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1.0 INTRODUCTION

Development on land affected by flooding will be assessed against the risk, hazard and adverse consequences caused by flooding. This chapter outlines Council's design criteria that aim to reduce property damage and ensure safety of persons.

Floodable land is any land that is affected by river, creek or localised flooding. The three types of flooding are described as follows:

- River flooding occurs when there is widespread prolonged rain over the catchment of the Brisbane River.
- Creek flooding occurs when bankfull capacities are exceeded. On average Brisbane's natural creeks have a 50-100% chance of exceeding their bankfull capacities in any one year.
- Local flooding occurs when components of the stormwater drainage system such as pipes and gully inlets are blocked and/or design capacity is exceeded and/or when the overland flow path is blocked by a building or fence. (Note: The 'Flood Search Flag' theme in Council's BIMAP database generally refers to indicative areas of known potential creek/river flooding problems based on historical flood records. The areas currently mapped under this theme do not extend to any areas with potential localised overland flow problems. The FloodWise Property Report is a free report issued by Council and is designed to provide property based information about flood levels.)

2.0 FLOOD IMMUNITY

2.1 RECONFIGURING A LOT

For a subdivision (freehold lots or community title scheme) where there is dedication and opening of road or where the subdivision creates more than 6 lots, design levels must comply with Table A1.1. The flood immunity standards are assigned to eliminate the creation of new lots below the desired flood immunity level.

TABLE A1.1
FLOOD IMMUNITY LEVELS FOR SUBDIVISION

Flooding type (Note 1)	**Minimum lot levels (mAHD)** (Note 4)	
	Residential	**Other than residential**
Brisbane River (Note 2)	DFL + 0.3m	DFL
Waterway[A]	100y ARI + 0.3m	100y ARI
Local flooding[B]	50y ARI + 0.3m	50y ARI
Storm tide (Note 3)	100y ARI + 0.3m	100y ARI

NOTES:

1. Where the site is subject to more than one type of flooding (ie local flooding and/or waterway flooding and/or river flooding and/or storm tide), the minimum flood immunity level is the highest level determined from these sources. It should be noted that the flood immunity level in some older inner city areas is often controlled by local ponding.
2. The Defined Flood Level (DFL) for Brisbane River is based on the 3.7 mAHD level at the Brisbane Port Office Gauge. This standard was adopted by Council on 2 December 2003.
3. A storm tide is the effect on coastal water levels of a storm surge combining with the normally occurring astronomical tide. Storm surge (or more correctly meteorological tide) is a rise above normal water level due to the combined effects of surface wind stress and atmospheric pressure fluctuations caused by severe weather conditions such as tropical cyclone. The 100 year ARI storm tide is 2.5 mAHD. This value incorporates 0.3 m allowance to offset the potential effects of climate change.
4. If no hydraulic modelling data is available, the applicant should engage a suitably qualified Registered Professional Engineer in Queensland (RPEQ) to undertake appropriate hydrologic and hydraulic assessments.

For the purpose of this chapter, an infill subdivision refers to a subdivision where there is no dedication and opening of road and where the subdivision creates 6 lots or less. Infill subdivision typically occurs in a site either fully or partly surrounded by developed sites, for example, reconfiguring an existing 1215 m^2 lot to 3 individual 405 m^2 lots with frontage to an existing road.

Lots must have an appropriate area and dimensions for the siting and construction of potential buildings, the provision of outdoor space, convenient vehicle access and parking. For this reason, it is required that 60% of the new lot size or 300 m^2 rectangular shaped area (whichever is the greater area), achieves the flood immunity standards specified in Table A1.1.

A A waterway (including those indicated on the Planning Scheme Maps) is defined as any element of a river, creek, stream, gully or drainage channel, including the bed and banks.

B Local flooding usually occurs when the capacity of the underground piped drainage system is exceeded and/or when the overland flow path is blocked. Localised overland flow paths generally traverse along roadways and in the older established areas, through private properties. A localised overland flow path is not characterised by well-defined bed and banks and the contributing catchment is generally less than 30 hectares.

