ABCB

Construction of Buildings in Flood Hazard Areas

2012

Handbook

NON-MANDATORY DOCUMENT

CONSTRUCTION OF BUILDINGS IN FLOOD HAZARD AREAS

INFORMATION HANDBOOK

VERSION 2012.3

Important Notice and Disclaimer

The Australian Building Codes Board (ABCB) and the participating Governments are committed to enhancing the availability and dissemination of information relating to the built environment. Where appropriate, the ABCB seeks to develop non-regulatory solutions to building-related issues.

This Handbook on Construction of Buildings in Flood Hazard Areas (the Handbook) is provided for general information only and should not be taken as providing specific advice on any issue. In particular, this Handbook is not mandatory or regulatory in nature. Rather, it is designed to accompany the ABCB Standard for Construction of Buildings in Flood Hazard Areas and to assist in making information on this topic readily available.

However, neither the ABCB, the participating Governments, nor the groups which have endorsed or been involved in the development of the Handbook, accept any responsibility for the use of the information contained in the Handbook and make no guarantee or representation whatsoever that the information is an exhaustive treatment of the subject matters contained therein or is complete, accurate, up-to-date or reliable for any particular purpose.

The ABCB, the participating Governments and groups which have endorsed or been involved in the development of the Handbook expressly disclaim all liability for any loss, damage, injury or other consequence, howsoever caused (including without limitation by way of negligence) which may arise directly or indirectly from use of, or reliance on, this Handbook.

Users should exercise their own skill and care with respect to their use of this Handbook and should obtain appropriate independent professional advice on any specific issues concerning them.

In particular, and to avoid doubt, the use of this Handbook does not–

- guarantee acceptance or accreditation of a design, material or building solution by any entity authorised to do so under any law;
- mean that a design, material or building solution complies with the National Construction Code (NCC); or
- absolve the user from complying with any Local, State, Territory or Australian Government legal requirements.

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Preface

The Inter-Government Agreement (IGA) that governs the ABCB places a strong emphasis on reducing reliance on regulation, including consideration of non-regulatory alternatives such as non-mandatory guidelines, Handbooks and protocols.

This Handbook is one of a series produced by the ABCB. The series of Handbooks is being developed in response to comments and concerns expressed by government, industry and the community that relate to the built environment. The topics of Handbooks expand on areas of existing regulation or relate to topics which have, for a variety of reasons, been deemed inappropriate for regulation. The aim of the Handbooks is to provide construction industry participants with best practice, non-mandatory advice and guidance on specific topics.

Construction of Buildings in Flood Hazard Areas has been identified as an issue that requires consistent uniform guidance. The Construction of Buildings in Flood Hazard Areas Handbook has been developed to foster a greater understanding of provisions in the ABCB Standard for Construction of Buildings in Flood Hazard Areas and to provide additional advisory information outside the scope of the Standard. This Handbook addresses the issues in generic terms. It is expected that this Handbook will be used to develop solutions relevant to specific situations in accordance with the generic principles and criteria contained herein.

This Handbook should be read in conjunction with the ABCB Standard for Construction of Buildings in Flood Hazard Areas.

It must also be emphasised that the Handbook either independently or in combination with the Standard, does not provide a stand-alone solution to mitigating life safety risk due to flooding. Reducing life safety risk due to flooding requires a comprehensive set of measures that consider flood hazard and function and aim to reduce risk to a manageable level. This may be achieved by limiting development within both hazardous areas and areas (such as floodways) where it may impact on flood behaviour for other developments. Within areas allowable for development, development controls or protection works may be used to reduce risk. This requires a suite of measures which generally involve a combination of effective land use planning considering flood hazard, flood mitigation measures, flood warning and emergency response strategies for flooding, and building standards. The balance of these measures will vary from new development areas to infill or redevelopment areas.

Therefore, with application of this Handbook, whether independent from or in combination with the Standard within flood hazard areas, in the absence of supporting measures, it is not possible to guarantee that a building constructed in accordance with these requirements will eliminate the risk of serious injury or fatality even in the defined flood event (DFE).

In addition, larger floods than the DFE can and will occur and even floods of the scale of the DFE can be variable and could exceed the design parameters and limitations of the Standard. Availability of assistance from emergency services or other avenues are important considerations that are not treated in the Standard.

Acknowledgements

The ABCB acknowledges the valuable contributions of members of an expert Reference Group that assisted the development of the Handbook.

The following organisations were represented on the Reference Group –

- Australian Government Attorney-General's Department
- Brisbane City Council
- Bureau of Meteorology
- Geoscience Australia
- Gold Coast City Council
- Hawkesbury City Council
- Housing Industry Association
- Insurance Australia Group
- Master Builders Australia
- NSW Department of Planning and Infrastructure
- NSW Office of Environment and Heritage
- Queensland Department of Local Government and Planning
- Risk Frontiers
- Tasmania Department of Justice

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Introduction

Reminder:

This Handbook is not mandatory or regulatory in nature and compliance with it will not necessarily discharge a user's legal obligations. The Handbook should only be read and used subject to, and in conjunction with, the general disclaimer at page ii.

The Handbook also needs to be read in conjunction with the building legislation of the relevant State or Territory, and the ABCB Standard for Construction of Buildings in Flood Hazard Areas. It is written in generic terms and it is not intended that the content of the Handbook counteract or conflict with the legislative requirements, any references in legal documents, any handbooks issued by the Administration or any directives by the Building Control Authority.

Background

In Australia, floods cause more damage on an average annual basis than any other natural disaster. From 1967 to 1999, the total cost of floods has been estimated at $10.4 billion or 29% of the average proportional annual cost of natural disasters. In addition, during the same period, floods were responsible for 18% of fatalities caused by natural hazards[1].

Historically our towns developed on riverbanks to facilitate the shipping of goods to and from the settlements, and where fertile soil existed, but this also left them vulnerable to flooding.

Mitigating risk to life in flooding requires a comprehensive set of measures that consider flood hazard and aim to reduce residual flood risk to a manageable level. This set of measures generally involves a combination of effective land use planning considering flood hazard, flood mitigation measures, flood warning and emergency response strategies for flooding, and building standards.

At present, Performance Requirements for flood resistant design and construction in the National Construction Code (NCC) are limited to ensuring the building or structure does not collapse when subjected to flood actions. Flood risk is generally regulated by the appropriate authority. This could be an individual local government which uses planning controls to restrict the location of buildings in flood hazard areas and in areas where development is permissible, have flood related development controls to limit the residual risk of flooding. Restrictions on location keep buildings away from areas where development may affect flood behaviour (including floodways), and away from the most hazardous areas (characterised by high

[1] Middelmann, M. H. (Editor) 2007, *Natural Hazards in Australia. Identifying Risk Analysis Requirements*, Geoscience Australia, Canberra, 2007.

velocities and/or depths). In the remaining areas where development is permissible building/development controls may include the requirement for the building or certain floors to be located above an established minimum flood level, such as the flood hazard level. The flood hazard level (FHL) considers both the defined flood level (DFL) from the defined flood event (DFE) plus a freeboard to provide above floor areas with protection from the DFE considering uncertainty in the DFL and other phenomenon such as wind and wake waves and local hydraulic affects.

This Handbook has been prepared to accompany the ABCB Standard for Construction of Buildings in Flood Hazard Areas (the Standard). The Handbook provides commentary on the provisions in the Standard together with additional advisory information.

Therefore, with application of this Handbook to flood hazard areas whether independent from, or in combination with, the Standard and in the absence of supporting measures, it is not possible to guarantee that a building constructed in accordance with these requirements will eliminate the risk of serious injury or fatality even in the DFE.

In addition, larger floods than the DFE can and will occur and even floods of the scale of the DFE can be variable and could exceed the design parameters and limitations in the Standard. Availability of assistance from emergency services or other avenues are important considerations not treated in this Standard.

It is important to understand that flood is a local hazard whose parameters, including depth and velocity, vary significantly within the flood hazard area. Modelling of the DFE generally provides information on average velocities within an area at the peak of the flood for the DFE rather than velocities at a specific location. Velocities and depths will generally increase in larger floods.

In addition, there are significant variations in the information available on flooding between areas within a local authority and between local authorities within Australia. This may result from the age of studies, the type of modelling undertaken, the information available to understand flood behaviour, or the reliance on historical flood information or estimates to provide an understanding of flood risk.

Flood investigations may have also resulted in mitigation works which may alter flood behaviour. These are local by nature and their benefits would generally be considered in studies on flooding for the area and considered by the local authority in determining its flood hazard area.

In some cases the local authority may require the proponent to engage a suitably qualified professional to determine the defined flood event and/or to gain a more detailed understanding of flood behaviour at the location. This may include ascertaining the specific design criteria necessary for this Standard and meeting other requirements established by the local authority.

In addition, flood behaviour can change with climate change, either due to sea level rise or due to potential increases in the intensity and frequency of flood producing rainfall events. In some cases this change will be significant, whilst in other cases it will be relatively minor. Sea level rise and increases in the intensity and frequency of flood producing rainfall events can alter flood flow velocities, water depths and levels in the DFE. This could impact upon the FHL and therefore the flood hazard area and the minimum floor levels set for buildings and the locations within this area where development is allowable given the flood hazard and potential impacts upon other properties.

Managing changing flood risks due to climate change relies upon the same mechanisms currently used to manage flood risk. That is, it requires a combination of: effective land use planning considering changing flood hazard; flood mitigation measures that consider climate change impacts on flooding; emergency response strategies for flooding that are robust and can adapt for changes in flood behaviour; and building standards (such as minimum floor levels for new buildings) that can be adapted to allow for climate change over time.

The degree of these changes will vary with the location and the timeframe over which changes are managed and different jurisdictions and authorities may have different requirements. The relevant appropriate authority can advise on how climate change impacts on flooding should be dealt with for the project in question.

Work has been undertaken both in Australia and overseas aimed at reducing the impacts of flooding on buildings through structural design and using compatible structural and non-structural building materials. However, as most of Australian works are local in character, most Australian building professionals are not familiar with the issue and there is no other national guidance on the subject.

Since the discussion of this issue may touch on planning, building and non-building topics, the development of a Handbook is seen as the most appropriate vehicle for approaching the subject. This approach also satisfies the Council of Australian Governments principles for best practice regulation.

Other Handbooks by the ABCB

The ABCB has produced a range of Handbooks and other educational material which can be downloaded from the ABCB website at www.abcb.gov.au.

COMMENTARY ON THE STANDARD 'CONSTRUCTION OF BUILDINGS IN FLOOD HAZARD AREAS'

1 SCOPE AND GENERAL

C1.1 General

The scope of the ABCB Standard on Construction of Buildings in Flood Hazard Areas (the Standard) is restricted to the current NCC objectives of health, safety, amenity and sustainability. Therefore the Standard primarily focuses on structural safety and life safety, rather than protection of property or building contents.

The current NCC does not contain detailed construction practice for buildings in flood hazard areas. However, although not targeted at flooding, the NCC does require buildings to have structural resistance to the action of liquids, ground water, and rainwater ponding by requiring compliance with Australian Standards for structural design. The aim of the Standard is to provide more specific requirements for construction in flood hazard areas

The construction measures contained in the Standard are not the only measures that should be considered to address issues arising for buildings in flood hazard areas. There are other measures that are outside the scope of the Standard. The scope of this Handbook extends further than the scope of the ABCB Standard and provides additional information on these issues.

The ABCB develops minimum technical standards relating to the structural and fire safety, health, amenity and sustainability for inclusion in the NCC. The NCC applies to all new building design and construction work and subject to State and Territory legislation alternations and additions to existing buildings. The NCC does not apply to existing buildings not undergoing work, and is adopted by every State and Territory.

The issue of whether new buildings can be constructed within part or any of the flood hazard area is a land use planning issue (in consideration of the flood risk) for the appropriate authority, primarily local, State/Territory government. Current building and planning regulations in a number of States and Territories enable local governments to define flood hazard areas and determine the height, above ground or defined flood level, to which the floor levels of habitable rooms must be built.

