

11. Guide to the Industrial hazard and risk assessment planning scheme policy

Brisbane City Plan 2014 (City Plan) has been developed by Brisbane City Council in consultation with the community and guides how land in Brisbane can be used and developed. This guide provides an overview of the content and rationale for City Plan provisions relating to industrial hazard and risk assessment planning.

This guide is for industrial hazard and risk specialists and developers and explains how the [Industrial hazard and risk assessment planning scheme policy](#) in City Plan applies to preparing preliminary hazard analysis reports for a development application.

Tools to help you understand City Plan

City Plan includes two online interactive planning tools: the [ePlan](#) (electronic version of [Brisbane City Plan 2014](#)) and the [interactive mapping tool](#) to make it easy for you to see what requirements may affect your development.

All of these tools can be found by visiting Council's website and searching for [Brisbane City Plan 2014](#).

Council's [interactive mapping tool](#) allows you to view a property on a map to see the zone, zone precinct, overlays and neighbourhood plans that apply to the site. It can also generate a property report that will help you identify the rules that apply to a development and the criteria Council will use to assess an application.

The [ePlan](#) contains details of the planning scheme and hyperlinks to help you find the requirements that relate to a proposed development.

Background of the Industrial hazard and risk assessment planning scheme policy

Industrial and storage activities involving hazardous materials can present a risk to the health and safety of people and the environment. Hazardous events arising from industrial and storage activities can include explosions, fire, release of toxic gas or release of toxic products of combustion. These events may result in fatalities, injury or damage to property or the biophysical environment. However, facilities that consume, handle or produce hazardous materials are an essential part of our society and generate significant benefits for the community.

Governments, industry and the community now recognise the need to identify, assess and control the risks that come from potentially hazardous industries. Appropriate siting and comprehensive risk impact assessment are essential in ensuring appropriate

development and securing the safety of the community and environment.

The [Industrial hazard and risk assessment planning scheme policy](#) contributes to achieving the strategic outcomes of City Plan by:

- protecting the health and wellbeing of sensitive uses from exposure to industrial hazards
- protecting existing lawful industrial uses from encroachment by incompatible sensitive uses.

The principal focus of the policy is off-site risk impacts; impacts outside the boundaries of a proposed facility which affect people, the environment, property and surrounding land uses. The policy applies to atypical and abnormal hazardous events and conditions and is not intended to apply to continuous or normal operating emissions of air or water pollutants. These issues are more appropriately dealt with by pollution control mechanisms in other parts of [City Plan](#) and in the [Environmental Protection Act 1994](#).

Role of the Industrial hazard and risk assessment planning scheme policy

The [Industrial hazard and risk assessment planning scheme policy](#) contains assessment methods for preparing a preliminary hazard analysis report. It also contains a graded approach for the risk assessment of industrial hazards.

The policy explains the requirements for a number of supporting safety assessment reports relating to proposed development intending to store significant quantities of hazardous chemicals. It also addresses development that encroaches existing hazardous industries through the Industrial hazards investigation overlay sub-category, as triggered by the Industrial amenity overlay code.

The [Industrial hazard and risk assessment planning scheme policy](#) is called up in the following codes:

- Bushfire overlay code
- Industry code
- Special purpose code
- Specialised centre code
- Service station code.

Each of these codes contains quantity thresholds for hazardous chemicals, as well as hazard and risk criteria relevant to the use covered by the code.

Performance outcomes in [City Plan](#) relating to technological hazards of fire, explosion and toxic release require that development minimises the risk to public safety, property and the environment and that it achieves the hazard and risk criteria contained in the relevant code. The code provides an acceptable solution of storing below a defined storage threshold quantity of hazardous chemicals. If this threshold is exceeded, you will be required to prepare a preliminary hazard analysis report to demonstrate achievement of this performance outcome.

The [Industrial hazard and risk assessment planning scheme policy](#) does not specify minimum performance requirements or types of technology that should be used to manage off-site impacts. The performance-based assessment requires you to demonstrate that the proposed or existing activity contains sufficient measures to meet the required risk and consequence criteria through the following hierarchy:

1. minimise quantities
2. separation
3. design
4. operational controls.

Preliminary hazard analysis report

A preliminary hazard analysis (PHA) report is an in-depth risk investigation, preliminary only in the sense that it is based on the preliminary information available at the time of the analysis (typically prior to detailed design). A need for further analysis may be necessary depending on any substantial changes that occur during design.

The PHA report needs to include a detailed hazard analysis and risk assessment and should:

- identify all potential hazards
- identify sensitive uses that may be affected by the hazards
- analyse each hazard in terms of consequence to people and the biophysical environment, and the likelihood of occurrence
- quantify the analysis and estimate the resultant risks to surrounding land uses and the environment
- assess the risks in terms of the location, land use planning implications and hazard and risk criteria and ensure that the proposed safeguards are adequate and that the development will not impose an unacceptable level of risk.

Figure 1 provides an overview of the integrated hazards-related assessment process.