2.3 OTHER DEVELOPMENTS

2.3.1 Definition

For the purpose of this chapter, other developments refer to a development or redevelopment in an established area, which usually involves the intensification of land use in a site either fully or partly surrounded by developed sites. Typical examples include:

- The start of a new use of the premises (eg construction of a factory on a vacant lot).
- The re-establishment on the premises of a use that has been abandoned.
- A material change in the intensity or scale of the use of the premises (eg changing use of land from a house to a multi-unit building, increasing the gross floor area, etc).

2.3.2 Design Floor/Pavement Levels

Brisbane City Council will only consider the intensification of land use in floodable areas if the flood hazard is acceptable. However, it is preferred that filling be undertaken (no adverse impacts in accordance with *City Plan*) to eliminate flood hazard risks in the first instance so that the lot has the required flood immunity.

The acceptable degree of hazard is characterised by an inundation depth of ≤0.5 m and flow velocity of ≤2.0 m/s and depth*velocity product of ≤0.6 m^2/s from all flooding sources except the Brisbane River. Flooding from these sources can peak in a matter of a few hours. The hazard criteria are applied to the building footprint measured from the outermost projections of all roofed buildings and structures. The adopted hazard parameters are generally based on the following criteria set out in the publication *Floodplain Management in Australia - Best Practice Principles and Guidelines* (Commonwealth of Australia, 2000):

- The ability to evacuate people and possessions by trucks.
- The ability for fit adults to wade through floodwaters.
- Low flood damage potential.

Brisbane River can take a day to peak between Wivenhoe dam and the Brisbane City Gauge, thus allowing time to disseminate flood warnings. For this reason, Brisbane City Council have adopted a risk management approach to selected building types at existing lots and infill sites that do not meet the prescribed flood immunity standard (refer Section 4.0) as a result of backwater influence from the Brisbane River or direct river flooding.

Design levels for buildings and incidental works must comply with the flood immunity standards specified in Tables A1.2 and A1.3. Design levels are assigned to each building class as defined in the *Building Code of Australia* (refer Section 2.3.3 for definitions). The assigned flood immunity standards for developments in an established area recognises that the site is constrained in meeting the higher standard as required for a subdivision, whilst achieving acceptable safety and amenity outcomes.

TABLE A1.2
CATEGORIES OF FLOOD IMMUNITY LEVELS

Flooding type (Note 1)	**Minimum design floor or pavement levels (mAHD)** (Note 4) (Refer Table A1.3 for assignment of these categories)				
	Category A	**Category B**	**Category C**	**Category D**	**Category E**
Brisbane River (Note 2)	DFL + 0.5m	DFL + 0.3m	DFL	20y ARI	20y ARI
Waterway[A]	100y ARI + 0.5m	100y ARI + 0.3m	100y ARI	100y ARI	20y ARI
Local flooding[B]	50y ARI + 0.5m	50y ARI + 0.3m	50y ARI	50y ARI	20y ARI
Storm tide (Note 3)	100y ARI + 0.5m	100y ARI + 0.3m	100y ARI	50y ARI	50y ARI

NOTES:

1. Where the site is subject to more than one type of flooding (ie local flooding and/or waterway flooding and/or river flooding and/or storm tide), the minimum flood immunity level is the highest level determined from these sources. It should be noted that the flood immunity level in some older areas is often controlled by local ponding.
2. The Defined Flood Level (DFL) for Brisbane River is based on the 3.7 mAHD level at the Brisbane Port Office Gauge. This standard was adopted by Council on 2 December 2003.
3. A storm tide is the effect on coastal water levels of a storm surge combining with the normally occurring astronomical tide. Storm surge (or more correctly meteorological tide) is a rise above normal water level due to the combined effects of surface wind stress and atmospheric pressure fluctuations caused by severe weather conditions such as tropical cyclone. The 100 and 50 year ARI storm tides are 2.5 mAHD and 2.2 mAHD respectively. These values incorporate 0.3 m allowance to offset the potential effects of climate change.
4. If no hydraulic modelling data is available, the applicant should engage a suitably qualified Registered Professional Engineer in Queensland (RPEQ) to undertake appropriate hydrologic and hydraulic assessments.