It is important to note that flood events are likely to arise and there will be locations in which the limitations stated in the Standard will be exceeded. Therefore, communities and households must be aware that all houses may not be protected during a major flooding event because of a number of factors. These factors may include-

(a) the flood event exceeds the defined flood event; or

(b) the flood water velocity exceeds 1.5m/s; or

(c) the depth of submersion of the lowest non-habitable floor exceeds 1m; or

(d) the flood level is higher than habitable floor level; or

(e) loss of foundation material due to excessive scour, mudslide or landslip; or

(f) excessive debris impact loading.

C1.2 Scope

The requirements of the NCC are applicable to all buildings. The Standard only specifies additional requirements and is not a comprehensive list of requirements for buildings in flood areas.

The NCC is a performance-based document. Buildings to be constructed in flood hazard areas are required to comply with the relevant Performance Requirements in NCC Volumes One and Two relating to flood. The Performance Requirements lists various 'heads of consideration' that must be considered during the design process.

The Performance Requirements enable the design of a building to be constructed in flood hazard areas to be developed from first principles to maximise its potential to meet specific occupant needs for a specific site.

The Standard provides two pathways for compliance. One pathway involves formulating an Alternative Solution which complies with the Performance Requirement. This involves the application of engineering practice from first principles and requires designers to apply professional judgment on all design issues.

The other pathway involves compliance with the Deemed-to-Satisfy (prescriptive) Provisions i.e. Clauses 2.3 to 2.10 of the Standard. These provisions only apply if certain limits such as maximum flow velocity and depth of submersion are not exceeded. This does not mean that buildings cannot be constructed if they fall outside these limits. It means that such a proposal would need to be considered as an Alternative Solution under the relevant Performance Requirements and must be assessed accordingly.

The Alternative Solution pathway involves the application of engineering principles in combination with appropriate design consideration as an alternative to the requirements in Clauses 2.3 to 2.10 of the Standard.

C1.3 Application

C1.3.1 Identification of applicable flood hazard areas

The term flood is used to describe the temporary condition of partial or complete inundation of normally dry land. The source of the flood could be the overflow of inland or tidal waters or the rapid accumulation of runoff or surface water from any source.

The identification of applicable flood hazard areas is a planning issue and State/Territory and/or local authorities should be consulted in this determination.

The DFE and DFL used by the appropriate authority (usually the local authority) to manage flood risk to property are generally determined through land use planning in consideration of flood risk management. It is often associated with a 1% chance of a flood of that size being exceeded in any given year or otherwise expressed as an annual exceedance probability of 1 in 100, or a 100-year Average Recurrence Interval (ARI) flood level. However, other flood events or information may be used by the local authority to manage flood risk to buildings or the particular flood situation at the location in question and in setting both the DFE and DFL.

There are significant variations in the information available on flooding between areas within a local authority and between local authorities within Australia. This may result from the age of studies, the type of modelling undertaken, the information available to understand flood behaviour, or the reliance of historical flood information or estimates to provide an understanding of flood risk.

Flood investigations may have also resulted in mitigation works which may alter flood behaviour. These are local by nature and their benefits would generally be considered in studies on flooding for the area and considered by the local authority in determining the flood hazard area.

In many cases information about flow velocities may not be known or may be limited. Modelling of the DFE may provide average velocities at the peak of flow within an area rather than peak velocities at a specific location. Therefore it is unlikely that the local authority will have specific information on flow velocities at a particular site in all cases.

Existing development in more active flow areas, including floodways, is more likely to be subjected to higher velocities of flow than permitted by the Deemed-to-Satisfy Provisions and is also more likely to impact upon flood behaviour elsewhere. Any additional development or redevelopment in these areas is also likely to be exposed to more hazardous conditions and requires careful consideration and assessment. Also note that the flow velocities could be expected to exceed the limits set in the Standard in many areas subject to local overland flooding.

The local authority may need to rely upon judgement as to where the Standard or its Deemed-to-Satisfy Provisions apply or request specific information from the proponent to determine whether the Standard applies and provide key criteria for design. This may limit the application of the Deemed-to-Satisfy Provisions by the local authority to backwater and inactive flow areas in the DFE where it is less likely the velocity nominated in the Deemed-to-Satisfy Provisions in the Standard would be exceeded.

In many cases detailed information on the depth of inundation at the development in question will rely upon the provision of survey advice from the proponent relative to flood level information determined in the DFE.

In some cases the local authority may require the proponent to engage a suitably qualified professional to determine the DFE and/or to gain a more detailed understanding of flood behaviour at the location. This may include ascertaining the specific design criteria necessary to enable consideration of the development in relation to the Standard and meeting other requirements established by the local authority.

The National Flood Information Database (NFID) shows there are at least 230,000 allotments below the 100-year ARI flood level. Of this figure, approximately 2/3 have a flood depth of less than 1m and approximately 3/4 have a flood depth of less than 1.5m.

Where a part of a flood hazard area is subject to mudslide, landslide, storm surge or coastal wave action while other parts are not affected, the Standard would only apply to those parts not affected. For example if part of an allotment of land is affected by landslip, but the part of the allotment where it is proposed to construct a building is not, the Standard could still apply to the building.

C1.3.2 Identification of applicable buildings

The Standard only applies to new Class 1, 2, 3, 4, 9a health care and 9c buildings and, subject to State and Territory legislation, alterations and additions to existing buildings of these classifications. Note that the NCC Performance Requirements for flood are also limited to Class 1, 2, 3, 4, 9a health care and 9c buildings. That means buildings of other classes are not subject to any requirements of the Standard.

Note that a basement carpark under a Class 2 building for instance is usually classified as a Class 7 part of the building. Also, a garage associated with a house can be classified as a Class 10 part of the building. Class 7 and Class 10 parts of the building are not covered by the Standard. However, the Standard would apply to the Class 1 or 2 part of the building above the Class 7 or 10 part. This would mean that structurally, the Class 7 or 10 part would need to adequately support the Class 1 or 2 part above in a defined flood event.

Class 1, 2, 3, 4, 9a health care and 9c buildings under the NCC are defined as-

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 —

- (i) a boarding house, guest house, hostel or the like—
  - (A) with a total area of all floors not exceeding 300 m^2 measured over the enclosing walls of the Class 1b; and
  - (B) in which not more than 12 persons would ordinarily be resident; or
- (ii) 4 or more single dwellings located on one allotment and used for short-term holiday accommodation,

which are 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 a 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 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 9c — an aged care building.

Aged care building means a Class 9c building for residential accommodation of aged persons who, due to varying degrees of incapacity associated with the ageing process, are provided with personal care services and 24 hour staff assistance to evacuate the building during an emergency.

Health-care building means a building whose occupants or patients undergoing medical treatment generally need physical assistance to evacuate the building during an emergency and includes—

(a) a public or private hospital; or

(b) a nursing home or similar facility for sick or disabled persons needing full-time care; or

(c) a clinic, day surgery or procedure unit where the effects of the predominant treatment administered involve patients becoming non-ambulatory and requiring supervised medical care on the premises for some time after the treatment.

There is also an elevation requirement in Clause 2.4 of the Standard which affects the usage of particular floor areas.

C1.4 Limitations

This Handbook is not intended to:

(a) override or replace any legal rights, responsibilities or requirements; or

(b) provide users with the specifics of the NCC.

This Handbook is intended to make users aware of provisions that may affect them, not exactly what is required by those provisions. If users determine that a provision may apply to them, the NCC should be read to determine the specifics of the provision.

C1.5 Normative References

These are the normative references referred to in this Standard. The use of other NCC referenced documents is also necessary in the design of buildings in flood hazard areas.

C1.6 Units

The Standard uses the SI units of kilogram (kg), metres (m), seconds (s), Pascals (Pa) and Newtons (N).

C1.7 Definitions

The terms used in this Standard primarily come from the Glossary of Floodplain Management in Australia – Best Practice Principles and Guidelines.

The level of freeboard above the DFL is to be determined by the appropriate authority (usually the local government). Freeboard is typically used to compensate for effects such as wave action and localised hydraulic behaviour. Depending upon the circumstances of the individual event, freeboard may provide protection from floods marginally above the DFL. However, freeboard should not be relied upon to provide protection for flood events larger than the DFE.

C1.8 Notation

The Standard uses letters and symbols in the calculation of flood actions. These letters and symbols are defined in the Standard.

C1.9 Performance-Based Standards

The Standard is referenced in the NCC. The NCC contains Performance Requirements for buildings constructed in flood hazard areas. The Standard contains solutions which are deemed-to-satisfy the Performance Requirements.

C1.10 Design Pathways

Because the NCC is performance-based, it allows a person to develop a solution which meets the Performance Requirements as an alternative to the prescriptive or Deemed-to-Satisfy Provisions in the Standard.

2 BASIC DESIGN REQUIREMENTS

The limitation states that the Standard only applies to Class 1, 2, 3, 9a health care and 9c buildings, and Class 4 parts of buildings.

C2.1 Compliance Requirements

This establishes that for compliance with the Standard, two pathways are available. Namely either compliance with the relevant NCC Performance Requirements (via an alternative solution) or compliance with the prescriptive elements of Clauses 2.3 to 2.10 of the Standard.

C2.2 Application

This establishes the application of Clauses 2.3 to 2.10 of the Standard. For situations outside these limits, an Alternative Solution in accordance with the Performance Requirements would be necessary.

C2.3 Flood Actions

C2.3.1 General

Within the limiting applications of the Standard, a single process for determining flood actions is used for all types of floods. It is useful however to be aware that there are differences between flood characteristics, flood loads and flood effects in riverine and coastal areas in terms of wave effects, depth, duration, direction of flow and debris.

C2.3.2 Hydrostatic Actions

Hydrostatic actions are those caused by stagnant water either above or below ground surface and are equal to the water pressure multiplied by the surface area on which the pressure acts. They can be divided into vertical downward loads, lateral loads and upward loads (buoyancy).

C2.3.3 Hydrodynamic Actions

Hydrodynamic actions are those induced by the flow of water above ground level. They are usually lateral loads. Accurate estimates of flow velocities during flood are difficult to make. Designers should consult the relevant local government and specialists in this area.

Since the Deemed-to-Satisfy Provisions of the Standard are only applicable to flood hazard areas with maximum velocity of floodwater of 1.5 m/s, and a maximum depth of submersion of non-habitable floors of 1m in the DFE, a general drag coefficient of 1.25 has been nominated for simplicity rather than a table of drag coefficients for different shapes.

Clause 2.3.3 of the Standard provides a simple equivalent hydrostatic formula for the computation of the hydrodynamic forces. This formula is only valid for slow moving water (flow velocity less than 3 m/s) and building aspect ratio (width to height) less than 12. For situations outside these limits, a full engineering analysis should be carried out.

C2.3.4 Debris Actions

Design for debris impact actions is difficult because the nature and size of the potential debris is uncertain. However, there is guidance in specialist literature on this issue. Nevertheless, within the limited application of the Standard, reliance is placed on the general robustness of the building to cope with debris actions.

C2.3.5 Wave Actions

Design for wave actions is possible and there is guidance in specialist literature on this issue. Within the limited application of the Standard, reliance is placed on the general robustness of the building to cope with wave actions. However, designers should investigate historical damages near a site to determine whether wave force can be significant and ought to be taken into account.

Sections 2.3.4 and 2.3.5 are adequate only if the application is limited to buildings within the currently proposed restrictions (1 metre inundation in slow moving water) but become more complex for buildings and general civil engineering structures subject to more severe conditions.

C2.3.6 Erosion and Scour

Erosion and scour can affect the stability of the foundation and can increase the flood actions on buildings. The usual methods to mitigate the effects of erosion and scour are to increase the depth of the foundation embedment or to setback buildings from potential danger zones. Erosion protection measures should be undertaken if potential for erosion due to flood actions is serious.

C2.3.7 Combinations of Actions

It is expected that estimates of the flood depth and the flow velocity are made conservatively (95 percentile value estimate with 75% confidence) for the Defined Flood Event (DFE) which is the ultimate design condition. A load factor of 1.0 has therefore been adopted in the Standard.