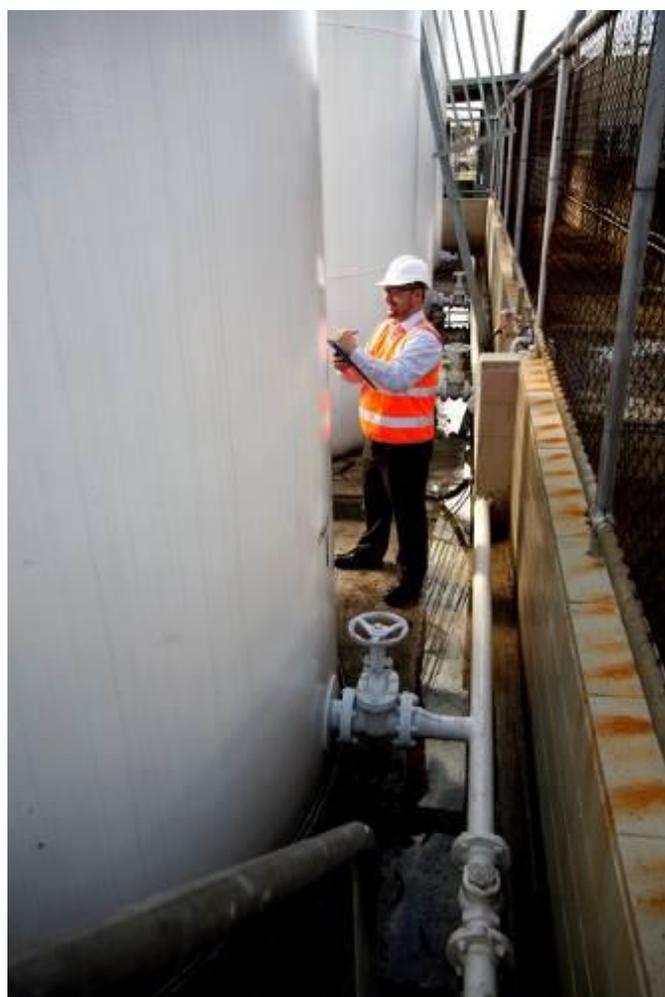
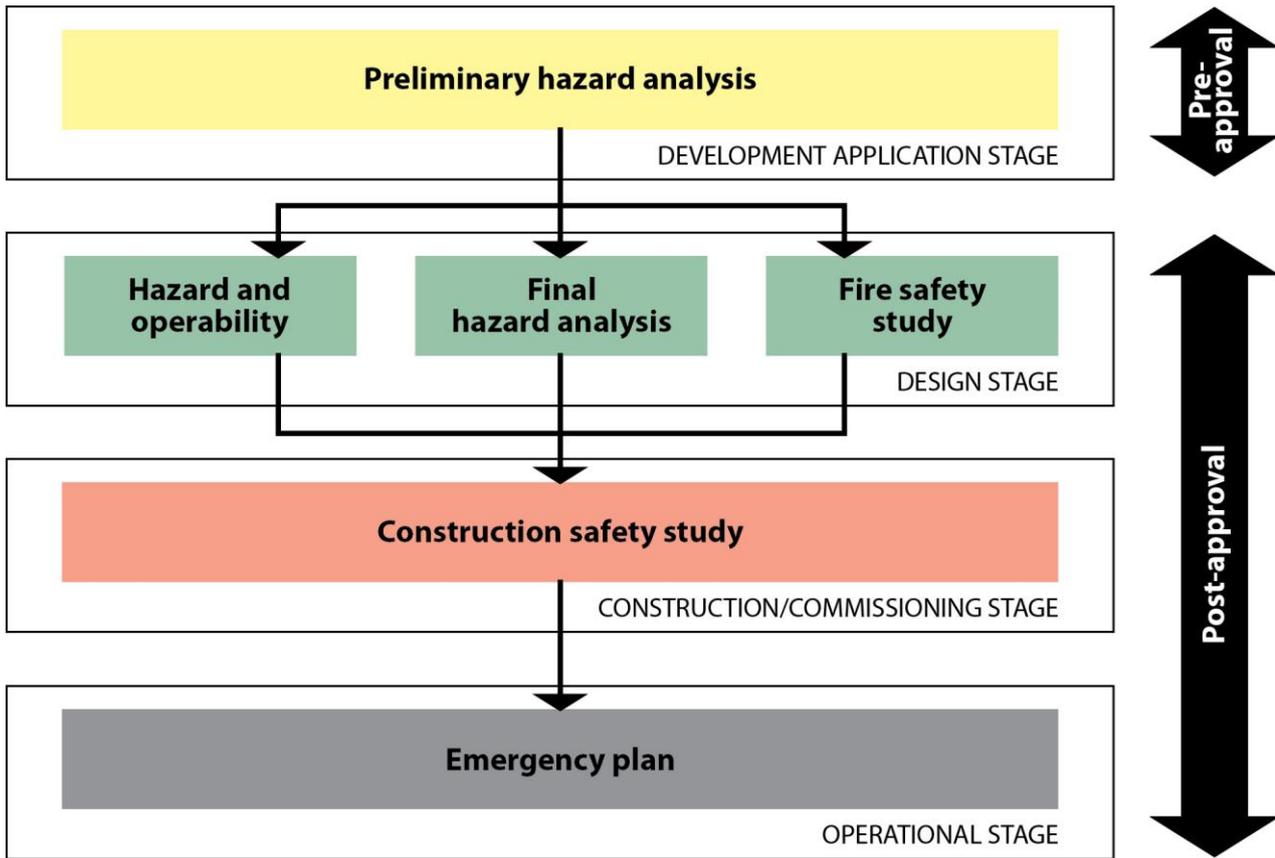


Figure 1 - Hazards-related assessment process



Hazard analysis and risk assessment

The hazard analysis and risk assessment approach acknowledges that hazard and risk (defined in terms of both the consequence and likelihood of hazardous events) from activities involving hazardous materials cannot be entirely eliminated. There will always be a residual risk which, in many cases, will extend beyond site boundaries. It is necessary to understand the nature of this residual risk and to develop and implement land use strategies and controls to cope with it.