A A waterway (including those indicated on the Planning Scheme Maps) is defined as any element of a river, creek, stream, gully or drainage channel, including the bed and banks.

B Local flooding usually occurs when the capacity of the underground piped drainage system is exceeded and/or when the overland flow path is blocked. Localised overland flow paths generally traverse along roadways and in the older established areas, through private properties. A localised overland flow path is not characterised by well-defined bed and banks and the contributing catchment is generally less than 30 hectares.

TABLE A1.3
ASSIGNED FLOOD IMMUNITY LEVELS

BCA building classification*	**Assigned design floor or pavement levels** (Refer Table A 1.1 for interpretation of flood immunity categories)
Class 1a & 1b, Class 2, Class 3, Class 4	Habitable room*: Category A Non-habitable room including patio and courtyard: Category B, except for Class 1a building where the 50y ARI + 0.3m applies to Brisbane River Non-habitable part of a Class 2 or Class 3 building excluding the essential services[@] control room: Risk management approach to Brisbane River flooding (refer Section 4) is permitted Garage associated with a building that is Class 1, 2, 3, or 4: Category B, except for Class 1a building where the 50y ARI + 0.3m applies to Brisbane River Carpark located in the building undercroft[#] of a multi-unit dwelling associated with a building that is Class 1, 2, 3, or 4: Category B Carport[1] or unroofed carpark: Category D Vehicular access and manoeuvring areas: Category D
Class 5, Class 6, Class 8	Building floor level: Category C, risk management approach to Brisbane River flooding is permitted (does not apply to the essential services[@] control room) Garage or carpark located in the building undercroft[#]: Category C Carport[1] or unroofed carpark: Category D Vehicular access and manoeuvring areas: Category D
Class 7a	Refer to the relevant building class specified in this table
Class 7b	Building floor level: Category C, risk management approach to Brisbane River flooding is permitted (does not apply to the essential services[@] control room) Vehicular access and manoeuvring areas: Category D
Class 9a, 9b, 9c	Building floor level: Category A Garage or carpark located in the building undercroft[#]: Category C Carport[1] or unroofed carpark: Category D Vehicular access and manoeuvring areas: Category D
Class 10a	Carparking facility: Refer to the relevant building class specified in this table Shed[2] or the like: Category D
Class 10b	Swimming pool: Category E Associated mechanical and electrical pool equipment: Category C Other structures: Flood immunity standard does not apply

* Refer Section 2.3.3 for definitions.

@ Essential services may include fire control panel, electrical switchboard, telephone, PABX, mains distribution, etc.

Basement carparks can be constructed to below the specified levels provided that suitably waterproofed perimeter walls, air vents, and entry/exit ramps at the carpark entrance are above the Defined Flood Level (DFL) for Brisbane River and 100 year ARI flood levels for all the other flooding sources.

1 A shelter for a motor vehicle, which has a roof and one or more open sides, and which can be built against the side of a building.

2 A slight or rough structure built for shelter and storage; or a large strongly built structure, often open at the sides or end.

The flood immunity standards specified in Table A1.3 may not be adequate for community infrastructure[3]. The *State Planning Policy 1/03: Mitigating the Adverse Impacts of flood, Bushfire and Landslide* (SPP 1/03) requires that these infrastructure have higher levels of flood protection than many other forms of development. Community infrastructure performs vital response and recovery roles during and immediately after a natural hazard event, or store valuable or irreplaceable items. The recommended flood immunity levels as set out in the *SPP Guideline 1/03* are provided in Table A1.4.