In the absence of more accurate hydrological analysis, the maximum recorded flood level is a reasonable approximation of the statistically defined DFE provided that the record is at least for 30 years.

The flood load factor is a function of the uncertainties in determining the flood actions. The uncertainties are dependent on the DFE. The benchmark DFE is the flood with annual probability of exceedance of 1:100 which is the design event associated with the ultimate limit state. It is assumed that the outcomes are determined by modelling and analysis with appropriate level of confidence (say 75%).

If the DFE is defined using another level of probability, then this can be compensated by adjusting the flood load factor accordingly.

If the DFE is based on the maximum recorded flood, then there will be more uncertainties involved. The length of the record is another useful indicator of the reliability of the figure. The flood load factors have therefore been adjusted to reflect the associated uncertainties.

The [0.9G, $0.5W_u$, $Y_F F_l$] combination primarily addresses the risk of uplift or buoyancy effects. The buoyancy effects for 1 m inundation for enclosed areas should be assumed to be on the conservative side by assuming water entries are blocked. There have been instances of houses floating away in a flood event.

C2.4 Floor Height Requirements

Land use planning instruments or planning schemes will generally establish minimum flood risk management related requirements. This may involve the restriction of the location of development and, where development is permissible, the establishment of minimum conditions that the development must satisfy. These minimum requirements often relate to both floor levels and fill levels.

The Standard requires habitable floors to be above the Flood Hazard Level (i.e. the DFL plus the freeboard) and non-habitable floors to be no more than 1m below the DFL (see figure C2.4), unless the appropriate authority determines otherwise.

Freeboard allows for wave action, local hydraulic factors, and some level of uncertainty in regard to the flood modelling and identification of the DFE. Freeboard for residential buildings would typically be a maximum of 0.5m unless the specific exposure factors at the location require a higher value. In shallow depths of local overland flow, often resulting from urban piped drainage system bypass, a smaller minimum freeboard of 0.3m is typically used.

The 1m maximum inundation of non-habitable floors only applies to an enclosed room with walls and does not apply where there are no walls (i.e. consists only of columns or posts). The flood action on an open structure is much less compared to a solid wall.

The reference to the floor level is a reference to the uppermost surface of the floor, not including any floor covering such as carpet or tiles. Where the floor has more than one level (ie a step down) the reference is to the lowest part of the floor.

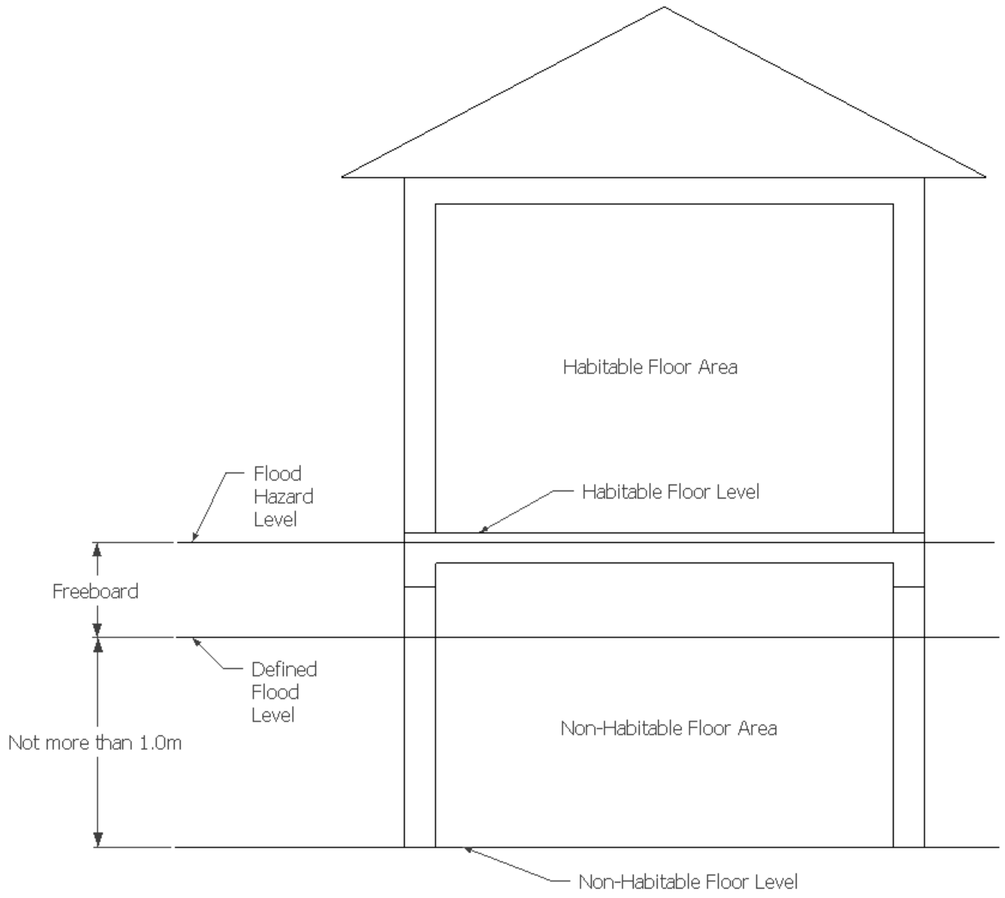

Figure C2.4 Elevation showing DFL

C2.5 Footing System Requirements

C2.5.1 General

The footing system of a structure must be designed to maintain the necessary support for the structure during a flood situation and in particular must be designed to prevent flotation, collapse or movement. The Deemed-to-Satisfy Provisions of the Standard are limited to a maximum flow of 1.5m/s. At higher velocities, more engineering input needs to be taken to ensure the footing system remains structurally adequate.

C2.5.2 Geotechnical Considerations

As the flood flow velocity increases, the risk of collapse and undermining of the footing system by scour increases.

C2.5.3 Footing System Depth

The footing system depth is dependent on a number of factors including foundation material, flood flow velocity, whether the footing system sits on fill or undisturbed soil, slope of land, and potential for landslip.

C2.5.4 Piers, Posts, Columns and Piles

Use of piles is most appropriate if erosion is an issue. Use of piers, posts, columns and piles lessen the interference with the flow of flood water compared with the use of fill to achieve the required elevation.

C2.5.5 Use of Fill

Whether the use of fill is permitted in flood hazard areas needs to be checked with the appropriate authority. Fill can reduce the capacity of the floodplain, exacerbate the flood risk or cause a nuisance for neighbouring property. Where the use of fill is permitted to elevate the house above the DFL or reduce potential inundation, care needs to taken to ensure the fill remains stable and is not adversely affected by erosion and scour.

C2.5.6 Use of Slabs

Flood hazard areas may restrict the construction option of a single storey house with a concrete slab-on-ground. Particularly where the use of fill is restricted, the elevation requirement means that the slab must be above the FHL. Where this is not possible, an alternative construction method, such as an elevated house would need to be considered. Again, care needs to be taken to ensure the flood does not erode or scour the material supporting the slab.

C2.6 Requirements for Enclosures below the Flood Hazard Level (FHL)

Some planning schemes and planning instruments will not permit enclosures below the FHL and may require minimum fill levels to be at the FHL. However, where enclosures are permitted below the FHL, the Standard only contains Deemed-to-Satisfy Provisions for wet flood-proofing and not dry flood proofing. This means the flood water must be allowed to enter and leave the enclosure below the FHL to equalise the hydrostatic pressure on both sides of the external walls. The holes in the walls must be large enough so as not to become easily blocked by debris.

The openings should meet the following criteria-

(a) doors and windows should not be counted as openings but openings can be installed in doors and windows; and

(b) there should be a minimum of two openings on different sides of each enclosed area; and

(c) the total net area of all openings should be at least 1% of the enclosed area; and

(d) openings should permit a 75 mm sphere to pass through; and

(e) any opening covers should not impede the flow of water; and

(f) consideration should be given to prevent the openings from becoming blocked.

C2.7 Requirements for Structural Attachments

Items such as decks and patios must be structurally adequate so as not to cause failure of the main building they are attached to. Any structure either designed to fail or not structurally adequate must be designed to not impact upon the structural adequacy of the building.

C2.8 Material Requirements

All materials used in the construction of the building must conform to the appropriate requirements of the NCC, including its referenced documents. In addition, materials that are exposed to water inundation should be given further consideration of their properties when wet in deciding whether they are suitable for use. These include-

(a) likely duration of exposure to wetness;

(b) changes to dimensions and strength when wet;

(c) water absorption rate and required drying time; and

(d) cost and feasibility of replacement of components.

The Deemed-to Satisfy Provisions of the Standard are only applicable for wet flood proofing. If dry flood proofing method is used, the proposed solution should be assessed as an Alternative Solution under the NCC requirements.

With wet flood proofing, the water is allowed to enter the building to reduce the built-up of hydrostatic pressure between the flood water and the inside of the building. The structural materials used below the FHL must therefore be water resistant to minimise the resulting damage.

Designers and building owners may choose to select water resistant non-structural materials for wall linings etc. However, there is an argument that it may be more cost effective to use non-water resistant non-structural materials (e.g. ordinary plasterboard), as such material can readily be removed to allow any cavities to drain and the structural members to fully dry out after inundation, and then later replaced with new material.

The Deemed-to-Satisfy Provisions in the Standard do not include provisions relating to dry flood proofing. For dry flood proofing, the building or relevant parts of the building envelope are made substantially impermeable to flood water. If this method is proposed, it would need to be considered on a case by case basis under the performance requirements. If this method is used, care must be taken to ensure the structural adequacy of the envelope of the dry food proofing part of the building to carry the differential hydrostatic pressure (in addition to the hydrodynamic action) created by the flood water. This pressure is quite severe and could cause major structural damage if not properly accounted for.

For further information on suitability of materials subject to flood inundation refer to Appendix C.

C2.9 Requirements for Utilities

C2.9.1 General

Utilities and associated equipment, if exposed to flood water (i.e. located below the FHL) should be designed, constructed and installed to prevent floodwater from entering and accumulating within the system. Note that this provision does not apply to an electrical meter for the building as the location for these meters is determined by the electrical authority.

Utilities and associated equipment should also be anchored to resist the forces generated by the flood (such as buoyancy) and should not be mounted on items or structures that could break away during the flood.

Utilities include electrical, plumbing, telecommunication, HVAC and similar services.

C2.9.2 Electrical

This provision is subject to the requirements of the electrical supply authority. So unless the electrical supply authority determines otherwise-

(a) Electrical service conduits and cables below the FHL should be waterproofed.

(b) Underground service conduits and cables should be buried at a depth sufficient to prevent damage caused by erosion and scour.

(c) Switches should be mounted above the FHL.

C2.9.3 Mechanical and HVAC systems, tanks and the like

This provision relates to the location and anchoring of mechanical related equipment such as ductwork, tanks, gas storage cylinders and the like.

C2.10 Requirements for Egress

During a defined flood event, it may be necessary for emergency services or other persons to rescue people trapped in a house by flood waters. Rescue could be by boat. Therefore, a means of exiting the house must be available to allow rescue. The exit route could be from a balcony, verandah, deck, door or openable window of sufficient size.

For further information on egress and evacuation before or during a flood, refer to the AEM series documents on Flood Safety.

C2.11 Additional State or Territory requirements

Refer Appendix B.

3 ADVISORY INFORMATION

C3.1 General

This Section provides supplementary, non-mandatory information to the Standard with the aim of improving resilience (or reducing vulnerability) of buildings when subject to flooding. The Standard was designed mainly to cope with infrequent flooding in the order of 1 in 100 annual exceedance probability.

This Section provides:

(a) Background information to the Standard requirements.

(b) Information on performance of types of construction and of materials under flooding conditions.

(c) Guidance on rehabilitation of buildings after a flood event.

(d) Sources for further information.

All references made in this Section are listed in Section 4.

C3.1.1 Flooding in Australia

In Australia, floods cause more damage on an average annual basis than any other natural disaster. From 1967 to 1999, the total cost of floods has been estimated at $10.4 billion or 29% of the average proportional annual cost of natural disasters. In addition, during the same period, floods were responsible for 18% of fatalities caused by natural hazards[2].