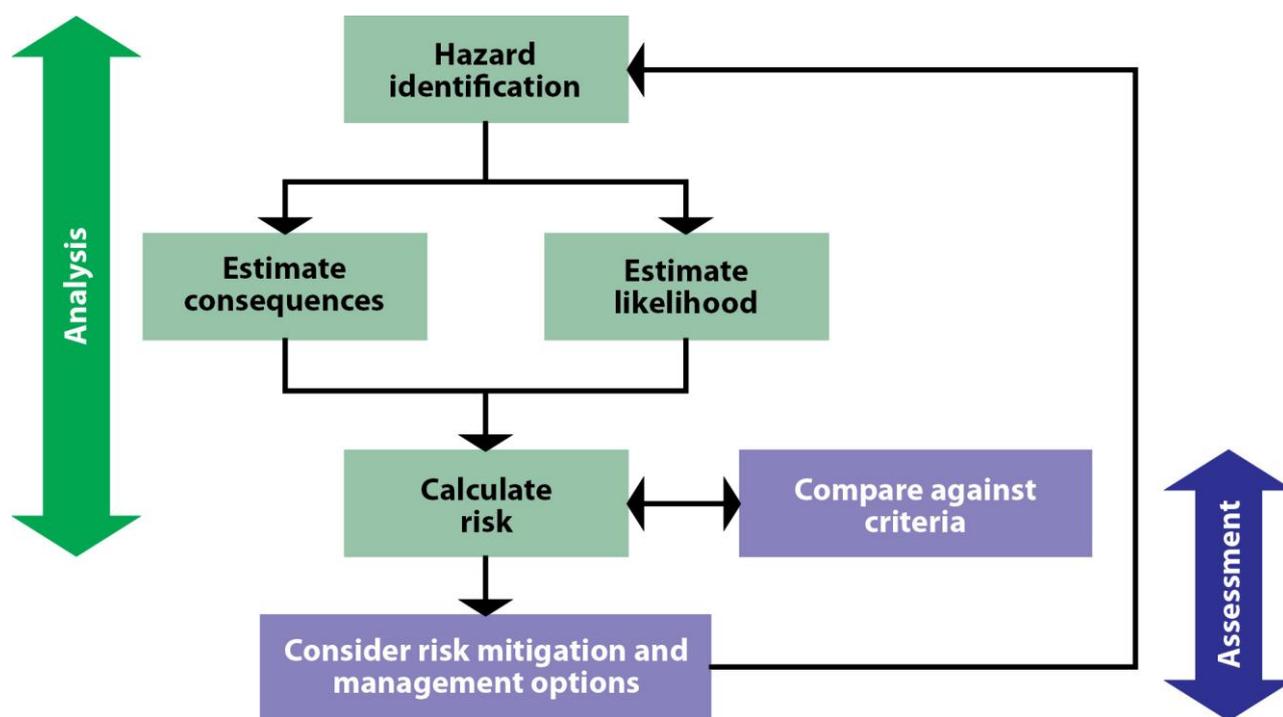
The main elements of hazard analysis are:

- identifying the nature and scale of all hazards at the facility, and selecting representative incident scenarios

- analysing the consequences of these incidents on people, property and the biophysical environment
- evaluating the likelihood of such events occurring and the adequacy of safeguards
- calculating the resulting risk levels of the facility
- comparing these risk levels with established risk criteria and identifying opportunities for risk reduction.

A schematic of the hazard analysis process is illustrated in Figure 2.

Figure 2 - Basic methodology for hazard analysis



Hazard identification involves identifying hazardous events, their potential causes and consequences (in qualitative terms). Reference is also made to the proposed operational and organisational safeguards that would prevent such hazardous events from occurring or, should they occur, that would protect the plant, its equipment, people and the environment. This process enables you to establish, in principle, adequate and relevant safeguards. Risks identified as having significant off-site impacts may require more detailed quantitative analysis, according to the graded, multi-level risk assessment.

Consequences Estimation involves assessing the effects of potentially hazardous incidents associated with the operations of a proposed development. Mathematical models and computerised tools are available to help estimate the effect of incidents such as fires, explosions or the release of toxic substances on people, buildings and the environment. It is essential to take into account the likelihood that hazardous incidents, while possible, may in fact never occur during the operating life of the development. This is because design, standards of construction and other operational safety controls would prevent their occurrence.

However, the assessment process must, fully account for the likelihood of hazardous incidents occurring, and for the likelihood of the effects of such incidents.

Likelihood Estimation involves identifying the probability of incidents occurring and the probability of particular effects should those events occur. For example, in the case of toxic gas storage, the probability of the failure of items such as storage vessels, transfer pipes and pumps with the resultant releases should be established. The frequency of elements such as wind and stability conditions also

need to be established to determine the likelihood of concentrations in the air or water, and hence of fatality, injury or other effects of exposure to people or the environment.

The consequence and likelihood estimations are cumulatively combined for the various hazardous incident scenarios to give a quantified risk level. Quantified risk assessment only needs to be performed if full or partial quantification is warranted.

The New South Wales (NSW) Department of Planning and Infrastructure's Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – Guidelines for Hazard Analysis provides further details on the techniques used in carrying out a hazard analysis.

Graded approach to risk assessment

The level and extent of a risk analysis depends on the nature, scale and location of each development. Section 3.1 of the [Industrial hazard and risk assessment planning scheme policy](#) describes a multi-level framework aimed at providing consistency and an appropriate level of analysis. In each case, the objective is to progress the analysis and its assessment only as far as is needed to demonstrate that the operation being studied does not, or will not, pose a significant risk to surrounding land uses. This may be achieved by using a combination of qualitative and quantitative approaches.

The hazard analysis methodology provides three levels of analysis.

Level 1 assessment

A level 1 assessment is essentially qualitative in nature and should, as a minimum, include:

- a formalised hazard identification, using such tools as word diagrams, simplified fault/event trees and checklists
- a generalised consequence analysis of the key risk contributors (using, for example, the results of the risk classification), to demonstrate that such consequences are kept within site boundaries
- an evaluation of the risks against the defined criteria in the relevant code
- a demonstration of the adequacy of proposed technical and management controls to ensure the ongoing safety of the proposed development.

Level 2 assessment

A level 2 assessment is semi-quantitative and should, in addition to all the elements of the level 1 analysis, include sufficient quantification of risk contributors to demonstrate that risk criteria will be met. In particular:

- there should be appropriate modelling tools used to calculate the consequences of all events shown by the preliminary assessment to have the potential for harmful off-site effects
- there should be an estimate of likelihood for each event confirmed by the consequence modelling to have significant off-site effects, using appropriate failure data and techniques such as fault and event trees
- there should be an indicative estimate of the off-site risk, taking into account the cumulative impact of multiple events
- the study must demonstrate that all relevant numerical risk criteria will be met.

