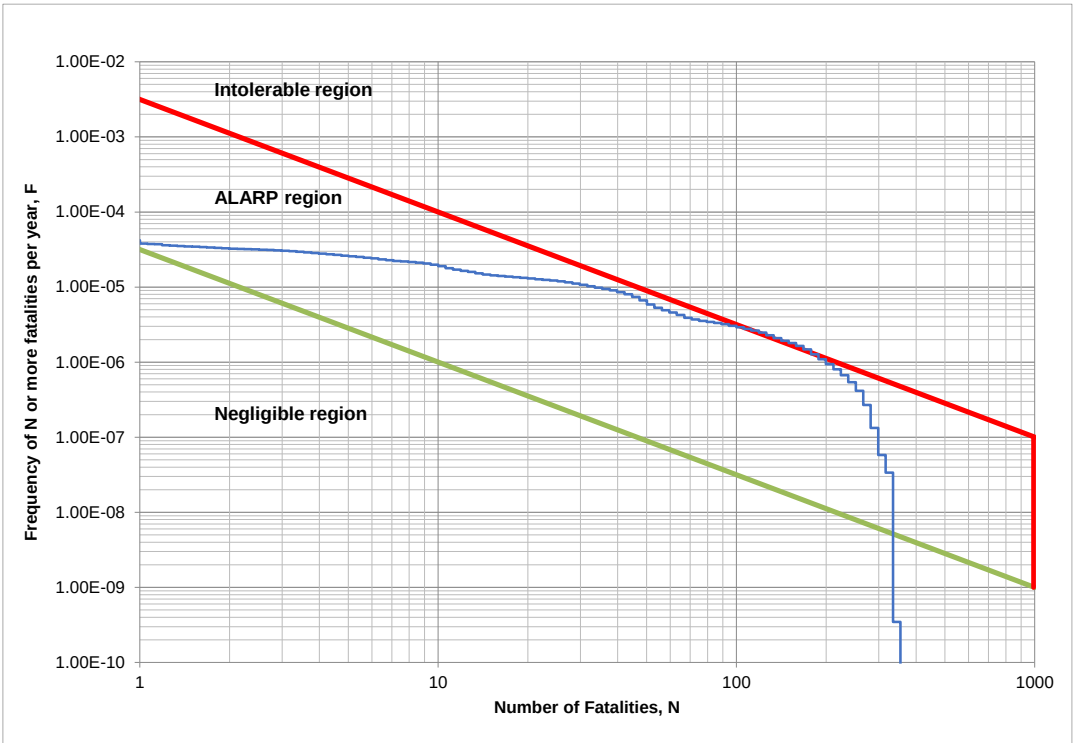
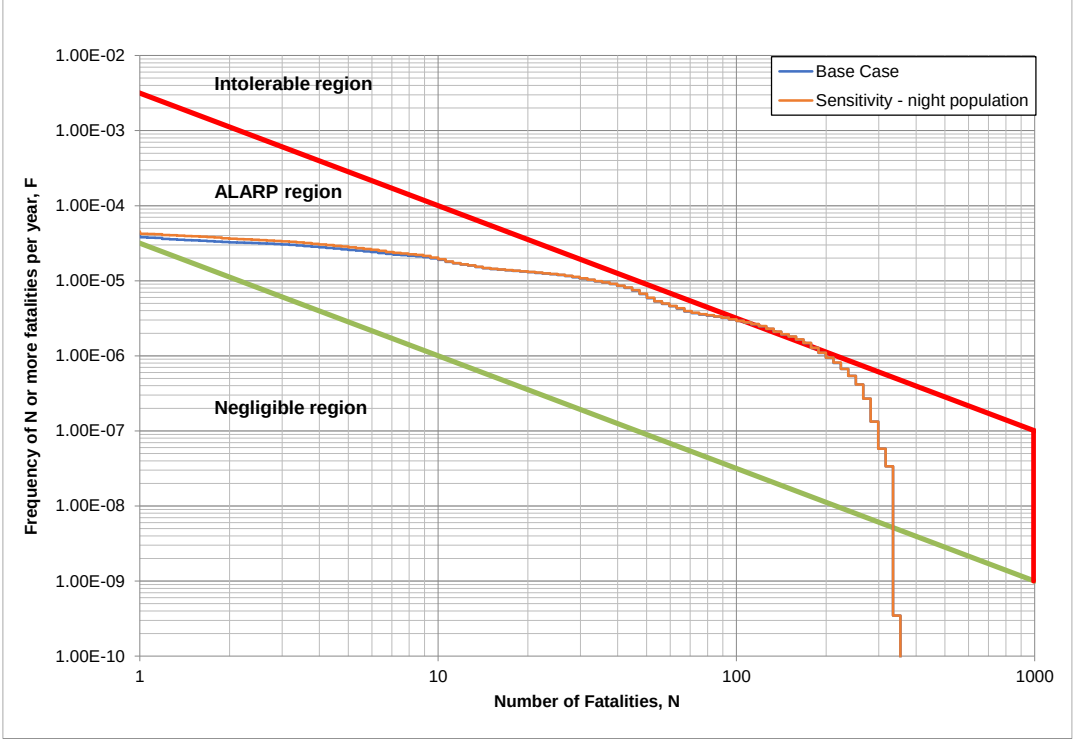