Historically our towns developed on riverbanks to facilitate the shipping of goods to and from the settlements, and where fertile soil existed, but this also left them vulnerable to flooding. Many towns have some mitigation works to reduce this risk. However, the flood risk remains because it is possible for floods to occur that are larger than the design floods for these mitigation works.

C3.1.2 Floodplain management

Floodplain management is outside the scope of this section and interested readers are referred to ‘Flood plain management in Australia: Best practice principles and guidelines’ SCARM

[2] Middelmann, M. H. (Editor) 2007, *Natural Hazards in Australia. Identifying Risk Analysis Requirements*, Geoscience Australia, Canberra, 2007.

Report 73, AEM Series Documents including 'Managing the Floodplain' or relevant State Manuals, such as the NSW Floodplain Development Manual[3].

Floodplain management is a partnership between government and the community using a range of measures to reduce the risks to people, property and infrastructure and therefore goes well beyond the scope of the Standard.

It requires a different mix of measures to manage flood risk to existing developed areas and future developed areas. This mix of measures will vary with location as there is no one size fits all solution to managing flooding.

Best floodplain management practice as outlined in SCARM and the AEM series document Managing the Floodplain, recommends the preparation of floodplain management plans to outline how the full range of flood risk faced by a community and its people, property and infrastructure, can be managed at a particular location. In new development areas it provides guidance to inform strategic decisions on where, what and how to develop the floodplain whilst aiming to manage residual flood risk to an acceptable level. Local authorities can use land use planning controls to influence the long term development of an area in consideration of flooding, by restricting the location of development (zonings) and placing conditions (controls) on it.

New development areas can be located away from: floodways, through which the main floodwaters flow; areas where the velocity and depth of floodwaters can be particularly hazardous; and where it is not possible for people to easily self evacuate to flood free areas and there is no practical alternative. Within the remaining developable land, additional conditions can reduce the exposure of the new development to flooding. These controls can include: minimum fill levels for land; minimum floor levels for buildings and other structural requirements (such as identified in the Standard); and the ability to evacuate people to flood free areas (with the latter considering the full range of flood risk).

For existing development areas flood risk is harder to manage due to the scale of development and the practicality, effectiveness and affordability of large scale mitigation measures. Redevelopment or extensions (and their occupants) to existing development in these areas may be exposed to a higher degree of hazard (velocity and depth) in the defined flood event or events up to the probable maximum flood (PMF) than those in new development areas, where planning controls can more effectively be used to reduce risk.

This Handbook and the Standard are only concerned with the construction of buildings in flood hazard areas. The DFE and DFL used by the appropriate authority to manage flood risk to property is generally determined in land use planning in consideration of flood risk management

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[3] Agriculture and Resource Management Council of Australia and New Zealand, SCARM Report 73, *Flood plain Management in Australia: best practice principles and guidelines*, CSIRO, 2000

and is often associated with a 1% chance of a flood of that size being exceeded in any given year or an annual exceedance probability of 1 in 100. However, other flood events or information may be used by the local authority for managing flood risk to buildings or the particular flood situation at the location in question and in setting both the DFE and DFL.

A recent survey by National Flood Information Database (NFID) shows at least 230,000 allotments below the 1% AEP flood level. Approximately 2/3 of these have a flood depth of less than 1m and approximately 3/4 have a flood depth of less than 1.5 m.

It is important to note that for the purposes of the Standard and this Handbook, the DFE does not define the extent of flood-prone land which is defined by the Probable Maximum Flood (PMF). The PMF is the largest flood that could conceivably occur at a particular location, resulting from the probable maximum precipitation. Generally it is not physically or financially possible to provide general protection against this event. The AEP for the PMF event is commonly assumed to be in the order of 10^{-4} to 10^{-7}. Therefore buildings built to the Standard may face higher velocities and depths than the DFE may generate.

The Standard specifies that the maximum depth of inundation of the lowest non-habitable floor is 1 m below the DFL. Habitable floor levels are to be above the FHL. The structural provisions of the Standard are based on this level of inundation. The Standard does however permit the appropriate authority to specify a different depth of inundation. If this level exceeds 1 m, additional structural analysis should be undertaken.

C3.1.3 Wet flood proofing principle

The Standard is based on the 'wet flood proofing' principle i.e. the flood water is intentionally allowed to enter and leave the building. The alternative approach is called 'dry flood proofing' i.e. the flood water is prevented from entering the building by either permanent or temporary barriers. 'Dry flood proofing' is considered not suitable for the majority of buildings in Australia because the hydrostatic forces are not equalised on both sides of the external wall, as is the case for wet flood proofing. Also, most houses would allow rising water to enter via gaps around door openings, weep holes, ventilation grilles and the like. Therefore, traditional house construction practice may not be suitable for dry flood proofing. If such a solution is proposed, it will be necessary to assess it under the 'Alternative Solution' provisions of the NCC.

'Wet flood proofing' will reduce the hydrostatic forces on the building elements, but it will require consideration of the effect of water immersion on building materials and assemblies.

The objective of the Standard is to minimise the damage to the structural components of a buildings which are expensive to repair and could lead to structural collapse. The rehabilitation of a flooded building should involve only cleaning, content replacement and minor repairs. However, if flood water can for example enter a wall cavity, wall linings may need to be removed to clean the cavity and allow structural members to dry out.

C3.1.4 Velocity of flood water

The Standard places a limit on its applicability on a maximum average velocity of flood water of 1.5 m/s. This is consistent with the FEMA standard[4]. However, other studies[5] show that wading by adults becomes difficult and dangerous when the depth of still water exceeds 1.2 metres or when the velocity of shallow water exceeds 0.8 metres per second. Safety is further compromised if the occupant is a child, elderly, infirm or fearful.

This means that where high set houses with non-habitable rooms underneath which have floor levels below the FHL are constructed, that if occupants try to evacuate once the DFL has been reached that they will be more exposed to hazardous conditions when evacuating. This highlights the importance of effective evacuation strategies that facilitate the evacuation of all affected residential buildings (including for aged care and health care facilities) before effective evacuation access is lost. Residents and emergency response planning would need to be made aware of such limitations.

The flow of water around a building in a flood event is a complex problem. A building in an open field is subject to a flow velocity similar to the ‘Greenfield’ velocity of the site (predevelopment). However as the density of buildings increases, the local flow velocity also increases and could be up to four times the ‘Greenfield’ velocity. Appendix B of the Guideline on Reducing Vulnerability of Buildings to Flood Damage[6] gives some guidance on the determination of velocity of flood water.

Since the forces on the building increase with the square of the velocity, building in areas subject to fast moving flood water should be avoided because of increasing risk to people and properties. A doubling in velocity means a quadrupling of the magnitudes of the hydrodynamic forces on the building.

C3.2 Structural Design

C3.2.1 Flood actions

Section 3.1, 3.2 and Appendix A of the Guideline on Reducing Vulnerability of Buildings to Flood Damage[6] contains some explanations of the flood actions that may cause building

[4] FEMA 348 Protecting Building Utilities from Flood Damage: Principles and Practices for the Design and Construction of Food Resistant Building Utility Systems

[5] Summarised in Cox, R. 2011 *People and vehicle safety in flooding waters.* Presentation to NSW Floodplain Management Association Conference, Tamworth 24 February 2011.

[6] Hawkesbury-Nepean Floodplain Management Steering Committee, 2006, *Reducing Vulnerability of Buildings to Flood Damage: Guidance on Building in Flood Prone Areas*, Parramatta, June 2006

damage. ASCE Standard ASCE/SEI 7-05 also contains useful information on the calculation of flood actions.

There are important differences in flood actions for different kinds of floods in riverine and coastal areas. For example, potential effects of wave actions are greater in coastal areas while flood duration can be much longer in riverine areas etc. The flood actions referred to in the Deemed-to-Satisfy provisions of the Standard are mainly directed at riverine areas with slow moving or stagnant water.

Hydrostatic actions are actions arising from pressure exerted by still water. The hydrostatic pressure at any point is always equal in all directions and acts perpendicular to the surface on which it is applied. The hydrostatic pressure induce horizontal forces which act on vertical and inclined surfaces of buildings such as walls and vertical forces (up and down) which act on horizontal and inclined surfaces of buildings such as floors. Vertical forces include buoyancy which generates an uplift force equal to the weight of the water being displaced. These forces make it difficult to dry proof buildings structurally. A water differential level of 100 mm can cause the plasterboard to break and a differential level of 1000 mm can cause damage to a brick wall. For wet proofed buildings, both of these forces from outside of the building are largely counteracted by those from the inside of the building and only the water differential level between inside and outside needs to be considered. Buoyancy effects however can be important for lightweight buildings and empty storage tanks and these items need to be structurally secured.

Hydrodynamic actions are actions arising from moving water. These induce forces which are proportional to the square of the flow velocity. These forces can be quite large. The SCARM Report[7] identifies that wading by able bodies adults becomes difficult and dangerous when the depth of still water exceeds 1.2m, when the velocity exceeds 0.8m/s, and for various combinations of depth and velocity between these limits. The SCARM Report also states that at velocities in excess of 2m/s, the stability of foundations and poles can be affected by scour. Also, at depths in excess of 2m, lightly framed buildings can be damaged by water pressure, flotation and debris impact, even at low velocities. The SCARM Report also identifies the degree of flood hazard depending on a variety of factors including flood depths and velocities. It identifies high hazard (ie fit adults have difficulty in wading to safety) when the maximum flood depth is up to 1m and maximum velocity is up to 1.5m/s. The Hawkesbury-Nepean Guidelines[6] find that a house subjected to flood water flowing at a velocity exceeding 1.5 m/s, half way up the wall (or approximately 1.2 m deep) could suffer damage to the cladding and/or frame.

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[7] Agriculture and Resource Management Council of Australia and New Zealand, SCARM Report 73, *Flood plain Management in Australia: best practice principles and guidelines*, CSIRO, 2000.

The calculation of the forces generated by moving water is complex and dependent on the shape and size of the building. The Standard provides a simple equivalent hydrostatic formula which is only valid if the flow velocity is less than 3 m/s and the aspect ratio (width to height ratio) is less than 12. For situations outside these limits, a proper engineering analysis should be carried out.

Debris actions are actions arising from impacts of debris floating in moving flood water. There is wide variation in impact loads depending on the nature of the debris and the velocity of the flood water. ASCE Standard 7-05 Section C5.4.5 provides a detailed discussion on the treatment of debris actions. It is generally considered that most of the currently used cladding systems in Australia are sufficiently robust to resist the impacts of objects 'normally encountered' for design conditions envisaged in the Standard.

Wave actions are actions arising from water wave propagating over surface water striking the building. Forces are generated by wave breaking on the surface of the building, uplift caused by shoaling wave beneath the building, wave run up and wave induced drag and inertia forces. Wave load calculation procedure is available in ASCE Standard 7-05. Wave action should be considered for flooding in the coastal zones. However, for the design conditions where this Standard is applicable, wave action is not considered to be a major factor in design.

Erosion and scour: These terms are used to indicate a general (erosion) or local (scour) lowering of the ground surface because of the flood actions. Erosion and scour can affect the stability of the foundation and lead to footing failures and therefore should be considered in design.

C3.2.2 Foundation design

Earthworks should be carried out in accordance with AS 3798 -2007[8] .

Footings should be constructed in accordance with AS 2870 – 2011[9]. It should be noted that for expansive soil, AS 2870 only considers moisture movement under normal seasonal conditions. More damage could therefore be expected when the foundation is subjected to more extreme conditions during and after a flooding event.

Issues concerning foundation design include:

(a) Erosion and scouring caused by flowing water.

(b) Collapse of soil caused by saturation.

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[8] AS 3798 -2007 'Guidelines on Earthworks for Commercial and Residential Developments'

[9] AS 2870 -2011 'Residential Slabs and Footings'

(c) Soil piping.

(d) Batter slumping.