Level 3 assessment

A level 3 assessment is a full quantitative risk assessment. The requirements of the NSW Department of Planning and Infrastructure's Hazardous Industry Planning and Advisory Paper (HIPAP) No. 6 – Hazard Analysis should be consulted for such a study.

A level 1 qualitative assessment may suffice provided all or most of the following conditions are met:

- screening and risk classification and prioritisation indicate there are no major offsite consequences and societal risk is negligible
- the necessary technical and management safeguards are well understood and readily implemented
- there are no sensitive surrounding land uses.

If the qualitative analysis cannot demonstrate there will be no significant risk, a further level of analysis is required. Partial quantification would normally be applied to developments where hazard identification and/or risk classification and prioritisation has identified

one or more risk contributors, with consequences beyond the site boundaries but with a low frequency of occurrence. Otherwise, a full quantitative analysis should be carried out.

On a large site, it is likely that the risk assessment will employ a combination of techniques. This ensures that the analysis effort is concentrated on areas of greatest hazard.

Some of the elements that need to be considered at each level, the tests of adequacy that may be applied in assessing the adequacy of a PHA and the acceptability of the risks are outlined in Sections 3.3, 3.4, 3.5 and Table 1 - Levels of analysis and assessment in the [Industrial hazard and risk assessment planning scheme policy](#).

Once you have identified any hazards and estimated their risks, you will need to compare the results against hazard and risk criteria stated in the relevant development code in the City Plan. This will help you determine whether or not the risk is tolerable

The criteria take into account the nature of surrounding land uses and the category of risk. They include elements such as individual and societal risk of fatality, injury/irritation and property damage.

Background information on the setting of the hazard and risk criteria is set out in NSW Department of Planning and Infrastructure's Hazardous Industry Planning Advisory Paper (HIPAP) No.4 - Risk Criteria for Land Use Safety Planning.

It is not possible to apply the full range of numerical criteria to level 1 and level 2 assessments, since the risk results are not fully quantified. The following principles should be followed in these cases.

Level 1 assessment (qualitative)

While the criteria that will be applied to a level 1 assessment will mostly be qualitative, some broad quantification arises out of the preliminary screening and risk classification and prioritisation stages.

These results should be used, in conjunction with the hazard identification, to demonstrate that the following broad criteria have been satisfied:

- containment of significant consequences within the site
- compliance with relevant codes and standards
- satisfaction of the principle of avoidance of avoidable risk.

Level 2 assessment (partially quantitative)

The criteria noted above for level 1 assessment also generally apply to level 2 assessments. Level 2 assessments must also demonstrate that the relevant numerical criteria will not be exceeded. This requires that the cumulative effects of those sources of risk with significant consequences beyond the site boundary will have been quantified and shown to be below the appropriate criteria. Specifically, this means that:

- no individual event should have off-site consequences (such as fatality or injury) at a frequency greater than that appropriate for the exposed land use
- at any point outside the site, there should be no combination of events which cumulatively will cause the individual risk criteria to be exceeded.

The use of generalised off-site risk contours, when they are available, may be useful in demonstrating that these requirements have been met.

Risk reduction and management

Even when you have demonstrated that risk criteria have been satisfied, you will need to maintain an ongoing program of risk minimisation and management. Three basic principles apply:

- As noted in the previous section, all avoidable risks should be avoided, meaning that risk contributors should be eliminated wherever technically and economically feasible.
- Risks from major hazards should be reduced wherever practicable, irrespective of their numerical contribution to the cumulative risk from the installation. The likelihood of major accidents should be reduced as far as possible.
- Every facility should have a strong safety management system in place to ensure safe operation throughout its life.

Post-approval design stage requirements - further studies

It is essential that the safety assessment process continues throughout the design, construction and commissioning of a potentially hazardous facility to refine and update the outcome of the development approval/risk assessment process. There also need to be measures to ensure the ongoing integrity of the safety systems throughout the life of a facility.

You will need to undertake additional studies at the post-approval design stage meaning that is, the output of one study should be used as an input to the others and all, in turn, as inputs to the design refinement process. This will help to ensure that adequate design and management measures are adopted, and that the facility will achieve and maintain the safety standards specified in the PHA study.

Each development will be considered on its merits and only studies relevant to the proposal are required. As an example, a fire safety study would not be required in

cases where there are essentially no flammable materials used as part of the development.

Five key studies are required at the post-approval design stage:

1. Hazard and operability study
2. Fire safety study
3. Emergency plan and procedures
4. Final (updated) hazard analysis
5. Construction safety study

Hazard and operability study (HAZOP)

At the design stage of the development, when detailed design information is available, hazard and operability (HAZOP) studies are required.

HAZOP studies are a particular form of hazard identification. They involve comprehensively and systematically examining the facility, section by section (usually on the basis of the flow/piping and instrumentation diagrams), using guide words.

HAZOP studies should be carried out by a team chaired and coordinated by an independent qualified person. Design engineers and personnel who will operate the facility should form part of the HAZOP study team. This examination identifies possible deviations from normal operating conditions which could lead to hazardous occurrences. The consequences and likelihood of such deviations are examined, and the adequacy and relevancy of available safeguards to detect such deviations and prevent/ protect against their resultant effects are evaluated in detail. This process enables a comprehensive evaluation of hazard control systems and produces recommendations for any necessary modifications.

It is essential that the HAZOP takes into account the results of the preliminary hazard analysis and risk assessment undertaken at the development approval stage. Information from the hazard analysis, particularly in relation to identified hazards and their consequences, is a valuable input to the HAZOP process. Where appropriate, input should also be drawn from the fire safety study and emergency plan preparation.

HAZOP studies should be completed and approved prior to the commencement of substantial construction on-site and certainly before the completion of design.

Detailed guidance for HAZOP studies is provided in the NSW Department of Planning and Infrastructure's Hazardous Industry Planning Advisory paper (HIPAP) No. 8 – HAZOP Guidelines.