TABLE A1.4
FLOOD IMMUNITY LEVELS FOR COMMUNITY INFRASTRUCTURE

Type of community infrastructure	**Recommended flood levels**
Emergency services	500y ARI
Emergency shelters	200y ARI
Police facilities	200y ARI
Hospitals and associated facilities	500y ARI
Stores of valuable records or items of historic or cultural significance (eg galleries and libraries)	200y ARI
State-controlled roads Works of an electricity entity not otherwise listed in this table Railway lines, stations and associated facilities Aeronautical facilities Communication network facilities	No specific recommended level but development proponents should ensure that the infrastructure is optimally located and designed to achieve suitable levels of service, having regard to the processes and policies of the administering government agency.
Power stations	500y ARI
Major switch yards	500y ARI
Substations	200y ARI
Sewage treatment plants	DFE
Water treatment plants	200y ARI

[3] The following types of community infrastructure provide services vital to the wellbeing of the community:
- police and emergency services facilities including emergency shelters;
- hospitals and associated institutions;
- facilities for the storage of valuable records or items of cultural or historic significance;
- State-controlled roads;
- railway lines, stations and associated facilities;
- aeronautical facilities;
- communication network facilities;
- works of an electricity entity under the Electrical Safety Act 2002; and
- water cycle management infrastructure.

2.3.3 Building Code Definitions

The classification of a building or part of a building is determined by the purpose for which it is designed, constructed or adapted to be used. Classifications in accordance with the *Building Code of Australia* (BCA) are as follows:

Class 1: one or more buildings which in association constitute -

(a) **Class 1a** - a single dwelling being -
  (i) a detached house; or
  (ii) one of a group of two or more attached dwellings, each being a building, separated by a fire-resisting wall, including a row house, terrace house, town house or villa unit; or

(b) **Class 1b** - a boarding house, guest house, hostel or the like
  (i) with a total area of all floors not exceeding 300 m^2 measured over the enclosing walls of the Class 1b; and
  (ii) in which not more than 12 persons would ordinarily be resident,

which is not located above or below another dwelling or another Class of building other than a private garage.

Class 2: a building containing 2 or more sole-occupancy units each being a separate dwelling.

Class 3: a residential building, other than a building of Class 1 or 2, which is a common place of long term or transient living for a number of unrelated persons, including -

(a) a boarding-house, guest house, hostel, lodging-house or backpackers accommodation; or

(b) a residential part of an hotel or motel; or

(c) a residential part of a school; or

(d) accommodation for the aged, children or people with disabilities; or

(e) a residential part of a health-care building which accommodates members of staff; or

(f) a residential part of a detention centre.

Class 4: a dwelling in a building that is Class 5, 6, 7, 8 or 9 if it is the only dwelling in the building.

Class 5: an office building used for professional or commercial purposes, excluding buildings of Class 6, 7, 8 or 9.

Class 6: a shop or other building for the sale of goods by retail or the supply of services direct to the public, including -

(a) an eating room, cafe, restaurant, milk or soft-drink bar; or

(b) a dining room, bar, shop or kiosk part of a hotel or motel; or

(c) a hairdresser's or barber's shop, public laundry, or undertaker's establishment; or

(d) market or sale room, showroom, or service station.

Class 7: a building which is -

(a) **Class 7a** - a *carpark*[4]; or

(b) **Class 7b** - for storage, or display of goods or produce for sale by wholesale.

Class 8: a laboratory, or a building in which a handicraft or process for the production, assembling, altering, repairing, packing, finishing, or cleaning of goods or produce is carried on for trade, sale, or gain.

Class 9: a building of a public nature -

(a) **Class 9a** - a health-care building; including those parts of the building set aside as a laboratory; or

(b) **Class 9b** - an *assembly building*[5], including a trade workshop, laboratory or the like in a primary or secondary school, but excluding any other parts of the building that are of another Class; or

(c) **Class 9c** - an *aged care building*

Class 10: a non-habitable building or structure -

(a) **Class 10a** - a non-habitable building being a *private garage*[6], carport, shed, or the like; or

(b) **Class 10b** - structure being a fence, mast, antenna, retaining or free-standing wall, swimming pool, or the like.

A building or part of a building may have more than one classification applying to the whole building or to the whole of that part of the building.

Habitable room means a room used for normal domestic activities, and -

(a) includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room and sunroom; but

(b) excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes-drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.