(e) Swelling and shrinking of soils following the movement of water.

Designers should have some knowledge of the site soil properties and site characteristics to assess whether any or all of the above issues are relevant. Section 3.4 and 4.1 of the Guideline on Reducing Vulnerability of Buildings to Flood Damage[6] provides more discussion on these issues.

C3.2.3 Building types

The Standard requires habitable floors to be placed above the FHL. This will put single storey slab-on-ground dwellings at a disadvantage if built on flood-prone land. The two-storey dwelling provides a better option in term of reducing flood damage to both the structure and its content. The elevated (high set) dwelling is another option worth considering. Section 4.2 of Reference [1] provides further discussion on building types.

C3.2.4 Construction materials

Distinction between structural and non-structural components should be made in the selection of construction materials used in parts of the building subject to inundation. The Standard only requires structural components to be water resistant for the duration of the flood.

There are different levels of material water resistance:

(a) Materials that are weakened when wet.

(b) Materials that are stable but porous that will need drying out after the flood.

(c) Materials that are not porous and not weakened when wet.

Material properties are also affected by the duration of the immersion (that could be as long as a week) and the quality of the flood water. Long term problems may also arise if inadequate attention is given to the cleaning up or in not allowing the structural members to dry out sufficiently (such as corrosion in steel and decay in timber). The selection of appropriate materials is also influenced by the ease and cost of repair and/or replacement. Section 4.3 of the Guideline on Reducing Vulnerability of Buildings to Flood Damage[6] provides further discussion of the suitability of various materials for construction on flood-prone land. Further information can also be obtained from the FEMA Bulletin on Flood Damage-Resistant Materials[10].

C3.2.5 Construction elements

Construction elements that are affected by water immersion under the terms of the Standard are the foundation, floors and walls.

(a) The foundation may fail due to erosion of the supporting soil or excessive settlement. Section 5.1 of the Guideline on Reducing Vulnerability of Buildings to Flood Damage[6] provides information on the advantages and disadvantages of different types of footing design.

(b) Concrete floors are relatively unaffected by water immersion. Wood-based flooring materials are affected by immersion at varying degrees. Insulation of floors is also affected by flood water. Section 5.2 of the Guideline on Reducing Vulnerability of Buildings to Flood Damage[6] provides further discussion on these issues.

(c) Walls should be able to resist the additional hydrostatic and dynamic pressures from flood water. The wall should also be robust to resist any debris loading. Issues may also arise from the support settlement while drying out.

Brickwork normally performs satisfactorily but minor cracking could occur if situated on expansive soil. External claddings such as timber, fibre cement, plastic or aluminium are not likely to be affected by flood water.

Silt may be deposited in wall cavities in framed construction and water trapped in the cavities may cause longer term problems. Internal wall lining such as plaster board may need to be removed to clean the cavity and allow the structural members to dry out.

Sections 5.3, 5.4, 5.5 and 5.6 of the Guideline on Reducing Vulnerability of Buildings to Flood Damage[6] provide further information on these issues.

[10] FEMA Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program Technical Bulletin 2 / August 2008

C3.3 Non-Structural Design

C3.3.1 General

Non-structural issues are mainly concerned with the protection of utilities such as electrical, plumbing, and heating, ventilation, and air-conditioning (HVAC) and other mechanical services in the event of flooding.

The protection of utilities is necessary since damage to equipment and disruption of utility services can cause a building to be uninhabitable even if the structure itself is not damaged.

The general rule is to place all these systems, including the control devices, above the DFL if at all possible. The placement of these systems is usually controlled by the appropriate authority in regard to these systems and the authority should be consulted and/or advised about potential flood problems. Reference [7] provides general advice on the protection of utilities. Note that the provision does not apply to the location of an electrical meter for the building as they are regulated by the electrical authority.

C3.3.2 Electrical

Where possible, wiring should be placed above the FHL. A practical option could be to place wiring in the roof space or the floor above and extend down the wall. The power points and switches in particular should be elevated above the FHL to gain extra protection. Conduits should be installed to ensure that water will be drained freely if subject to immersion.

Fixed electrical equipment such as air conditioners and hot water systems should be mounted above the FHL to reduce the chance of inundation.

C3.3.3 Sewerage

The main issue with sewerage systems during flooding is the potential for the backflow of sewage into the building. Refer to plumbing regulations or separate State/Territory requirements to determine whether backflow protection devices should be fitted for this purpose.

C3.3.4 Storage tanks

The main issue with storage tanks is the possibility that they may float or pop out of the ground due to buoyancy and therefore they should be designed to resist the uplift forces. Above ground tanks should be placed above the FHL if possible.

C3.4 Assessment and Repair of Flood Damage Buildings

The assessment and repair of flood damage buildings is an important issue for health and safety reasons as well as to prevent longer term structural problems. The BRANZ Bulletin 455[11] and the Timber Queensland Guide to Assessment and Repair of Flood Damaged Timber and Timber Framed Houses[12] should be consulted for further information.

Additional matters to check after inundation by flood waters include whether the termite management system has been compromised, particularly chemical systems, integrity of flashings, and monitoring of residue moisture and the presence of mould.

C3.5 Identification of flood hazard areas

The DFE and DFL used by a local authority to manage flood risk to property are generally determined in land use planning in consideration of flood risk management. It is often associated with a 1% chance of a flood of that size being exceeded in any given year or an annual exceedance probability of 1 in 100. However, other flood events or information may be used by the local authority for managing flood risk to buildings or the particular flood situation at the location in question and in setting both the DFE and DFL.

There are significant variations in the information available on flooding between areas within a local authority and between local authorities within Australia. This may result from the age of studies, the type of modelling undertaken, the information available to understand flood behaviour, or the reliance of historical flood information or estimates to provide an understanding of flood risk. This will mean different levels of information availability.

Flood investigations may have also resulted in mitigation works which may alter flood behaviour. These are local by nature and their benefits would generally be assessed in studies for the area and considered by the local authority in determining the flood hazard area.

In many cases information about flow velocities will not be known or will be limited. Modelling of the DFE may provide velocities at the peak of flow within an area rather than peak velocities at a specific location. Therefore it is unlikely that the local authority will have specific information on flow velocities at a particular site in all cases.

Existing development in more active flow areas, including floodways, is more likely to be subjected to higher velocities of flow than permitted by the Deemed-to-Satisfy Provisions and is also more likely to impact upon flood behaviour elsewhere. Any additional development or

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[11] BRANZ BULLETIN 455 Restoring A House After Flood Damage, December 2004

[12] Timber Queensland, Guide to Assessment and Repair of Flood Damaged Timber and Timber Framed Houses Technical Guide (Revised 19th Jan 2011)

redevelopment in these areas is also likely to be exposed to more hazardous conditions it requires careful consideration and assessment. Also note that the flow velocities could also be expected to exceed the limits set in this Standard in many areas subject to local overland flooding.

The local authority may need to rely upon judgement upon where the Standard applies or request specific information from the proponent to determine whether the Standard applies and provide key criteria for design. This may limit the application of the Deemed-to-Satisfy Provisions by the local authority to backwater and inactive flow areas in the DFE where it is less likely the velocity nominated in the Deemed-to-Satisfy Provision in the Standard would be exceeded.

In many cases detailed information on the depth of inundation at the development in question will rely upon the provision of survey advice from the proponent relative to flood level information determined in the DFE.

In some cases the local authority may require the proponent to engage a suitably qualified professional to determine the DFE and/or to gain a more detailed understanding of flood behaviour at the location. This may include ascertaining the specific design criteria necessary to enable consideration of the development in relation to the Standard and meeting other requirements established by the local authority.

C3.6 Appropriate location of and control of development in flood hazard areas through land use planning

Best floodplain management practices, as outlined in SCARM and the AEM Series document Managing the Floodplain recommends the preparation of floodplain management plans to gain an understanding of flood behaviour and outline how the full range of flood risk faced by a community and its people, property and infrastructure, can be managed at a particular location.

In new development areas floodplain management plans provide information to guide strategic decisions on where, what and how to develop the floodplain whilst reducing residual flood risk to people, property and infrastructure to an acceptable level. Local authorities can use planning controls to influence the long term development of an area in consideration of flooding, by restricting the location of development (zonings) and placing conditions (controls) on it.

New development areas can be located away from: floodways, through which the main floodwaters flow; areas the velocity and depth of floodwaters can be hazardous; and where it is not possible for people to readily self evacuate to flood free areas and there is no practical alternative. Within the remaining developable land, additional conditions can reduce the exposure of new development to flooding. These controls can include: minimum fill levels for land; minimum floor levels for buildings and other structural requirements (such as identified in the Standard); and the ability to evacuate people to flood free areas (with the latter considering the full range of flood risk).

In existing development areas flood risk is harder to manage due to the scale of development and the practicality, effectiveness and affordability of large scale mitigation measures. Redevelopment or extensions to existing development and its occupants in these areas may be exposed to a higher degree of hazard (velocity and depth) in the defined flood event or events up to the probable maximum flood (PMF) than those in new development areas, where planning controls can more effectively be used to reduce risk.

This Handbook and the Standard are only concerned with the construction of buildings in flood hazard areas. The DFE and DFL used by a local authority to manage flood risk to property are generally determined in land use planning in consideration of flood risk management. It is often associated with a 1% chance of a flood of that size being exceeded in any given year or an annual exceedance probability of 1 in 100. However, other flood events or information may be used by the local authority for managing flood risk to buildings or the particular flood situation at the location in question and in setting both the DFE and DFL.

Various references and publications containing information that may be of assistance to designers or relevant authorities are listed in Sections 4 and 5.

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Appendix A NCC 2013 Extracts

BCA Volume Two (similar provisions in BCA Volume One)

P2.1.1 Structural stability and resistance to actions

(a) A building or structure, during construction and use, with appropriate degrees of reliability, must—
   (i) perform adequately under all reasonably expected design actions; and
   (ii) withstand extreme or frequently repeated design actions; and
   (iii) be designed to sustain local damage, with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage; and
   (iv) avoid causing damage to other properties,

   by resisting the actions to which it may reasonably be expected to be subjected.

(b) The actions to be considered to satisfy (a) include but are not limited to—
   (i) permanent actions (dead loads); and
   (ii) imposed actions (live loads arising from occupancy and use); and
   (iii) wind action; and
   (iv) earthquake action; and
   (v) snow action; and
   (vi) liquid pressure action; and
   (vii) ground water action; and
   (viii) rainwater action (including ponding action); and
   etc

P2.1.2 Construction of buildings in flood hazard areas

(a) A building in a *flood hazard area* must be designed and constructed, to the degree necessary, to resist flotation, collapse or significant permanent movement resulting from the action of hydrostatic, hydrodynamic, erosion and scour, wind and other actions during the *defined flood event*.

(b) The actions and requirements to be considered to satisfy (a) include but are not limited to—
   (i) flood actions; and
   (ii) elevation requirements; and
   (iii) foundation requirements; and
   (iv) requirements for enclosures below the *flood hazard level*; and
   (v) requirements for structural connections; and
   (vi) material requirements; and
   (vii) requirements for utilities; and
   (viii) requirements for occupant egress; and
   (ix) impacts to other structures and properties.

Limitation:
P2.1.2 only applies to a Class 1 building.

P2.2.1 Surface water

(a) *Surface water*, resulting from a storm having an *average recurrence interval* of 20 years and which is collected or concentrated by a building or *sitework*, must be disposed of in a way that avoids the likelihood of damage or nuisance to any *other property*.
(b) *Surface water*, resulting from a storm having an *average recurrence interval* of 100 years must not enter the building.

Limitation:
P2.2.1(b) does not apply to a Class 10 building where in the particular case there is no necessity for compliance.

PART 3.10.3 FLOOD HAZARD AREAS

Appropriate Performance Requirements:
Where an alternative design is proposed as an *Alternative Solution* to that described in Part 3.10.3, that proposal must comply with-
(a) *Performance Requirement* P2.1.2; and
(b) The relevant *Performance Requirements* determined in accordance with 1.0.10.