Fire safety study

The objective of a fire safety study is to ensure that the proposed fire prevention, detection, protection and fighting measures are appropriate for the specific fire hazard and adequate to meet the extent of potential fires for the development.

This study involves case-specific hazard analysis and design of fire safety arrangements that respond to the

specific hazards and risks associated with the development, as well as meeting relevant codes and regulatory requirements. The case-specific approach offers the benefit of fire safety measures being tailor-made and cost effective.

The fire safety study should be concerned with all the effects of fire. It therefore should not only address the direct effects of flame, radiant heat and explosion, but also the potential for the release of toxic materials and combustion products in the event of fire, as well as the potential for the release of contaminated fire-fighting water.

The results of HAZOP, PHA and updated hazard analysis should provide the basis for fire safety requirements. The relationship between fire safety systems and emergency plans and procedures should be clear.

Fire safety studies should be prepared with, and approved by, the Queensland Fire and Rescue Service. They should be done at an early stage, prior to substantial construction on-site and certainly well before the start of operations.

The NSW Department of Planning and Infrastructure's Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 – Fire Safety Study Guidelines provides further detail on the scope, content and procedures of fire safety studies.

Emergency procedures and plans

Ongoing safety of a development of a potentially hazardous nature requires the preparation of plans and procedures to deal with emergencies. Emergency planning can reduce both the likelihood and magnitude of potentially hazardous incidents and reduce the consequences of incidents that do occur.

Emergency planning can reduce the likelihood of incidents occurring by ensuring that, when potentially dangerous situations develop, the response is both quick and appropriate. The magnitude can be reduced through early control which, for example, limits the size of a spill or fire. The consequences of any given incident can be reduced by such measures as control, evacuation and clean-up.

It is essential that emergency procedures and plans are not of a generalised nature, but are tailored to the needs and hazards at each facility, and at each locality. Hazard analysis and HAZOP should identify hazards and the nature and extent of consequences to help formulate emergency procedures, resource requirements and their implications. The results of the fire safety study should also be used as an input. Formalised emergency plans should be prepared with, and approved by, Queensland Emergency Services before the commencement of operations.

The NSW Department of Planning and Infrastructure's Hazardous Industry Planning Advisory Paper (HIPAP) No. 1 – Emergency Planning provides a comprehensive outline of the scope and content of emergency plans and guidance for their preparation by industry.

Updated hazard analysis and risk assessment (Final hazard analysis)

When detailed HAZOP, fire studies and emergency plans are completed, the design finalised, and the safety control systems determined to a final stage, the preliminary hazard analysis and risk assessment should be updated. The final hazard analysis and risk assessment should follow the same principles as the preliminary studies, but assumptions and results reworked to fully account for the detailed design information and precise safeguards.

The principles of multi-level risk assessment used in the preliminary studies also apply to the final hazard analysis. Future plant operations, updates and extensions should be based on the risk levels identified in the final hazard analysis. The risk impact should not be worse than the predicted risk impact identified in the preliminary hazard analysis report. The updated (final) hazard analysis and risk assessment studies should be finalised and approved before the commencement of any operations.

The final hazard analysis needs to be prepared in accordance with NSW Department of Planning and Infrastructure's Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 – Guidelines for Hazard Analysis.

Construction safety study

A construction safety study is to be carried out to ensure facility safety during construction and commissioning, particularly when there is interaction with existing operations. The study will result in formalised arrangements that ensure the safety of workers and of surrounding land uses during construction. These studies should focus on the potential for hazardous materials incidents.

A construction safety study is an integral part of the approval process and is typically carried out after project design has been completed. The construction safety study focuses on construction-related hazards that have the potential to affect site operations, which may in turn lead to off-site impacts. Occupational health and safety issues are dealt with outside the planning system.

Construction and commissioning safety assurance should act as a final check on the appropriateness of the design and specification, and should ensure that the facility is built safely and commissioned in accordance with the design intent.

The construction safety study identifies all hazards which are specific to the demolition, construction and commissioning activities associated with the proposed development. It also identifies the safeguards that will be put in place to ensure those hazards are controlled.

This study is relevant to new development as well as modifications and additions to existing development. It also applies to the demolition of a facility at the end of its operating life, whether or not it is to be replaced. The following areas are given particular attention:

- demolition of existing plant and structures
- contamination

- hazardous materials for demolition/construction
- excavation hazards
- interaction with continuing operations
- drainage arrangements
- natural events
- hazardous materials during commissioning
- sequencing of commissioning activities.

Further guidance on the form and content of construction safety study reports can be obtained from NSW Department of Planning and Infrastructure's Hazardous Industry Planning Advisory Paper (HIPAP) No. 7 – Construction Safety.

Development within the Industrial hazards investigation overlay sub-category

Ideally, the risk from potentially hazardous facilities, especially those with potential for a major accident, should be controlled to such a degree that it does not restrict surrounding development on safety grounds. In practice however, it is seldom possible to eliminate risk completely and development controls need to be established to ensure that new development does not increase overall risk by increasing exposure to the consequences of major accidents.

The Industrial amenity overlay code applies to assessable development within the Industrial hazard investigation area sub-category of the Industrial amenity overlay. The overlay identifies risk/consequence-based investigation areas around major hazard facilities and facilities storing 10% or more of the quantity thresholds, as defined in the *Work Health and Safety Regulation 2011*.

These investigation areas provide a clear flag for developers and assessment officers that appropriate consideration needs to be given to ensure that proposed development is located, designed and constructed to achieve the hazard and risk criteria defined in the Industrial amenity overlay code.

Council recognises that, in most cases, developers will not be able to undertake an accurate preliminary hazard analysis report for their development proposal due to the difficulty in obtaining detailed technical information from the facility, or facilities, in the vicinity. Much of this information would be considered either commercial-in-confidence or of security concern and, therefore, would not be expected to be made available to potential developers of nearby properties. In these circumstances, upon receipt of an application for development within an investigation area, Council will refer the application to the Hazardous Industries and Chemicals Branch, Queensland Division of Workplace Health and Safety for technical advice on the appropriateness, of the development.