---

4 Carpark means a building that is used for the parking of motor vehicles that is neither a private garage nor used for the servicing of vehicles, other than washing, cleaning or polishing. (Source: BCA)

5 Assembly building means a building where people may assemble for -
(a) civic, theatrical, social, political or religious purposes; or
(b) educational purposes in a school, early childhood centre, preschool, or the like; or
(c) entertainment, recreational or sporting purposes; or
(d) transit purposes. (Source: BCA)

6 Private garage means -
(a) any garage associated with a Class 1 building; or
(b) any single storey of a building of another Class capable of accommodating not more than 3 vehicles, if there is only one such storey in the building; or
(c) any separate single storey garage associated with another building where such garage is capable of accommodating not more than 3 vehicles. (Source: BCA)

3.0 ROAD TRAFFICABILITY

3.1 STANDARDS

All new dedicated or internal roads within any subdivision (freehold lots or community title scheme) must comply with the minimum levels specified in Table A1.5.

TABLE A1.5
FLOOD IMMUNITY LEVELS FOR NEW ROADS WITHIN A SUBDIVISION

Flooding type (1)	**Minimum design levels at crown of road (mAHD)** (4)	
	Residential development	**Industrial/ commercial development**
Brisbane River (2)	Defined Flood Level	50y ARI
Waterway[A]	100y ARI	50y ARI
Local flooding[B]	50y ARI	50y ARI
Storm tide (3)	100y ARI	100y ARI

NOTES:

1. Where the site is subject to more than one type of flooding (ie local flooding and/or waterway flooding and/or river flooding and/or storm tide), the minimum flood immunity level is the highest level determined from these sources. It should be noted that the flood immunity level in some older areas is often controlled by local ponding.
2. The Defined Flood Level (DFL) for Brisbane River is based on the 3.7 mAHD level at the Brisbane Port Office Gauge. This standard was adopted by Council on 2 December 2003.
3. A storm tide is the effect on coastal water levels of a storm surge combining with the normally occurring astronomical tide. Storm surge (or more correctly meteorological tide) is a rise above normal water level due to the combined effects of surface wind stress and atmospheric pressure fluctuations caused by severe weather conditions such as tropical cyclone. The 100 year ARI storm tide is 2.5 mAHD. This value incorporates 0.3 m allowance to offset the potential effects of climate change.
4. If no hydraulic modelling data is available, the applicant should engage a suitably qualified Registered Professional Engineer in Queensland (RPEQ) to undertake appropriate hydrologic and hydraulic assessments.

The existing dedicated road fronting the development or providing access within 200 m of the development must comply with the flood immunity standards specified in Table A1.6. In addition, the level of serviceability of the existing dedicated road must also conform to the requirements of Section 3.2.

A A waterway (including those indicated on the Planning Scheme Maps) is defined as any element of a river, creek, stream, gully or drainage channel, including the bed and banks.

B Local flooding usually occurs when the capacity of the underground piped drainage system is exceeded and/or when the overland flow path is blocked. Localised overland flow paths generally traverse along roadways and in the older established areas, through private properties. A localised overland flow path is not characterised by well-defined bed and banks and the contributing catchment is generally less than 30 hectares.

TABLE A1.6
FLOOD IMMUNITY LEVELS FOR EXISTING DEDICATED ROAD
PROVIDING ACCESS TO OR FRONTING A DEVELOPMENT

Flooding type [1]	**Minimum design levels at crown of road (mAHD)** [2]			
	Local access [3]	**Neighbourhood access** [3]	**Industrial access** [3]	**District access/ suburban route/ arterial route** [3]
Brisbane River	20y ARI	50y ARI	20y ARI	50y ARI
Waterway[A]	20y ARI	50y ARI	20y ARI	50y ARI
Local flooding[B]	20y ARI	20y ARI	20y ARI	20y ARI
Storm tide [4]	20y ARI	50y ARI	20y ARI	50y ARI

NOTES:

1. Where the site is subject to more than one type of flooding (ie local flooding and/or waterway flooding and/or river flooding and/or storm tide), the minimum flood immunity level is the highest level determined from these sources. It should be noted that the flood immunity level in some older areas is often controlled by local ponding.
2. If no hydraulic modelling data is available, the applicant should engage a suitably qualified Registered Professional Engineer in Queensland (RPEQ) to undertake appropriate hydrologic and hydraulic assessments.
3. Refer to Chapter 1 of Part B of this document for description of the road hierarchy.
4. A storm tide is the effect on coastal water levels of a storm surge combining with the normally occurring astronomical tide. Storm surge (or more correctly meteorological tide) is a rise above normal water level due to the combined effects of surface wind stress and atmospheric pressure fluctuations caused by severe weather conditions such as tropical cyclone. The 50 and 20 year ARI storm tides are 2.2 and 2.1 mAHD respectively. These values incorporate 0.3 m allowance to offset the potential effects of climate change.