Acceptable construction manual

3.10.3.0

Performance Requirement P2.1.2 for Class 1 buildings constructed in a *flood hazard area* is satisfied if the building is constructed in accordance with the ABCB Standard for Construction of Buildings in Flood Hazard Areas.

Appendix B Additional State and Territory requirements

The following provides a summary of relevant State/Territory flood related building and planning provisions. The information was provided by the State/Territory administrations in October/November 2010.

B.1 Northern Territory (NT)

Part 10 (Areas liable to flooding) of the NT Building Regulations under the Building Act regulates buildings in flood prone areas.

Reg 37 (Flood prone areas) specifies that the parts of the Territory included in Schedule 4 are prescribed as flood prone areas.

Reg 38 (Flood levels) specifies that the flood level for a flood prone area is the 1 in 100 year flood level. However, the Director may also determine the flood level.

Reg 39 (Requirements in flood prone areas) specifies that in relation to a building constructed in a flood prone area:

(a) the height of the lowest floor level, or lowest part of the floor level, of a habitable room shall be not less than 300 mm above the flood level;

(b) the structural design of the building shall be adequate to withstand flooding giving consideration to:

(i) the site, size and shape of the building;

(ii) the effect of buoyancy on the sub-structure of the building; and

(iii) the stresses that the depth and velocity of water and the impact of water borne debris may have on the structure.

NT Planning Scheme Clause 6.14 (Land subject to flooding and storm surge) specifies that in a Defined Flood Area (ie the area that is inundated by the 1% Annual Exceedence Probability flood event):

(a) the minimum floor level of habitable rooms should be 300mm above the flood level for the site; and

(b) the use of fill to achieve required floor levels should be avoided.

Local Governments have no powers to develop their own building, planning or other requirements to control the construction of buildings in flood prone areas

B.2 Australian Capital Territory (ACT)

The ACT's main urbanised area is greater Canberra, and as Canberra is comparatively new, and "intensively designed", there are notionally no relevant "flood prone areas" available for construction. Isolated settlements and pre-ACT villages incorporated into the ACT have no flood prone areas available for construction either, (Hall village, Tharwa village, Uriarra settlement, Oaks Estate, etc).

Government controls release of new land for urbanisation and ensures land is not released for construction in flood prone areas.

B.3 Western Australian (WA)

Planning and Development Act 2005

Town Planning (Buildings) Uniform General By-laws 1989

Section 23. Land liable to flooding - A building shall not be constructed on land defined by the council as being liable to flooding or inundation.

Many of the 'at risk' local governments incorporate provisions into their individual Town Planning Schemes (TPS). Each TPS is different but a general overview is that developments require planning approval; council has power to not issue approval in areas at risk of flooding; there is an ability for council to liaise with other government departments (such as Department of Water); and minimum FFLs may be determined by council.

Examples of WA Local Government Flood Prone Planning Policies

B.3..1 Shire of Beverley TPS No. 2

Clause 4.5 Flood Prone Areas provides the process and conditions for how developments on land identified within the extent of a 1 in 100 year flood for Avon River will be dealt with. Including—

1. Developments will require planning approval
2. Council will consult with the Water Authority of Western Australia
3. Council may determine the FFL for any buildings in the planning application.

B.3..2 Shire of York TPS 2

Clause 5.4 Avon River Flood Fringe provides 8 provisions that deal with the development of land within flood plan areas identified in the Avon River Flood Study. Including no development in these areas if the council or water agency thinks that is appropriate, requirement for planning approval, minimum FFL heights, fencing, and rehabilitation of land.

B.3..3 Shire of Moora TPS 4

4.10 LAND LIABLE TO FLOODING

Notwithstanding anything elsewhere appearing in the Scheme development of land identified in the Moore River Flood Study adopted by the Water and Rivers Commission as within the extent of 100 year flood shall be subject to the following:

(a) in addition to a building licence, the Council's planning approval is required for all development including a single house and such application shall be made in accordance with the provisions of the Scheme.

(b) in determining an application for planning approval the Council shall consult with the Water and Rivers Commission.

(c) development which includes a building or structure shall not be permitted unless in accordance with recommendations of the Water and Rivers Commission.

(d) the Council may accept that an applicant consults with the Water and Rivers Commission and demonstrates compliance with the recommendations of the Water and Rivers Commission to the satisfaction of the Council in which case the Council is not required to act in accordance with paragraph (b) of this sub-clause.

B.3..4 Shire of Carnavon TPS 10

Clauses 6.8 and 6.9 deal with flooding and storm surge.

Cyclonic Storm Surge Affected Areas

Areas subject to the potential threat of inundation by cyclonic storm surge are given consideration in respect to floor heights and structural adequacy.

Flood Prone Areas

Where any development is proposed which is in area or location subject to the influence of - flooding (river overflow); flood (localised drainage problems); or storm surge, it is to be assessed for construction systems and floor heights to enable the development to be adequately above the estimated flood level for that location.

B.3..5 City of Mandurah TPS No. 3

5.5.5 Land Subject to Flood Risk, Damage, Hazard or Erosion by Water

Council shall not approve development on land that is subject to flood risk, damage, hazard or erosion by water unless the owner is prepared to indemnify Council against any claim for damages and to charge the land with the indemnity. Development shall not be permitted even with such indemnification where the development would cause problems relating to flood management, environmental degradation or erosion, or the land is flood prone.

B.4 Victoria (VIC)

Building Regulations 2006, Regulation 802(2) sets out the purposes of Regulation 802, what is considered to be land that is in an area liable to flooding.

Land can be identified in a planning scheme under the *Planning and Environment Act 1987* as being in an area liable to flooding.

Land may be designated by the relevant council as being in an area liable to flooding if it is likely to be flooded by waters from a waterway or any land upon which water concentrate (see para (d)(i) and (ii).

Building Regulations 2006 - Regulation 802

Flood areas

(1) This regulation does not apply to-

(a) a Class 10 building; or

(b) an unenclosed floor area of a building; or

(c) an alteration to an existing building if the area of the existing building is not increased by more than 20m2.

(2) For the purposes of this regulation, land is in an area liable to flooding if-

(a) by or under the *Water Act 1989* it is determined as being liable to flooding (however expressed); or

(b) it is identified in a planning scheme under the *Planning and Environment Act 1987* as being in an area liable to flooding; or

(c) it is described on a certified or sealed plan of subdivision or plan of strata subdivision or plan of cluster subdivision (as the case requires) as being liable to flooding (however expressed); or

(d) it is designated by the relevant council as likely to be flooded by waters from-

(i) a waterway, as defined in section 3 of the *Water Act 1989*; or

(ii) any land upon which water concentrates or upon or over which surface water usually or occasionally flows (whether in a defined channel or otherwise) including land affected by flow from a drainage system.

(3) The report and consent of the relevant council must be obtained to an application for a building permit if the site is on an allotment that is in an area liable to flooding.

(4) The report and consent of the relevant council under subregulation (3) need not be obtained to an application for a building permit if-

(a) a planning permit is required for the construction of the building; and

(b) the relevant planning scheme regulates the level of the lowest floor of the building in relation to any flood level declared under the Water Act 1989 or otherwise determined by the floodplain management authority or the relevant council.

(5) The relevant council must not give its consent under subregulation (3) if it is of the opinion that there is likely to be a danger to the life, health or safety of the occupants of the building due to flooding of the site.

(6) In its report under subregulation (3) the relevant council may specify a level for the surface of the lowest floor of a building on the site.

(7) Before specifying a floor level under subregulation (6) the relevant council must-

(a) consult with the floodplain management authority for that site; and

(b) specify a level at least 300mm above any flood levels declared under the Water Act 1989 or otherwise determined by the floodplain management authority, unless the authority consents to a lower floor level.

(8) The relevant council must without delay advise the floodplain management authority and the sewerage authority for that site of the floor level (if any) specified under subregulation (6).

B.5 Queensland (QLD)

The *Sustainable Planning Act 2009* provides that a planning scheme must not include provisions about building work, to the extent the building work is regulated under the *Building Act 1975* (BA).

Section 31 of the BA provides a head-of-power for local governments to include building provisions in a planning scheme if permitted by a regulation.

Section 13 of the *Building Regulation 2006* (BR) states:

(1) a local government may, in a planning scheme or by a temporary local planning instrument under the Planning Act or a resolution –

(a) designate part of its area as a natural hazard management area (flood); and

(b) declare the level to which the floor levels of habitable rooms as defined under the NCC of buildings on the land must be built.

(2) The local government must, in designating a natural hazard management area (flood), comply with 'State Planning Policy1/03 Mitigating the Adverse Impacts of Flood, Bushfire and Landslide', adopted by the Minister on 19 May 2003.

(3) The local government must keep a register of the natural hazard management areas (flood) it designates and when each designation was made.

Natural hazard areas (flood) can be designated through a provision of a local law, planning scheme or local government resolution.

The State Planning Policy 1/03 (SPP) sets out the State's interest in ensuring the natural hazards of flood, bushfire and landslide are adequately considered when making decisions about development. The SPP informs the way in which local planning instruments address natural hazards.

The SPP states that, generally, the appropriate flood event for determining a natural hazard management area (flood) is the 1% Annual Exceedance Probability (AEP) flood. The outcomes recommended from both the Victorian Bushfires Royal Commission and the Queensland Floods Commission of Inquiry will inform the review of the SPP.

The policy can be accessed at: http://www.dlgp.qld.gov

Provisions in the SPP which are of particular relevance to floods include A1.1, A3.1, A3.2, A4.2, and A5.2.

B.6 New South Wales (NSW)

In NSW local government councils are responsible for managing their flood risk. They are encouraged to define a range of flood affected areas including floodway (where water flow is a key function), flood storage areas (where water storage is an important flood function), the flood planning area (area where the majority of controls apply for flooding) and flood prone land (the extent of the probable maximum flood for emergency response and recovery purposes). Flood prone areas in NSW, unlike other states, include both riverine and local overland flooding areas. Councils are at different stages in defining these areas with very few councils currently able to map all flood prone land. Local government, with technical support from the State Government and financial support from State and in some cases Commonwealth Government have undertaken a wide range of studies and developed a range of management plans which provide essential information for the management of flood risk. The NSW Government's Flood Prone Land Policy and Floodplain Development Manual outline government policy and direction on policy implementation. The Manual is consistent with the National Best Practice Manual.

NSW flood related planning requirements for local councils are set out in Ministerial Direction No. 4.3 Flood Prone Land, issued under section 117 of the *Environmental Planning and Assessment Act 1979*. It requires councils to ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy as set out in the *NSW Floodplain Development Manual 2005*. It requires provisions in a Local Environmental Plan on flood prone land to be commensurate with the flood hazard of that land. In particular, a planning proposal must not contain provisions that:

- permit development in floodway areas,
- permit development that will result in significant flood impacts to other properties,
- permit a significant increase in the development of that land,
- are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or
- permit development to be carried out without development consent except for the purposes of some agriculture, roads or exempt development.

The direction requires that a planning proposal must not impose flood related development controls above the residential flood planning level (typically the 1% flood plus 0.5m freeboard) unless adequately justified to the satisfaction of the Department of Planning and Infrastructure.

The full direction No. 4.3 Flood Prone land can be obtained on line at:
http://www.planning.nsw.gov.au/LinkClick.aspx?fileticket=dOkLhSFp9eo%3d&tabid=248&language=en-AU

When preparing comprehensive Local Environmental Plans councils use a Standard Instrument template which includes the following model provision (clause 7.3) for flooding in areas where flooding matters cannot be fully addressed by limiting land uses, such as where an existing zone and existing land uses include residential accommodation.

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to:

(a) land that is shown as “Flood planning area” on the Flood Planning Map, and

(b) other land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land; and

(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) Subclause (5) applies to:

(a) land shown as “projected 2100 flood planning area” and “projected 2050 flood planning area” on the Flood Planning Map; and to

(b) other land below the projected 2100 flood planning level and the projected 2050 flood planning level as a consequence of projected sea level rise.