However, to minimise unnecessary costs and delays, Council recommends that developers contact the Hazardous Industries and Chemicals Branch during the early stages of any development proposal and obtain

an initial indication of any likely development constraints.

Hazard and risk criteria

The identification of hazards and the quantification of risks outside the boundaries of a potentially hazardous development, and the assessment of that risk in terms of the nature of land uses in the vicinity provide the basis for compatible land use safety planning.

To ensure a consistent approach to risk assessment and decision-making, formal criteria has been established. Judgement can be made against this criteria to determine the compatibility of different land uses.

There are two dimensions of risk which should be considered separately, individual and societal. On the one hand, the individual's concern about their own life or safety, and is mostly independent of whether the risk is from an isolated incident or a large scale disaster. Society's risk perception is mostly influenced by multiple fatality or injury disasters.

When a risk is to be imposed on an individual or a group of people (e.g. by locating a hazardous facility in an area), the concept of acceptability of that risk is that it should be low, relative to other known and tolerated risks.

In assessing the tolerability of risk from potentially hazardous development, both qualitative and quantitative aspects need to be considered. These include:

- avoiding all avoidable risks
- reducing the risk from a major hazard wherever practicable, even where the likelihood of exposure is low
- containing the effects of significant events within the site boundary, where possible
- ensuring further development does not pose any incremental risk where the risk from an existing installation is already high.

Individual risk

Risk results are most commonly expressed in terms of human fatality. However, the analysis and results can, also be expressed in other terms such as levels of injury, property damage or environmental damage.

Individual fatality risk

Individual fatality risk is the risk of death to a person at a particular point. Regulators have concluded that if a risk from a potentially hazardous installation is below most risks being experienced by the community, then that risk may be tolerated. This is consistent with the basis of criteria used in City Plan, as well as those adopted by most authorities nationally and internationally.

City Plan has adopted a fatality risk level of one in a million per year (1×10^{-6} per year) for industrial hazards, as the limit for risk acceptability for residential

area exposure. This limit is also important when considering land use proposals in the vicinity of potentially hazardous facilities.

It is also necessary to account for variations in the duration of exposure to that risk at any particular point by any one individual. People's vulnerability to the hazard and their ability to take evasive action when exposed to the hazard also need to be taken into account.

The one in a million criteria assumes that residents will be at their place of residence and exposed to the risk 24 hours a day and continuously day-after-day for the whole year. In practice this is not the case and this criterion is therefore conservative.

People in hospitals, children at school or older people are more vulnerable to hazards and less able to take evasive action, if needed. A lower risk than the one in a million criteria (applicable for residential areas) is more appropriate for such cases. On the other hand, land uses such as commercial and open space do not involve continuous occupancy by the same people. The individual's occupancy of these areas is on an intermittent basis and the people present are generally mobile. As such, a higher level of risk (relative to the permanent housing occupancy exposure) may be tolerated.

A higher level of risk is generally considered acceptable in industrial areas.

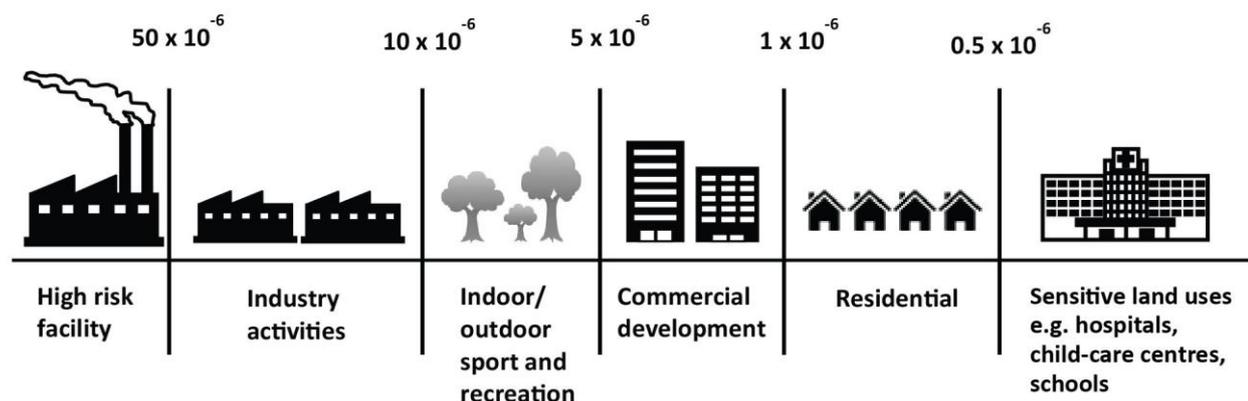
The following risk assessment criteria are used for assessing the safety of location of a potentially hazardous development, or for land use planning in the vicinity of existing hazardous installations.

Note: These criteria are stated in the relevant development codes. An expanded description of the criteria is given below.

1. Hospitals, schools, child-care facilities and aged-care housing development should not be exposed to individual fatality risk of more than half in one million per year (0.5×10^{-6}).
2. Residential developments and places of continuous occupancy, such as hotels and tourist resorts, should not be exposed to individual fatality risk levels of more than one in a million per year (1×10^{-6} per year).
3. Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres, should not be exposed to individual fatality risk levels in excess of five in a million per year (5×10^{-6} per year).
4. Sporting complexes and active open space areas should not be exposed to individual fatality risk levels of more than ten in a million per year (10×10^{-6} per year).
5. Individual fatality risk levels for industrial sites at levels of 50 in a million per year (50×10^{-6} per year) should, as a target, be contained within the boundaries of the site where applicable.

Figure 3 below summarises the relative tolerance of various land uses in regard to individual fatality risk.

Figure 3 - Individual fatality risk levels for various land uses



While individual fatality risk levels should include all components of risk (i.e. fires, explosions and toxicity), there may be uncertainties in correlating toxic concentrations to fatality risk levels. The fatality risk assessment should not rely on any one dose-effect relationship, but involve a review of available data.