3.2 SERVICEABILITY

The level of serviceability to be provided to traffic at a waterway crossing will depend upon the ARI of the flood for which the creek crossing will be passable to traffic and the duration of road closure during times of flooding. Trafficability will depend upon the combination of depth and velocity of flow over a floodway, when the frictional resistance between a vehicle's tyres and the floodway surface is overcome and the vehicle loses stability.

A A waterway (including those indicated on the Planning Scheme Maps) is defined as any element of a river, creek, stream, gully or drainage channel, including the bed and banks.

B Local flooding usually occurs when the capacity of the underground piped drainage system is exceeded and/or when the overland flow path is blocked. Localised overland flow paths generally traverse along roadways and in the older established areas, through private properties. A localised overland flow path is not characterised by well-defined bed and banks and the contributing catchment is generally less than 30 hectares.

Trafficable access to the development site from at least one suburban route (or higher category road network) is required to maintain emergency services. In this instance, the applicant must satisfactorily demonstrate compliance with the two trafficability criteria specified below, applied to the road network between the development site and the closest suburban or convenience centre. Council will also consider other issues such as the number of affected properties and the proposed use of the development.

1. The **time of closure** for the 50 year ARI flood event from all the nominated flooding sources with the exception of Brisbane River, must not exceed 6 hours
2. The **Average Annual Time of Closure (AATC)** from all the nominated flooding sources with the exception of Brisbane River, must not exceed 2 hours.

Road closure is normally assumed when the total head (static plus velocity) on a carriageway with a two-way crossfall or across the highest edge of a carriageway with a one-way crossfall exceeds 300 mm. For detailed procedures or explanations of terminologies, the applicant should make reference to the publication *Waterway Design. A Guideline to the Hydraulic Design of Bridges, Culverts and Floodways* (Austroads, 1994).

The time of closure is calculated by drawing a horizontal line on the hydrograph at the trafficable discharge level and measuring the time for which the flow is above this level. (Note: The time of closure for each ARI event is not necessarily the design hydrograph that produces the highest peak flood level but rather the critical duration envelope is usually derived from a series different duration flood hydrographs. For example for a given trafficable capacity, the 24 hour storm may generate the longest time of closure at the crossing rather than the 6 hour critical duration storm that produces the highest peak flood level at the crossing.)

4.0 BRISBANE RIVER FLOODING

4.1 BACKGROUND

The Brisbane River has been the focus of city life, trade and commerce since the settlement of Brisbane. The Brisbane River catchment covers an area of 13 570 km^2 and is bounded on the west by the Great Dividing Range and by a number of smaller coastal ranges to the east and north. Most of the catchment comprises forest and grazing land, with the exception of the Brisbane-Ipswich metropolitan areas and a number of small rural townships. Several dams and reservoirs, most notably Somerset Dam and Wivenhoe Dam, regulate the flows in the Brisbane River and its major tributaries.

4.2 RISK MANAGEMENT APPROACH

4.2.1 General

Flood risk management is a formal means of identifying and managing the existing, future and residual risks of flooding. A suitably qualified professional consultant must be engaged to undertake the risk management evaluation in accordance with the framework outlined in AS 4360 Risk Management. The key aim is to ensure that risks (including safety, environmental, social and economic) associated with the proposed use are compatible with the level of flood immunity. For example a warehouse for the purpose of storing perishable goods such as fruits and vegetables will incur less flood damage losses when compared to a warehouse used to store electrical appliances. The storage of hazardous chemicals may not be an appropriate use.