Figure 6.4: Societal risk F-N curve – increased night-time population in urban services land (adjacent to Clyde/Parramatta Terminals)



6.5. Qualitative risk

Qualitative criteria were reviewed as described in Section 4.3.2. From this review, qualitative criteria (a) and (c) were found to be applicable. The Master plan was tested against the two criteria as shown in Table 6.3, and met them both.

Table 6.3: Qualitative criteria results

HIPAP 10 qualitative principle	Measurement	Result
(a) All 'avoidable' risks should be avoided.	Review whether evacuation for the proposed development is feasible within the consequence affected zone. Evacuation is less feasible with high density populations and sensitive land uses, such as schools, hospitals, and correctional facilities.	The master plan contains land with high density residential proposed, however these do not fall within consequence affected zone and so this principle is met.
(c) The consequences (effects) of the more likely hazardous events (i.e., those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.	There is no 'installation boundary' for the pipelines and so this principle is not applicable. For Viva Energy sources, 'more likely' hazardous events will be reviewed to determine whether they extend offsite.	More likely hazardous events at Viva Energy have been reviewed and do not extend beyond the site boundary, and so this principle is met.

7. CONCLUSIONS AND FUTURE PLANNING CONSIDERATIONS

The Camellia-Rosehill Place Strategy has been developed to guide future growth over the next 20 years. Analyses reported in this document:

- Identified the hazards present in the Precinct in the context of the requirements of the State Environment Planning Policy No. 33 (SEPP 33), Ref [1].
- Developed a quantitative risk model for the Precinct incorporating locations exceeding the SEPP 33 thresholds.
- Assessed the risk results against qualitative and quantitative criteria for strategic land use planning in HIPAP 10, Ref [2], and determined the appropriate level of land use safety planning around the locations exceeding the SEPP 33 thresholds related development and infrastructure.
- Provided land use safety advice to inform the Camellia-Rosehill Place Strategy.