(5) When determining development to which this subclause applies, council must take into consideration any relevant matters outlined in subclause 3(a) – (e), depending on the context of the following:

(a) the proximity of the development to the current flood planning area; and

(b) the intended design life of the development; and

(c) the scale of the development; and

(d) the sensitivity of the development in relation to managing the risk to life from any flood, and

(e) the potential to relocate, modify or remove the development.

Subclauses (4) & (5) can only be used once a council has identified the 'projected 2100 flood planning area' and 'projected 2050 flood planning area' as outlined in the Flood Risk Management Guide 2009, which updates the sea level rise information in the NSW Floodplain Development Manual 2005.

The flood clause accommodates climate change induced sea level rise as set out in the NSW Sea Level Rise Policy Statement, which sets sea level rise planning benchmarks of 40cm by 2050 and 90cm by 2100 relative to 1990 levels. The clause is also consistent with the NSW Coastal Planning Guideline: Adapting to Sea Level Rise that shows councils how they can incorporate the sea level rise planning benchmarks into their strategic and statutory land use planning and development assessment processes.

In addition to the above strategic processes and provisions for development requiring consent, the NSW State Environmental Planning Policy (Exempt and Complying Development Codes) 2008, known as the Codes SEPP, aims to provide streamlined assessment processes for development that complies with specified development standards.

The Codes SEPP includes specific requirements for buildings proposed to be constructed on a 'flood control lot'. Clause 3.36C of the Codes SEPP is particularly relevant to the proposed ABCB Standard as follows.

3.36C Development standards for flood control lots

(1) This clause applies:

(a) to all development specified for this code that is to be carried out on a flood control lot, &

(b) in addition to all other development standards specified for this code.

(2) The development must not be on any part of a flood control lot unless that part of the lot has been certified, for the purposes of the issue of the relevant complying development certificate, by the council or a professional engineer who specialises in hydraulic engineering as not being any of the following:

(a) a flood storage area,

(b) a floodway area,

(c) a flow path,

(d) a high hazard area,

(e) a high risk area.

(3) The development must, to the extent it is within a flood planning area:

(a) have all habitable rooms no lower than the floor levels set by the council for that lot, and

(b) have the part of the development at or below the flood planning level constructed of flood compatible material, and

(c) be able to withstand the forces of floodwater, debris and buoyancy up to the flood planning level (or if on-site refuge is proposed, the probable maximum flood level), and

(d) not increase flood affectation elsewhere in the floodplain, and

(e) have reliable access for pedestrians and vehicles from the development, at a minimum level equal to the lowest habitable floor level of the development, to a safe refuge, and

(f) have open car parking spaces or carports that are no lower than the 20-year flood level, and

(g) have driveways between car parking spaces and the connecting public roadway that will not be inundated by a depth of water greater than 0.3m during a 1:100 ARI (average recurrent interval) flood event.

(4) A standard specified in subclause (3) (c) or (d) is satisfied if a joint report by a professional engineer who specialises in hydraulic engineering and a professional engineer who specialises in civil engineering confirms that the development:

(a) can withstand the forces of floodwater, debris and buoyancy up to the flood planning level (or if on-site refuge is proposed, the probable maximum flood level), or

(b) will not increase flood affectation elsewhere in the floodplain.

Because of the above strategic and statutory planning provisions that endeavour to keep residential buildings *away* from hazard areas, additional specific provisions have not been included in the NSW building regulations for buildings constructed in flood prone areas.

NSW defines ‘flood prone land’ as ‘land subject to inundation by the probable maximum flood (PMF)’. This is consistent with definitions in SCARM (2000).[13]

B.7 South Australia (SA)

South Australia’s initiative, ‘Better Development Plans’ (BDP) provides generalised policies for use in council development plans throughout the State. The intent behind the BDP is to

[13] SCARM (2000) *Floodplain Management in Australia: Best Practice Principles and Guidelines*. Agriculture and Resource Management Council of Australia and New Zealand, Standing Committee on Agriculture and Resource Management (SCARM). Report No 73. CSIRO Publishing, 2000

promote best practice planning policy across all councils. Each council can then add to this base policy, more specific planning policy which relates to their circumstances.

It should be noted that all councils in South Australia are in the process of converting to the BDP policy system.

BDP provides general policy on flooding under the heading 'Hazards' – Principles of Development Control:-

Flooding

4 Development should not occur on land where the risk of flooding is likely to be harmful to safety or damage property.

5 Development should not be undertaken in areas liable to inundation by tidal, drainage or flood waters unless the development can achieve all of the following:

(a) it is developed with a public stormwater system capable of catering for a 1 in 100 average return interval flood event

(b) buildings are designed and constructed to prevent the entry of floodwaters in a 1 in 100 year average return interval flood event.

6 Development, including earthworks associated with development, should not do any of the following:

(a) impede the flow of floodwaters through the land or other surrounding land

(b) increase the potential hazard risk to public safety of persons during a flood event

(c) aggravate the potential for erosion or siltation or lead to the destruction of vegetation during a flood

(d) cause any adverse effect on the floodway function

(e) increase the risk of flooding of other land

(f) obstruct a watercourse.

Typically in South Australia, planning policy dictates design for the prevention of entry of floodwaters of a 1 in 100 year average flood event. Some examples of local government development plan policy follows. The requirements are not prescriptive in building design but instead place the onus on the applicant to show that their building design will mitigate flooding.

B.7..1 Tea Tree Gully Council Example

Example of Tea Tree Gully Council Development Plan, following the BDP model for policy on development located in floodwater areas (excerpt below) and overlay maps (attachment 1 and 2). The overlay maps identify ‘development constraints’ which include mapping of river/creek floodwater areas.

Hazards (Flooding)

4 Development should not occur on land where the risk of flooding is likely to be harmful to safety or damage property.

5 Development should not be undertaken in areas liable to inundation by tidal, drainage or flood waters unless the development can achieve all of the following:

(a) it is developed with a public stormwater system capable of catering for a 1 in 100 year average return interval flood event

(b) buildings are designed and constructed to prevent the entry of floodwaters in a 1 in 100 year average return interval flood event.

6 Development, including earthworks associated with development, should not do any of the following:

(a) impede the flow of floodwaters through the land or other surrounding land

(b) increase the potential hazard risk to public safety of persons during a flood event

(c) aggravate the potential for erosion or siltation or lead to the destruction of vegetation during a flood

(d) cause any adverse effect on the floodway function

(e) increase the risk of flooding of other land

(f) obstruct a watercourse.

7 Development located in the River/Creek floodwater areas shown on Overlay Maps – Development Constraints should be able to demonstrate that it will not impact unduly on the free flow of floodwaters either upstream or downstream from the proposed development.

B.7..2 Adelaide Hills Council Example

The Adelaide Hills Council has the most detailed information on flood hazard, having two categories of hazard, being low to high category and extreme flood hazard category. The relevant parts are included below:-

Principles of Development Control

10 Development should not be undertaken on land subject to flooding as shown on Figures AdHiFPA/1 (attachment 3) to 19, or within other areas subject to flooding or inundation by a 100 year return period flood event, unless buildings are designed and constructed to prevent the entry of floodwaters from a 1 in 100 year average return interval flood event.

11 Development located on land subject to flooding as shown on Figures AdHiFPA/1 to 19, or within other areas subject to flooding or inundation by a 1 in 100 year average return interval flood event, should not:

(a) impede the flow of floodwaters through the land or other surrounding land;

(b) occur where the risk of flooding is unacceptable having regard to personal and public safety and to property damage;

(c) increase the potential hazard risk to public safety of persons during a flood event;

(d) aggravate the potential for erosion or siltation or lead to the destruction of vegetation during a flood;

(e) cause any adverse effect on the floodway function.

B.7..3 Gawler Council Example

Gawler Council has detailed policies surrounding the Gawler Rivers flood plains. Map GRFP/1 (attached) shows the extent of the policy area.

Gawler Rivers Flood Plain Policy Area

Introduction

In addition to the applicable zone policies, the Gawler River Flood Plain Policy Area policies apply to the area shown in: Maps Ga/13 to 20 and Figure GRFP/1 (attachment 4).

Applicable zones: Deferred Urban, Rural, Special Uses, Residential, Residential Historic (Conservation), Residential Park, Light Industry and General Industry Zones.

Desired Character

The Policy Area is defined by the Australian Height Datum (AHD) for the 1:100 year Average Recurrence Interval (ARI) flood level, taking into account also subsequent modification as a consequence of mitigation works to protect specific locations. The floodplain supports a range of rural and urban activities.

Rural Areas:

Agricultural production should continue in the rural areas of the Policy Area whilst the natural environment of the floodplain is maintained and protected with no new residential or other forms of built form in close proximity of the riverbank. Land uses or activities that are suitable in the Policy Area, subject to design considerations include:

(a) river structures for irrigation management (channels, pumping stands);

(b) recreation uses;

(c) continuation of existing primary production including horticulture, but with improvements to existing management practice and subject to conditions regarding protection from floodwaters;

(d) Upgrading or replacement of existing dwellings and ancillary buildings subject to conditions regarding protection from flood waters, dwellings, providing there is 100 metre set-back from the top of the riverbank and the finished floor level is 300 millimetres above the Australian Height Datum (AHD) for the 1:100 year Average Recurrence Interval (ARI) flood level.

Urban Areas:

Infill residential development is provided for in residential zones, but in broadacre residential areas it is not appropriate for these to be developed until local or regional mitigation measures are installed. The following uses will be considered:

(a) dwellings in areas characterised by existing residential development providing the finished floor level is 300 millimetres above the Australian Height Datum (AHD) for the 1:100 year Average Recurrence Interval (ARI) flood level, but no dwellings in broadacre residential areas;

(b) elevated buildings in locations identified for recreation or business use;

(c) recreation uses.

B.7..4 West Torrens Council Example

Stormwater Management

Major system

74 The design of the land division should enable the major storm drainage system to have the capacity to safely convey major stormwater flows.

Design Techniques (Design Techniques illustrate ONE WAY of satisfying the above principle).

74.1 The major storm drainage system has the capacity to safely convey stormwater flows for Average Recurrence Interval (ARI) = 100 years, assuming 50 percent minor system blockage; and

74.2 The major storm drainage system design outflow is matched to the capacity of any existing downstream system.

74.3 The design of the stormwater drainage system shall be based upon the onsite detention of all stormwater (roof and surface water) exceeding a maximum permitted discharge of 20litres per second for a rainfall 1 in 20 years recurrence interval.

75 The arrangement of roads, allotments, reserves and open space should enable where possible as is required for water quality and use for non potable purposes the provision of a major storm drainage system that:

(a) contains and retains creeks and vegetation;

(b) incorporates, where practical, sports grounds and other less flood sensitive land uses;

(c) incorporates, where required, detention and retention basins;

(d) enhances residential amenity; and

(e) integrates with the open space system and provides recreational opportunities.

Minor system

76 The design of the land division should facilitate a minor storm drainage system which has the capacity for minor stormwater flows and should:

(a) not overload adjoining downstream systems; and

(b) where practicable, provide for stormwater to be detained and retained close to its source.

Design Techniques (Design Techniques illustrate ONE WAY of satisfying the above principle)

76.1 The minor storm drainage system has the capacity to convey stormwater flows for ARI = 5 years for suburban residential lots with neighbourhood densities (1) not greater than 20 dwellings per ha, and ARI = 10 years for neighbourhood densities greater than 20 dwellings per ha.

(1) Neighbourhood density means the ratio of the number of dwellings to the area of the land (including associated neighbourhood or local facilities) they occupy. The area includes internal public streets, all areas of public open space, local community services, local employment areas, and half the width of adjoining arterial roads.

76.2 The minor system design outflow is matched to the capacity of any existing downstream system.

76.3 The design of the stormwater drainage system shall be based upon the onsite detention of all stormwater (roof and surface water) exceeding a maximum permitted discharge of 20litres per second for a rainfall 1 in 20 years recurrence interval.

B.8 Tasmania (TAS)

The TAS Building Act 2000 and the Building Regulations 2004 require that the floor level of habitable rooms must be 300mm above the prescribed designated flood level.