4.2.2 Warning Time

Flood hazard can be reduced by evacuation if adequate time is available. The longer the warning period, the greater time there is available for evacuating people and removing goods and possessions. However, even if people and possessions are fully evacuated, a flood will still cause significant damage to buildings and to infrastructure and still cause substantial community disruption.

Available warning time is determined largely by catchment characteristics. The larger the catchment and the slower the rate of rise of floodwaters, the longer the available warning time. In small steep catchments, there is often no available warning time as the catchments respond too quickly.

Brisbane City Council has a flood forecasting model that utilises Council's network of real time rainfall and flood level monitoring systems and flood modelling program, together with Council's geographical information system (BIMAP) to provide a flood warning and information service to the community. Brisbane River can take a day to peak between Wivenhoe dam and the Brisbane City Gauge, thus allowing time to disseminate flood warnings.

4.2.3 Scope of Application

The risk assessment only applies to a select group of building types (nominated in Table A1.3) proposed in development sites located in established areas that do not meet the prescribed flood immunity standard for Brisbane River.

4.2.4 Risk Management Process

There are instances where the exact use is not known (eg centre and industrial activities) and instances where the use is known (eg lobby of an apartment block). Therefore the risk management formulation should cover a range of proposed and likely uses. The key elements of the flood risk management process should include:

1. Identification of the stakeholders exposed to or affected by the risk of flooding.
2. Identification of public and private property, social systems and environmental elements at risk of flooding.
3. Estimation of flood risks ie the likelihood and consequences of flooding. This evaluation will involve the undertaking of a quantitative analysis that uses numerical values (rather than the descriptive scales used in qualitative and semi-quantitative analysis) for both consequences and likelihood. The quality of the analysis depends on the accuracy and completeness of the numerical values used.
4. Assessment of the acceptability of flood risk. This evaluation will involve the determination of the total flood damage (potential) for a range of annual exceedance probabilities (PMF, 1%, 2%, 5%, 10%, 20%, 50%), and the average annual damage. Flood damages are generally divided into two categories of tangible and intangible damages. Tangible damages[7] are financial and can be measured in monetary terms. Intangible damages[8] are usually difficult to estimate in financial terms. The owner (and future owners) must assume all responsibility

[7] Tangible damages include the cost of repairing items damaged by floodwaters or the loss in value caused by floodwaters wetting goods and possessions (direct damages), together with the loss of wages and extra outlays incurred during clean-up and in post-flood recovery (indirect damages).

[8] Intangible damages include the increased levels of physical and psychological illness and emotional distress caused by the flood. A flood is a traumatic experience for many.

and all liability for all losses, damages and costs that might be incurred as a result of the reduced flood immunity standards.

5. Definition of flood risk management strategies. As a minimum, this assessment must address the following items.
   - The proposed method of perpetuating the restricted use (through appropriate forms of legal documentation, notation on titles, rate notices, etc) and conveying the risk management data to future owners and leaseholders.
   - The procedure to conduct emergency evacuation and rescue operations.

5.0 CYCLIST AND PEDESTRIAN FACILITIES

On road cyclist and pedestrian facilities must comply with the road trafficability standards specified in Section 3. However off road facilities including those traversing through parks and adjacent to watercourses, should generally achieve at least the 2y ARI flood immunity standard for all flooding sources except Brisbane River. In the case of Brisbane River and the Moreton Bay area, the design level should be a minimum of 2.1 mAHD. Where the site is subject to more than one type of flooding sources, the more stringent criteria will apply. Council approval is required for lesser standards.