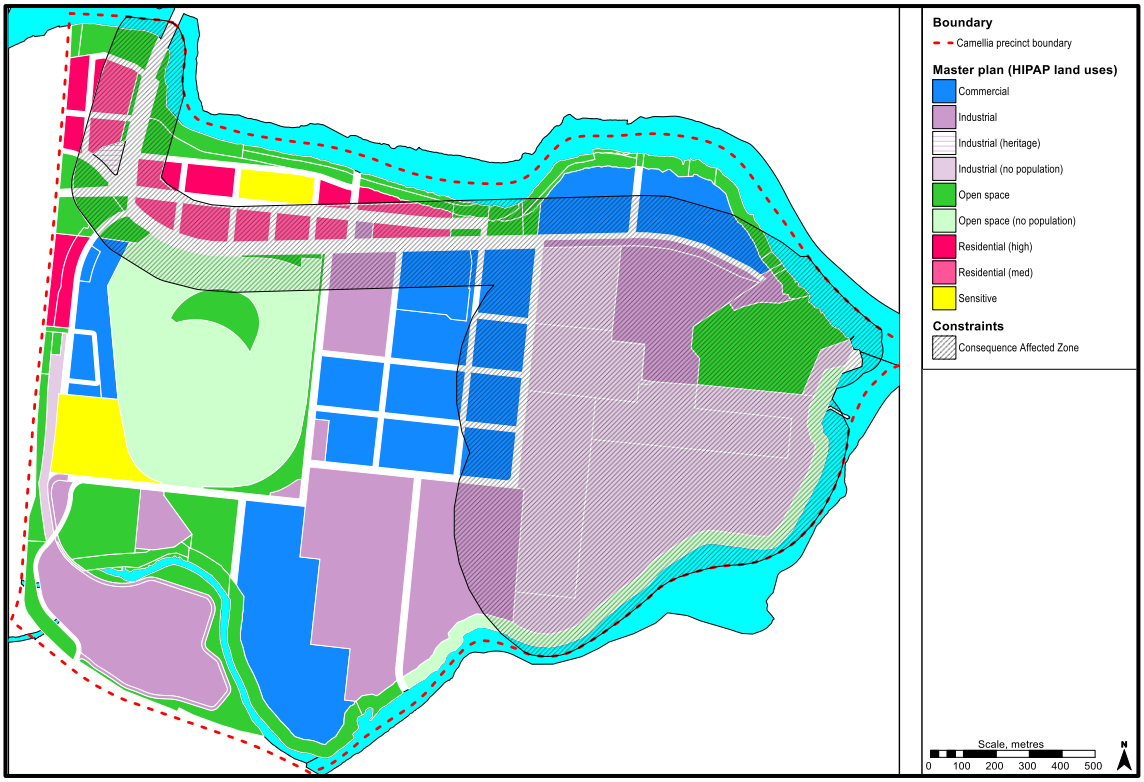
The master plan complies with all qualitative and quantitative risk criteria defined in HIPAP 10, Ref [2], incorporating:

- the separation distance from potentially hazardous industrial facilities
- the separation distance from the pipelines
- population limits specified on development in the Precinct, especially in the pipeline 'consequence affected zone'.

The following planning considerations are recommended:

- Developments proposed with 'sensitive' uses, such as childcare centres, hospitals and aged care facilities in the consequence affected zone (Figure 1.2) need to be referred to DPE (hazards) for comment to ensure that they comply with the qualitative risk criteria.
- The hazard risk analysis and master planning have been undertaken through an iterative process and the resulting Town Centre cap of 10,000 dwellings appears to be the maximum tolerable to maintain acceptable societal risk levels. Further population intensification would **not** meet the risk criteria in HIPAP 10. The consent authority must therefore consult DPE (hazards) if a development is proposed with a population greater than that allowable for any location, particularly those defined as Town Centre (medium) in the master plan (refer to Figure 7.1) prior to submission of a Preliminary Hazard Analysis. A review of land use safety considerations and compliance with HIPAP 10 will be required.
- All development applications must refer to the pipeline operator for comment as per the State Environmental Planning Policy (Transport and Infrastructure) 2021, subdivision 2 'development adjacent to pipeline corridors'.

Figure 7.1: Consequence affected zone



8. REFERENCES

[1] NSW Department of Planning, “Hazardous and Offensive Development Application Guidelines: Applying SEPP 33,” 2011.

[2] NSW Department of Planning, “HIPAP No.10 - Land Use Safety Planning,” 2011.

[3] NSW Government, “NSW 2019–20 Licensed Pipelines - Performance Report,” https://energy.nsw.gov.au/sites/default/files/2021-06/2019-20-licensed-pipelines-performance-report-210221.pdf, June 2021.

[4] NSW Department of Planning, “HIPAP No.6 - Guidelines for Hazard Analysis,” 2011.

[5] Conservation of Clean Air and Water in Europe (CONCAWE), “Performance of European Cross-country Oil Pipelines: Statistical summary of reported spillages in 2012 and since 1971,” 2013.

[6] Health and Safety Laboratory, “Update of pipeline failure rates for land use planning assessments,” Health and Safety Executive, 2015.

[7] Energy Institute, “IP Research Report - Ignition probability review, model development and look-up correlations,” 2006.