Ten mapped floodplains and other areas subject to flooding including tidal.

A new Statewide (Planning) Code is under consideration as part of a Planning Directive.

Local Government cannot have its own building related controls. Individual planning schemes may address flood prone land at this stage. Uniformity will occur under the Planning Directive.

The Building Act 2000

159. Land subject to flooding

A person must not erect or place a building containing habitable rooms on land subject to flooding unless the floor level of each habitable room in the building is 300 millimetres or more above the prescribed designated flood level for that land.

The Building Regulations 2004

12. Land subject to flooding

For the purposes of section 159 of the Act, the following is the designated flood level:

(a) 600 millimetres above ground level or the highest known flood level, whichever is the highest, for land known to be subject to flooding other than as provided in paragraph (b) or (c);

(b) the level which has a 1% probability of being exceeded in any year for the following watercourse floodplains:

(i) the Derwent River through New Norfolk;

(ii) the upper reaches of the Tamar River and the lower reaches of the North Esk River;

(iii) the Huon River at Huonville and Mountain River;

(iv) the South Esk River through Perth and Longford to the Tamar River;

(v) the Jordan River below Pontville;

(vi) the Mersey River through Latrobe;

(vii) the Bagdad Rivulet;

(viii) the Elizabeth River through Campbell Town;

(ix) the Meander River through Deloraine;

(x) the Macquarie River through Ross;

(c) 600 millimetres above the ordinary high-water mark of the spring tide for land on which flooding is affected by the rise and fall of the tide.

Appendix C Extracts from the Guideline on Reducing Vulnerability of Buildings to Flood Damage

Extracts from the Guideline on Reducing Vulnerability of Buildings to Flood Damage.[6]

For infrequent flooding (i.e. above the 1 in 100 AEP flood planning level) the degree of corrosion in heavier gauge mild steel nails and bolts used in timber framing and structural steel connections is unlikely to be critical to require avoiding mild steel. However, for all nails used for framing anchor and straps, AS 1684.2 requires corrosion protected flat head connector nails irrespective of their exposure to moisture.

4.3.1.2 Fastenings and Adhesives

The level of corrosion protection required for fixing hardware (nails, screws, hinges, etc.) depends on a number of factors. Better quality hardware should be used where:

- subject to frequent and/or prolonged wetting,
- it is structurally critical and at risk of severe corrosion,
- the hardware is difficult to examine periodically after a flood,
- the hardware is difficult to replace if severe corrosion does occur,
- inundation by seawater can be expected, and/or
- there is little cost difference involved.

Given that flooding is a relatively low probability in the life of a building placed above a flood planning level such as a 1 in 100 AEP event, most of the heavier mild steel gauge bolts, nails and screws used in structural applications such as timber framing or connecting steel beams do not warrant corrosion-free alternatives. Unless there is constant or prolonged wetting, corrosion should be limited and restricted to the surface. In a more corrosive environment or in critical areas, consideration could be given to using galvanised or stainless steel hardware. The definition of critical areas is somewhat subjective but they could be those satisfying one or more of points above.

Adhesives and sealants that are available for construction are made from a wide range of materials and their performance, when immersed in water, will not generally be obvious. Most perform poorly in this regard and great care should be taken in their application. Of the more common materials solvent-based neoprene adhesives are the best, followed by rubber-based adhesives.

Of the less common materials two-part epoxies and polysulphide epoxy resins perform well. Among the common wood glues resorcinol based glues perform better than melamine urea formaldehyde. PVA glues are the most common wood glues; however, they absorb water and lose their strength. Sealants are also used for their bonding properties. Common sealants in order of greatest water resistance are:

• polysulphide sealants,

• silicone sealants,

• rubber-based sealants,

• epoxy putty,

• polyurethane joint filler (bitumen impregnated), and

• water-based acrylic.

4.3.2 Types of House Construction

4.3.2.1 Traditional House Construction

The vast majority of houses are constructed from:

• brick veneer (a brick wall outside a frame structure),

• light-clad frame (a frame structure directly covered with materials such as timber, aluminium, vinyl, or fibre cement sheet or boards), or

• full brick (two brick walls separated by a cavity). Also referred to as double or cavity brick. Brick veneer and light-clad frame houses normally use a timber or light gauge steel frame which commonly has internal plasterboard lining. They are readily constructed by the building trades, such as carpenters and bricklayers, and are often the most cost-effective forms of construction especially for detached houses because the industry and market are geared to this product. Brick ties and other components that are embedded in mortar are a special case. It is well established that components in mortar corrode at a significantly higher rate than those in the air spaces within the building envelope. This is particularly the case if the mortar beds have been immersed in saline or brackish water. Thus it is a wise precaution to ensure that stainless steel or other high durability materials are used for brick ties.

All these forms of construction use a wall cavity, Figure 57 Concrete panel houses which have problems following a flood, such as trapping silt and retaining moisture in any wall insulation. These issues and possible solutions are discussed in Section 5.4.

4.3.2.2 Concrete Panel Housing

Construction techniques normally associated with commercial and industrial developments are now being used for unit, townhouse and other medium/high density residential developments, (Figure 57). The panels are durable, but depend on the connections to stay in place. If the connections are not appropriately designed and protected they may fail under load or may corrode over time.

Concrete Panel Housing (CPH) comprises external walls and often internal walls made of vertically positioned concrete panels. These can be either precast on site (tilt up construction) or made in a factory and transported to site for placement (precast construction), (Figure 58). The flood performance of CPH is excellent, due to its inherent strength and imperviousness. When used as an isolated concrete wall, i.e. without external cladding or internal lining, this form of construction will suffer no damage and will only need a hose and scrub down or, at the worst, repainting.

Many of the recommendations in these guidelines are applicable to CPH construction. As CPH is engineered for a specific design and constructed by specialists, these guidelines do not include detailed advice on CPH specific flood-effective designs. The principles of these guidelines can be easily applied in their design to suit floodplain conditions. Some important applications to be considered are:

• CPH is usually built with slab-on-ground floors, so in flood prone areas consideration should be given to raising the slab above the surrounding ground level with compacted fill (see Section 5.1.2). It is also practical to have CPH built with raised, suspended floors, using timber or steel framed flooring or suspended in situ or precast concrete slab floors.

- As the panels are reinforced concrete, the simplest approach is to design the walls to resist hydrostatic forces. If this is uneconomic, then it is vital to have near-floor level openings for the entry of rising floodwaters to prevent unbalanced hydrostatic forces forming (see Section 3.2.1). Section 3.2.1.3 gives advice on the provision of sufficient water inlets which can also allow outflow of receding floods. Construction details of openings are best left to the designer, but consideration should be given providing efficient floodwater entry and exit while also providing a thermal, vermin and intruder barrier.

• Minimum repairs are needed when the concrete panels are not lined or clad but rather have appropriate external and internal finishes applied. Acrylic painting of the wall is the simplest internal finish. CPH walls can also be lined internally with plasterboard placed either directly on the wall or on battens (or furring channels) attached to the wall. Battened lining can be used in conjunction with insulation in locations requiring additional thermal insulation, (Figure 59).

While battened linings result in the formation of a cavity and a moisture trap, it does not reduce the flood advantage that CPH offers because the structural performance of the concrete wall will not deteriorate. Additional insulation should be incorporated in the wall itself in the form of sandwich construction, (Figure 60).

For the best flood performance, it is recommended that internal walls also be constructed from solid concrete rather than lined frames. Where internal linings are used over concrete panel walls, allowance should be made for water entry and exit near the skirting. Also where battens support the wall lining, they should be placed vertically wherever practical, to provide better drainage of floodwaters and an improved drying environment. The skirting should be removable or have perforations in water resistant material.

The use of metal door frames should enhance resistance to water damage.

Currently, CPH is economic in unit type developments where repetition and mass production of the panels reduces costs. However, CPH can be used for larger two-storey houses where CPH can be cost competitive with double brick construction.

More information on Concrete Panel Housing is available in the Cement and Concrete Association of Australia's publication "The Concrete Panel Homes Handbook", which can be downloaded from the website: www.concrete.net.au.

4.3.2.3 Blockwork Construction

The two most common forms of residential blockwork construction are:

• autoclaved aerated concrete (AAC) blocks, and

• concrete blocks.

Lightweight AAC blocks commonly used in residential buildings are very porous. If immersed, they can absorb a high volume of water and this can lead to damage of other components. The waterproof coatings usually applied on the exposed wall surfaces are to protect against light wetting, e.g. rainwater, rather than protecting against water immersion over several days. Wherever they are laid below ground, the usual recommendation is that they should be imperviously sealed e.g. with bitumous sealant. Thus without special treatment, they may not be suitable in flood prone areas, (Figure 61). In contrast, concrete blocks will not be damaged by floodwaters and can be easily cleaned after a flood. A house constructed of single-leaf concrete masonry and concrete floors, metal door frames with no skirting boards has very low vulnerability to water damage. In some climates the presence of empty cores in the blocks may not provide sufficient thermal insulation and they may need to be lined or clad thereby increasing flood repairs (see Section 5.4.1 for problems with wall cavities).

Concrete block walls also have the benefit that they can be reinforced to increase their strength in bending, which brick constructed walls are unable to resist. Reinforced concrete or concrete block walls can also be used to provide extra strength to walls at risk from debris and flow velocity.

4.3.2.4 Other House Construction Types

There are a number of alternative construction methods and materials, including:

• mud brick,

• rammed earth,

• reverse masonry veneer, and

• straw bale.

As these types of construction are relatively uncommon area, they are not considered in these guidelines. Key considerations about their flood performance include:

• structural integrity of the material upon immersion,

• how the product and installation will affect drying time,

• the potential for deposition of floodwater contaminants in cavities, and

• the behaviour of the material in relation to other components.

The most important consideration is the effect of immersion for extended periods on the material. It is vital to realise that waterproof coatings may be sufficient to stop rain water from entering and/or damaging the integrity of the material, but quite often will not prevent damage when immersed in water.

4.3.3 Minimising Water Retention and Absorbency

The main factors influencing water damage are the duration of a flood, the length of time components stay wet, the materials used and the detailing. Water can be retained in all sorts of traps and hollows that are a problem in flood prone areas. These include:

• hollows around foundation piers and against sub-floor brick walls

• the space between the underside of kitchen cupboards and the floor

• the base of built-in wardrobes and similar areas

• undrained brick cavities in full-brick construction

• the base of brick chimneys

• under bathtubs and prefabricated shower trays

• sealed cavities in double-sided plasterboard walls and hollow core doors

• the spaces immediately above any ceiling, including the void between a ceiling and the floor immediately above in multi-storey construction.

Water that is retained in these places can delay drying out and promote corrosion in metal items and fungal decay in timber or other organic materials. A long duration flood allows water to soak into materials and sealed cavities, saturating them and maximising the potential for damage. For example, timber will become fully saturated and swell, the pore structure in concrete will become saturated, while the voids in hollow core doors and sealed stud and plasterboard cavities will fill up with water.

The drying time for a building that has been immersed for a prolonged period is measured in months. The damage caused can vary, from mechanical damage caused by timber swelling through to the disintegration of some materials and the onset of fungal decay and corrosion. This will be worsened by the presence of trapped silt and/or absorbent wall and ceiling insulation.

The following four steps will minimise the potential for water absorption and water damage:

1. Choose materials and construction details that are critical to the minimisation of these effects.

2. Choose materials that are not affected by water.

3. Avoid moisture traps in house designs and during building by ensuring clean and tidy construction e.g. wall cavities kept free of building debris and waste.

4. Seal porous materials against water entry. For example, sealing the end grain of timber can significantly decrease water absorption as the open end grain can absorb water at a rate up to 10 times that of the side grain. Some tests have shown that perhaps the best end grain sealer is two-part polyurethane filler or two coats of oil-based primer. The latter is likely to be slightly less effective but easier to apply. Other products may be satisfactory but, because of the problems with reapplying the sealer once constructed, a check should be made with the manufacturer that the product has been proven to provide long-term protection against water absorption without cracking or peeling. Section 5 addresses in more detail what can be done for the individual components within a house.