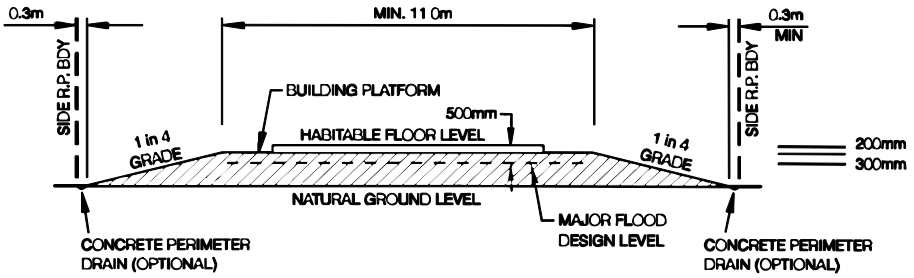
6.0 EARTHWORKS

Any earthworks activities adjacent to waterways and overland flow paths must comply with all the provisions of the *Brisbane City Plan* (refer to illustration on Figure A1.1). The applicant should ensure that the development proposal does not adversely impact on the hydraulic conveyance or flood storage.

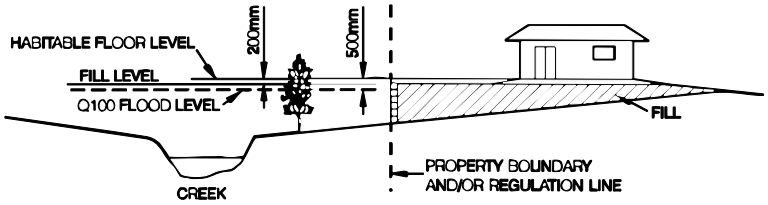
Hydraulic conveyance is a measure of the flow carrying capacity of a watercourse and is a function of the geometry and surface impedance of that watercourse. The loss of conveyance from obstruction or filling is usually characterised by increases in flood levels upstream. Mathematical models that are appropriate to assess the impacts of flood flow conveyance include HEC-RAS steady state hydraulic model and MIKE-11 hydrodynamic model.

As floodwaters flowing in a watercourse rise during a flood event and overtop the banks, a portion of floodwaters are transferred into storage areas of the floodplain where the flow velocities are small in comparison with the main channel. The loss of critical **flood storage** from obstruction or filling is usually characterised by increases in flow velocities and/or flood levels downstream. Mathematical models that are appropriate to assess the impacts of flood storage include RAFTS runoff routing model and MIKE-11 hydrodynamic model.

For overland flow paths that are not designated channels (channels usually have clearly defined bed and banks) or waterways, the overland flow path may be altered to suit the development provided that the 50y ARI depth*velocity product is $\leq 0.6\ m^2/s$. Compensatory earthworks must not cause the depth velocity product to exceed $0.6\ m^2/s$ nor concentrate flows onto adjacent properties. Flood storage capacity areas below the 50y ARI flood levels must be preserved by matching any filled area with an excavated area of equal volume at the same levels.



FILLING OF LAND (BATTERS)



FILLING OF LAND (RETAINING WALLS)

NOTES:

1. Where the neighbouring property is low lying with existing drainage problems Council may require a concrete perimeter drain at the toe of the embankment or retaining wall.
2. The toe of all embankments adjoining public space (eg park, road reserve, etc) should be at least 0.3 m clear of the property alignment. All embankments to neighbouring properties are to be maintainable. In most cases, a batter of 1V in 4H is desirable but steeper landscaped embankments may be considered. Where the property adjoins parkland the batters are to be no steeper than 1V in 6H to allow easy access.
3. Retaining walls instead of the earth batters may be accepted with approval of Development Assessment subject to appropriate landscaping to soften the visual impact of the retaining wall. Refer to Chapter 3 of Part B of this document.
4. Retaining wall structures should conform to the requirements set out in the Building Regulation 2006. In general any retaining walls greater than 1.0 m in height will require a building application and structural certification. Where the combined height of a fence and a wall exceeds 2.0 m, the aforementioned requirements plus the written authorisation from the neighbour will need to be provided with the engineering drawings.

FIGURE A1.1
TYPICAL FILLING EXAMPLE

7.0 LEVEES

Historically, levees have been used as a structural flood mitigation measure in Brisbane to reduce existing flood losses. However, Council will not permit the use of levees in new developments to satisfy flood immunity standards, for the following reasons:

- There is no guarantee that the levees will remain with the land.
- Levees are a band-aid solution rather than an intrinsic solution.
- There is possibility that levees can be breached or overtopped in extreme storms, which can lead to an increase in damage, and subsequently greater potential for damage.