APPENDIX A. ASSUMPTIONS (AMPOL PIPELINE)

Aspect	Assumption	Comments
Leak frequency	Ampol pipeline <20mm [pinhole and fissure]: 6.3E-5/km-y 20-80mm [hole]: 9.0E-5/km-y >80mm [split and rupture]: 9.4E-5/km-y	Camellia is based on CONCAWE, Ref [5], and used only the pipeline failure rates for 'cold' material. An alternative data set would be HSE data, Ref [6], which is based on a review of available data in 2015. Compared with the HSE data, the overall leak frequency is similar, as is the frequency for the two smaller hole sizes. However, the CONCAWE data gives a higher leak frequency for the >80 mm hole. HSE use CONCOWE data for mechanical and corrosion failures, which dominate the smaller hole sizes, but use another source (UKOPA) for ground movement, 'other' and third-party interference which dominate the larger hole sizes. The leak frequencies used are appropriately conservative.
Ignition probability	Cox, Lees and Ang 0.01 to 0.08	Cox et. al is a 'standard' ignition probability model. There are alternatives and the Institute of Energy (IE) are the most recent, Ref [7]. For 'pipe-liquid-industrial', the maximum ignition probability is very similar (0.07 vs 0.08 for Cox et. al). For smaller flowrates the ignition probability for the IE correlation is smaller than Cox et. al. The ignition probabilities used are appropriately conservative.
Event tree	100% to the pool fire consequence for underground pipelines	All ignition probability for the Ampol pipeline underground sections is used for pool fire consequence in the Camellia model. The consequence defined for a leak from an underground pipeline is appropriate.
Consequences	Release rate limited to pumping rate. Underground section: Pool fire (limited to 50 m diameter) Aboveground section: Pool fire, jet fire or flash fire Pool fire modelling was carried out in TNO (Gexcon) Effects v9.	Camellia uses appropriate limitations on the release rate and pool fire size.
Fire frequencies	<20mm (23m diameter pool fire): 1.9E-6/km-y 20-80mm (43m diameter pool fire): 7.2E-6/km-y >80mm (43m diameter pool fire – flowrate limited): 8.4E-6/km-y	The Camellia model includes escalation between the Jemena and Ampol pipelines. This means that any ignited leak from the Jemena pipeline over 10 mm in diameter is assumed to result in a failure of the Ampol pipeline, and hence the Ampol pipeline >80 mm leak frequency was increased accordingly (approximately 1E-06/km-y). For the underground sections of the Ampol pipeline (adjacent to the town centre), the fire frequencies include escalation from the Jemena pipeline.

<table>
<tr><th>Aspect</th><th>Assumption</th><th>Comments</th></tr>
<tr><td>Indoor and outdoor vulnerability</td><td>
<table>
<tr><th rowspan="2">Heat radiation intensity (kW/m^2)</th><th colspan="2">Percentage fatality (outside)</th><th rowspan="2">Exposure percentage inside [overall fatality probability]</th></tr>
<tr><th>120 s exposure</th><th>30 s exposure</th></tr>
<tr><td>Flame</td><td>100%</td><td>100%</td><td>100% [1]</td></tr>
<tr><td>23</td><td>100%</td><td>95%</td><td>100% [0.95]</td></tr>
<tr><td>14</td><td>100%</td><td>47%</td><td>50% [0.235]</td></tr>
<tr><td>4.7</td><td>50%</td><td>0%</td><td>0% [0]</td></tr>
</table>
</td><td>Camellia uses a 30s exposure time and changes the impact depending on whether the exposed population is inside or outside.
The model includes consequences at 4.7 kW/m^2 and so the fatality probability between 14kW/m^2 and 4.7kW/m^2 is interpolated.
The vulnerability model has taken credit for protection of indoor population, but is still appropriately conservative.</td></tr>
<tr><td>Pipeline length</td><td>All pipelines in the Precinct, plus fixed sources compared with the societal risk criteria.</td><td>Societal risk is compared on a precinct-wide basis, rather than over a 1 km length. A sensitivity analysis was conducted assuming a 1 km section and the results were similar, and hence the overall precinct basis was retained.</td></tr>
<tr><td>Risk</td><td>The frequency and consequence data were manually entered into TNO (Gexcon) RiskCurves v9.0.26.</td><td>Individual risk contours were output from RiskCurves. Population was entered into the model (Day and Night) as described in Section 5.2. The fraction indoors (lower vulnerability) was assumed to be 90% during the day and 99% at night.</td></tr>
<tr><td>Pressure and flowrate</td><td>Maximum Allowable Operating Pressure (MAOP) for the pipeline is used (7,500 kPag) and a mass flowrate of 91 kg/s</td><td>The MAOP is appropriately conservative, but the pool fire consequence is modified (reduced) by use of a limiting flowrate assumption.</td></tr>
</table>