Individual injury risk

Relying entirely upon fatality risk criteria may not account for the following factors:

- society is concerned about risk of injury as well as risk of death
- fatality risk levels may not entirely reflect variations in people's vulnerability to risk as some people may be affected at a lower level of hazard exposure than others.

It is therefore appropriate that risk criteria also be set in terms of injury.

Note: These criteria are stated in the relevant development codes. An expanded description of the criteria is given below.

Heat radiation

For the purpose of injury, a lower heat radiation level (relative to that level which may cause fatality) is appropriate. The 4.7 kW/m^2 heat radiation level is considered high enough to trigger the possibility of injury for people who are unable to be evacuated or seek shelter. That level of heat radiation would cause injury after 30 seconds' exposure. Accordingly, a risk injury criterion of 50 in a million per year at the 4.7 kW/m^2 heat flux is applied. The suggested injury risk criterion for heat radiation can therefore be expressed as follows.

- incident heat flux radiation at residential and
- sensitive use areas should not exceed 4.7 kW/m^2 at a frequency of more than 50 chances in a million per year.

Explosion overpressure

An explosion overpressure level of 7 kPa may be used as the level above which significant effects to people and property damage may occur. This uses a similar analysis to the heat flux injury level method.

Accordingly, an injury risk criteria of 50 in a million at the 7 kPa explosion overpressure level is applied. The suggested injury/damage risk criterion for explosion overpressure can therefore be expressed as follows.

- Incident explosion overpressure at residential and sensitive use areas should not exceed 7 kPa at frequencies of more than 50 in a million per year.

Toxic exposure criteria

Depending on the concentration, the nature of the material, and the duration and mode of exposure (i.e. via the respiratory tract, lungs, skin or ingestion), the effects of toxicants can include fatality, injury (e.g. damage to lungs and respiratory system, damage to nervous system, emphysema, etc.) to irritation of eyes, throat or skin and nuisance. Effects can also be classified as acute, chronic or delayed.

The assessment criteria and dose-effect relationships vary from one chemical to another. Toxic criteria applicable to one chemical may not necessarily be appropriate for others. Therefore, each case should be justified on its merits using a thorough search of available and known dose-effect relationships as the basis for assessment. Incidents with injurious impact on people should be kept to low frequencies.

The injury risk criteria for toxic gas/smoke/dust exposure are as follows:

- toxic concentrations in residential and sensitive use areas should not exceed a level which would be seriously injurious to sensitive members of the community following a relatively short period of exposure at a maximum frequency of 10 in a million per year
- toxic concentrations in residential and sensitive use areas should not cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community over a maximum frequency of 50 in a million per year.

Risk of property damage and accident propagation

The siting of a hazardous installation must account for the potential of an accident at the installation, causing damage to buildings and propagating to neighbouring industrial operations. This may lead to further hazardous incidents - the so-called 'domino effect'. The siting process must also account for existing risk conditions at the proposed site.

The principle of setting risk criteria to reflect the potential for accident propagation is that the risk of an accident at one plant triggering another accident at another neighbouring plant should be low and that adequate safety separation distances should be provided as part of siting and layout of plant and equipment.

Note: These criteria are stated in the relevant development codes. An expanded description of the criteria is given below.

Heat radiation

Heat radiation levels of 23kW/m² as the result of fire incidents at a hazardous plant may affect a neighbouring installation to the extent that unprotected steel may suffer thermal stress, potentially resulting in structural failure. This may trigger a hazardous event unless protection measures are adopted.

The criteria for risk of damage to property and of accident propagation can therefore be stated as follows:

- incident heat flux radiation at neighbouring potentially hazardous installations, or at land zoned to accommodate such installations, should not exceed a risk of 50 in a million per year for the 23kW/m² heat flux level.

Explosion overpressure

Explosion overpressure levels of 14kPa, as the result of explosions at a hazardous plant, may damage piping and low-pressure equipment at a neighbouring plant. It is therefore appropriate that the probability of these levels of impacts at neighbouring installations be relatively low. A probability of 50 in a million per year is adopted for assessment purposes.

The explosion overpressure level of 14kPa is also sufficient to cause significant damage to buildings and therefore, is appropriate as the basis for a risk of damage criteria. A probability of 50 in a million per year is also adopted for assessment purposes.

The criteria for risk of damage to property and of accident propagation can therefore be stated as follows:

- incident explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings should not exceed a risk of 50 in a million per year for the 14kPa explosion overpressure level.

These criteria do not remove the need to consider higher consequence levels at lower frequencies. The hazard analysis should consider the whole picture, not just the nominated quantitative criteria.

Societal risk

Societal risk assessment takes into account the fact that society is particularly intolerant of accidents which, though infrequent, have a potential to create multiple fatalities.

Hazards giving rise to societal concerns share a number of common features. They often give rise to risks:

- that could cause multiple fatalities
- where it is difficult for people to estimate intuitively the actual threat
- where exposure involves vulnerable groups, e.g. children
- where the risks and benefits tend to be unevenly distributed, e.g. between groups of people with the result that some people bear more of the risks and others less, or through time so that less risk may be borne now and more by some future generation.

People are more averse to societal risks and therefore more likely to insist on stringent regulation.

Note: These societal risk criteria are stated in the relevant development codes. An expanded description of the criteria is given below.

Relevant development codes in City Plan have adopted the use of so-called FN-curves (obtained by plotting the frequency (F) of an event occurring against the number of people (N) the event might kill). The technique provides a useful means of comparing the impact profiles of man-made accidents with the equivalent profiles for natural disasters to which society is exposed. It should be emphasised that these criteria are indicative only, but can be a useful additional tool in the decision-making process.

The FN curve for societal risk criteria adopted in the relevant codes shows three societal risk bands:

- negligible
- as low as reasonably practicable (ALARP)
- intolerable.

It should be noted that, irrespective of the numerical risk criteria, the broad aim should be to avoid avoidable risk. Figure 4 on the following page illustrates the application of the principles of ALARP.

The ALARP principle

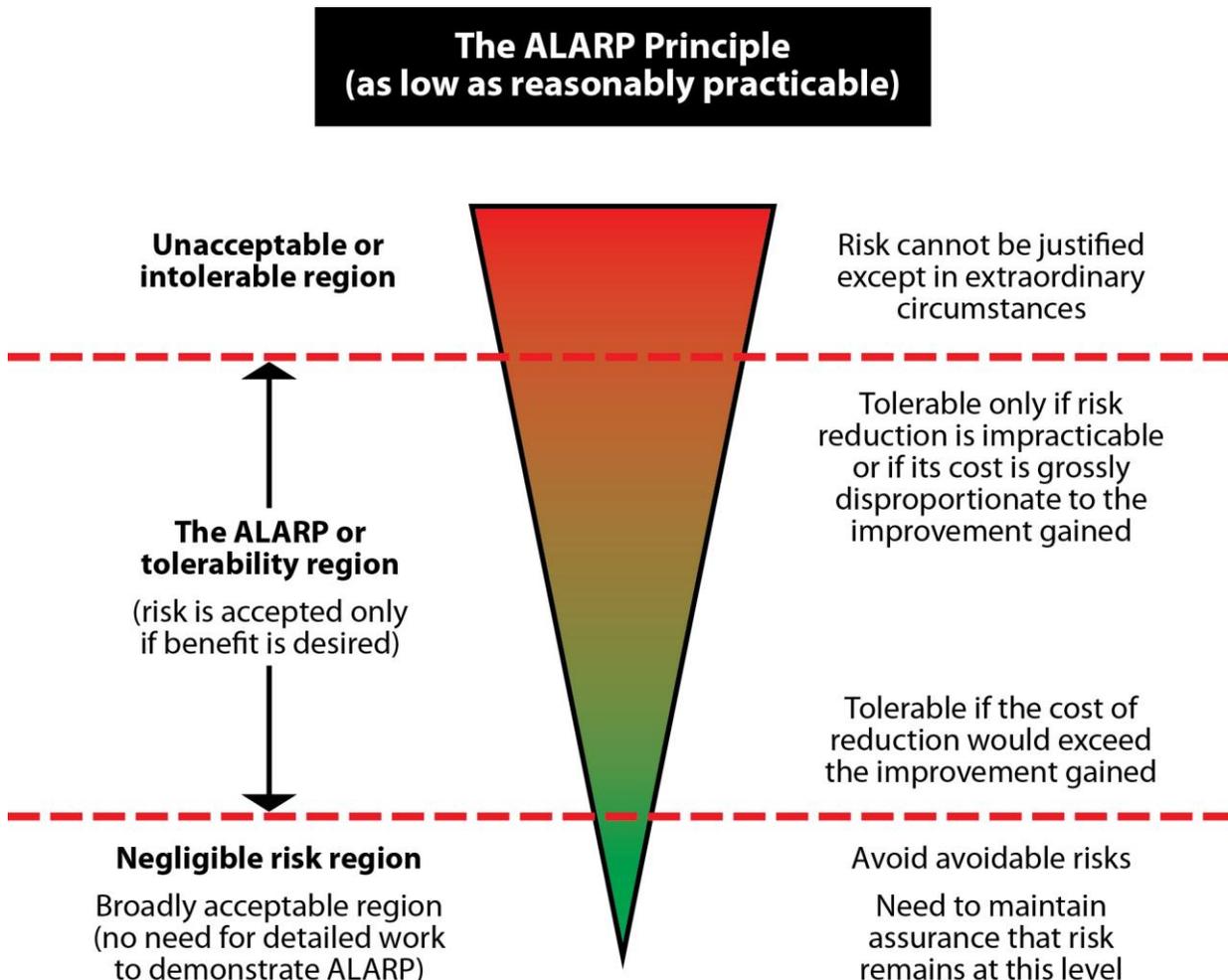
No industrial activity is entirely free from risk. As such many companies and regulators around the world require that safety risks are reduced to levels that are as low as reasonably practicable, or ALARP.

The ALARP region lies between unacceptably high and negligible risk levels. Even if a level of risk for a baseline case has been judged to be in this ALARP region it is still necessary to consider introducing further risk reduction measures to drive the residual risk downwards. The ALARP level is reached when the time, trouble and cost of further reduction measures become unreasonably disproportionate to the additional risk reduction obtained.

Risk can be reduced by avoidance, adopting an alternative approach or increasing the number and effectiveness of controls. The greatest opportunity to achieve the lowest residual risk is at the concept stage of a new project where you can identify alternative options that achieve the optimal balance of safety and function.

Once the concept is selected and early design progresses, the attention shifts to considering alternative layout and system options to optimise inherent safety. In the detailed design phase, the focus moves on to examining alternative options for improving safety systems. During operations, the attention is on collecting feedback, improving procedures and managing change to maintain the residual risk at an ALARP level. However, with advances in technology, what is ALARP today may not be ALARP tomorrow, so periodic reviews will be necessary.

Figure 4 - Applying principles of ALARP



Risk and hazard criteria for development in the vicinity of potentially hazardous facilities

The same risk and hazard criteria used for assessing industrial development of a potentially hazardous nature are equally relevant and applicable to assessing development in the vicinity of potentially hazardous facilities, namely:

- individual fatality risk
- individual injury risk
- property damage and accident propagation risk
- societal risk.

The criteria adopted in the Industrial amenity overlay code apply to all development proposed within the

Industrial hazard investigation area sub-category of the Industrial amenity overlay.

More information

For more information about City Plan visit www.brisbane.qld.gov.au and search for *Brisbane City Plan 2014*, or phone Council on (07) 3403 8888.

Disclaimer: The content of this information sheet is a summary and has been prepared to assist the reader to understand City Plan. Please refer to the full City Plan document, entitled Brisbane City Plan 2014, on Council's website for further detail.